A PROCESS MODEL FOR DESIGNING PERFORMANCE DASHBOARD USING VISUALIZATION TECHNIQUES

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KUALA LUMPUR

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SOFTWARE ENGINEERING (SOFTWARE TECHNOLOGY)

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ABSTRACT

Data visualization is the presentation of data in a pictorial or graphical format. It enables decision-makers to see data analysis presented visually, so they can observe difficult concepts or identify new patterns. With interactive visualization, we can take the concept a step further by using technology to drill down into charts and graphs for more detail, interactively changing what data see and how it is processed. With the help of data visualization, it is expected to promote creative data exploration. A performance dashboard is one of the most common use cases for data visualization, and it enables decision-makers such as executives and managers to monitor the performance of an organization at one glance. It is essential to go through a proven process model that includes all aspects of designing a performance dashboard. To date, there is a lack of systematic process to design a performance dashboard that using the right performance metrics to measure the Key Performance Indicators (KPIs) and selecting appropriate visualization techniques for visualizing the performance analysis in a dashboard. This research aim is to propose a new process model for designing a performance dashboard using the visualization technique. A case study was conducted to evaluate the functional suitability and usability of the proposed process model by developing a taxation performance dashboard. The evaluation results show that it is feasible to apply the proposed process model to design am effective and usable performance dashboard for analyzing and monitoring the performance of a department.

Keywords: Performance dashboard, Visualization techniques, Visual Mapping, Dashboard Design, KPI

MODEL PROSES UNTUK MENYEDIAKAN PAPAN PEMUKA PRESTASI MENGGUNAKAN TEKNIK VISUALISASI

ABSTRAK

Visualisasi data adalah pembentangan data dalam format bergambar atau grafik yang membolehkan para pembuat keputusan melihat analisis data yang dibentangkan secara visual, supaya mereka dapat melihat konsep yang sukar atau mengenal pasti corak-corak baru. Dengan visualisasi interaktif, kita boleh mengambil konsep ini satu langkah lagi oleh menggunakan teknologi untuk mengetengahkan carta dan graf untuk lebih terperinci, menukar secara interaktif data yang dilihat dan bagaimana ia diproses. Dengan bantuan visualisasi data, diharapkan untuk menggalakkan penerokaan data kreatif. Papan pemuka prestasi adalah salah satu kes penggunaan yang paling umum untuk visualisasi data, dan membolehkan pembuat keputusan seperti eksekutif dan pengurus untuk memantau prestasi sesebuah organisasi dengan pantas. Sangat penting untuk melalui model proses yang terbukti yang merangkumi semua aspek reka bentuk Pada papan pemuka prestasi, setakat ini terdapat kekurangan proses sistematik untuk mereka bentuk papan pemuka prestasi yang menggunakan metrik prestasi yang tepat untuk mengukur Petunjuk Prestasi Utama (KPI), dan memilih teknik visualisasi yang sesuai untuk memvisualisasikan analisis prestasi di papan pemuka. Tujuan penyelidikan ini adalah untuk mencadangkan model proses baru untuk merekabentuk papan pemuka prestasi dengan menggunakan teknik visualisasi. Kajian kes telah dijalankan untuk menilai kemungkinan proses model yang dicadangkan dengan membangunkan papan pemuka prestasi cukai. Hasil penilaian menunjukkan bahawa ia adalah layak untuk menggunakan model proses yang dicadangkan untuk merekabentuk papan pemuka prestasi yang berkesan dan boleh digunakan untuk menganalisis dan memantau prestasi jabatan.

Kata kunci : Papan pemuka prestasi, teknik Visualisasi, Pemetaan Visual, Reka Bentuk Papan Pemuka, KPI

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LIST OF SYMBOLS AND ABBREVIATIONS

ARD	:	Afghanistan Revenue Department
KPI	:	Key performance indicators
PM-DPD	:	Process Model for Designing performance dashboard
KPI-TI	:	Key performance indicators for taxpayer information
KPI-AD	:	Key performance indicators for Audits
KPI-RT	:	Key performance indicators for Revenue collection and Target
KPI-AR	:	Key performance indicators for Arrears
KPI-OB	:	Key performance indicators for Objections
KPI-ENF	:	Key performance indicators for Enforcement
UI	:	User Interface

CHAPTER 1: INTRODUCTION

This chapter introduces the research background following by problem statement, research questions, objectives, scope, and highlights the significance of this research. The last section is the thesis outline, which presents the organization of this thesis.

1.1 Background

The early visualizations were used for travel, commerce, religion, and communication (Ward, Grinstein, & Keim, 2015). Data visualization arise with the advent of computer graphic (Nielson, Hagen, & Müller, 1997), and it has defined the science of visual representation. Card and Mackinlay (1997) describe two types of data visualization. Scientific visualization includes scientific data with an inherent spatial component; for example, wind tunnel vector data or three-dimensional medical images. On the other hand, information visualization comprises abstract, non-spatial data, for example, financial data or document collections. Data has many characteristics, such as types and number of variables and types of data; most of the data visualization taxonomies are based on the type of data involved (Card & Mackinlay, 1997).

Some specific steps need to be taken into consideration when we define the visualization of data. Ward et al. (2015) propose a design pipeline to design and develop a dashboard. Broadly, it starts from raw data to convert to some fundamental data type and then decide for specific visualization and finally map the geometry data to the image. The dashboard is one of the most helpful visualization tools in Business Intelligence (BI) (Negash & Gray, 2008), and its' become famous after the Enron scandal in 2001 (Few, 2006b). There are two significant types of design perspectives of the dashboard (Sarikaya, Correll, Bartram, Tory, & Fisher, 2019; Yigitbasioglu & Velcu, 2012), which are functional features and visual features. Functional features apply the purpose of the dashboard and explain what information dashboard presenting and what dashboard can

perform. On the other hand, the visual features illustrate how efficiently and effectively information is presented.

The concept of performance dashboard derived from the balance-score card. (Cleverley & Cleverley, 2005) To structure the information in the performance dashboard (Eckerson, 2010), propose and describe the three layers' structure); the author uses the acronym of MAD for these layers, which stands for monitor, analyzes and drill the data. The logic behind this structure is, first monitor key metrics for exceptions and then analyze the information and to obtain the extra information and get a better picture of the exception and then check the details report before taking any action.

To design a performance dashboard, two perspectives need to be considered. Firstly, the right data or KPIs need be selected for the dashboard. Secondly, it is crucial for choosing the suitable visualization techniques for analyzing and presenting the data or KPIs (Brath & Peters, 2004; Janes, Sillitti, & Succi, 2013; Sarikaya, Correll, Bartram, Tory, & Fisher, 2019). KPIs are defined as metrics which have an intense effect on the organization and assist the organization to measure and determine progress towards organizational goals. (Cynthia McKinney, FHIMSS, & Ray Hess, 2012). The scorecard survey is one way to identify the KPIs, which should be collected from the company or organization (Kaplan & Norton, 1995).

1.2 Problem Statement

A performance dashboard is a graphical user interface that contains the measure of a business or organization's performance to enable managerial decision-making (Yigitbasioglu & Velcu, 2012). All aspects and characteristics of a performance dashboard were studied and identified from the literature review. To date, most of the existing study only design a performance dashboard with limited aspects and simple steps. There is a lack of systematic way to design a performance dashboard. To design an

effective dashboard, it is crucial to have a systematic process model covers all the common characteristics and main aspects determined from the literature review for designing a performance dashboard.

Many performance dashboards are not designed to be effective and useful (Few, 2006). They visualize the performance information to impress the end-users by the graphical capability of the dashboard but the information visualization may not meet the needs of monitoring the main KPIs. It is important to select appropriate visualization techniques to present the right information. For example, visual mapping to select an appropriate visualization technique is an essential step for designing a performance dashboard, however, it is not included or not performed systematically in most of the existing studies for design of a performance dashboard (Karami & Safdari, 2016; Kumar & Belwal, 2017; Mahmoodpour, Lobov, Lanz, Mäkelä, & Rundas, 2018; Noonpakdee, Khunkornsiri, Phothichai, & Danaisawat, 2018; Shamsuzzoha, Hao, Helo, & Khadem, 2014; Tokola, Gröger, Järvenpää, & Niemi, 2016; Vilarinho, Lopes, & Sousa, 2018; Widjaja & Santoso, 2014). The main intent of using the performance dashboard is to support decision making (Sarikaya et al., 2019) and it is also a remedy to information overload problems by providing an all-inclusive performance management package in one manageable solution. If the information is inadequately presented, the performance dashboard often misguide and distracts the decision maker's attention (Yigitbasioglu & Velcu, 2012).

It is also crucial to follow some design principles in the process of designing a performance dashboard in order to address the design challenges. Design principles guide the design process, capture best practices, and make the recognition of the essential elements that should be included (Maheshwari & Janssen, 2014). However, most of the

existing studies do not emphasize on design principles that can be applied in the design of a performance dashboard.

1.3 Research Questions

The following questions were established to achieve the aim of this study:

- What are the existing processes of designing a performance dashboard?
- What are the data visualization techniques that can be applied to design a performance dashboard?
- How can a process model be applied to design a performance dashboard?

1.4 Objectives

The objectives of the study are:

a) To identify the existing processes of designing a performance dashboard.
b) To propose a process model for designing a performance dashboard using visual mapping approach.
c) To evaluate the functional suitability and usability of the proposed process model in designing a performance dashboard.

1.5 Scope

The scope of this study is to propose a new process model for designing a performance dashboard using data visualization techniques. This study proposed four phases that have to be taken for designing a performance dashboard. For selecting an appropriate visualization technique, this study only includes main factors to be considered for customizing KPIs and selecting appropriate visualization techniques based on visual mapping. The case study evaluated the proposed process model for designing a performance dashboard for taxation. The data was collected from the Afghanistan Revenue Department (ARD).

1.6 Significance of the Research

To date, several studies have been conducted to design and develop a performance dashboard. No study has been conducted to discuss all aspects of a performance dashboard identified during the literature review. The expected outcome of this study is to improve the software process for designing performance dashboard. The new process model will support development teams in designing and developing a performance dashboard. Based on the proposed model, an effective and usable performance dashboard can be designed and developed to assist the decision-makers such as executives and managers for managing performance of an organization and supporting managerial decision-making.

1.7 Thesis Outline

The content of this thesis contains the following: -

Chapter 1: The Introduction chapter addresses an overview of the study conducted. Subsections under this chapter, such as problem statements, research questions, objectives, and significance of the research, will provide readers, a complete understanding of this study.

Chapter 2: The Literature Review chapter presents the background of all keywords related to this study. The content of this chapter includes data visualization, dashboards, performance dashboards, Dashboard design, KPIs, visualizations techniques, and current related processes and their analysis for the designing performance dashboard.

Chapter 3: the Research Methodology chapter, demonstrates precisely the entire methodology practiced in this study. Each step of the applied methodology is discussed in the details.

Chapter 4: The Proposed Work chapter will present a precise explanation of the proposed process model for designing a performance dashboard using data visualization techniques.

Chapter 5: The case study chapter, provides a case study of evaluating the functional suitability and usability of the proposed process model for designing a performance dashboard. The implementation of each step is discussed with the details.

Chapter 6: The conclusion chapter concludes overall research, discuss how the objective of the research is achieved, it also discusses the limitation and future work for this research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter comprises the comprehensive background of the research topic and discuss the previous related work. This chapter begins with the introduction to data visualization and it discusses importance and history. Section 2.3 introduces the taxation, related work in data visualization and core and supportive functions of the taxation system. Sections 2.4, 2.5 and 2.6 discuss the dashboard visualization, performance dashboards, dashboard design, gives an introduction and importance of KPIs respectively. Section 2.7 analyzes different types of data visualization techniques that can be used to analyze and visualize performance information. Section 2.8 discusses studies related to this research. Lastly, a summary is presented at the end of this chapter.

2.2 Data visualization

Visualization is the delivery of information using graphical representations. Before the written language come to the existing, pictures and graphical representation was the mechanism communication. (Peters, 2015).

The ancient visualizations were used for travel, commerce, religion, and communication. For example, maps provided help and support for travelers. The Peutinger Map, which is shown in Figure 2.1("First surviving sheet of the Peutinger Map,"), was an early road map 70,000 miles highway of the Roman world, with roads (in red) and their estimated mileage.

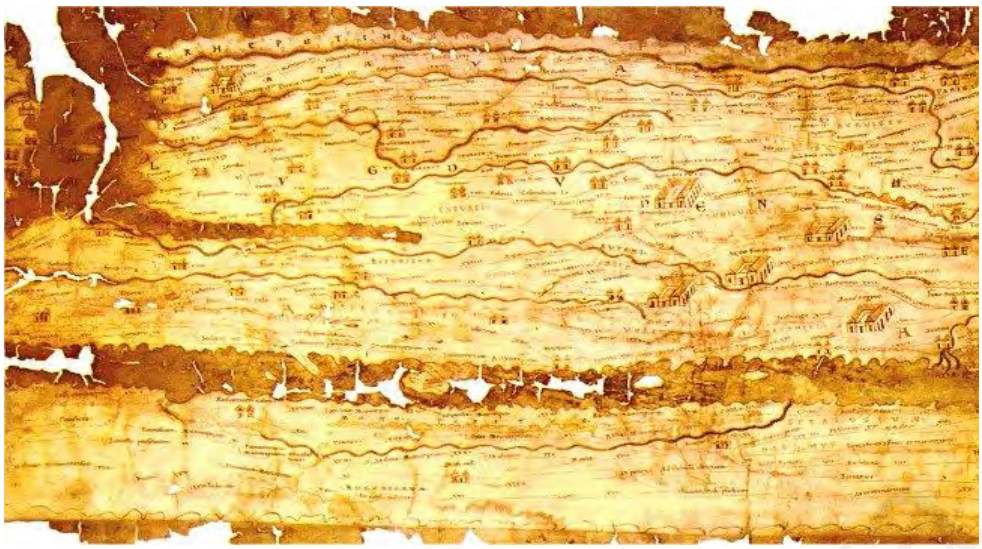

Figure 2.1: A copy of Peutinger Map sets ("Peutinger Map," 2018)

Data visualizations begin with the arrival of computer graphics (Nielson, Hagen, & Müller, 1997), and it is named as the science of visual representation. Initially, scientific visualization was applied to indicate to visualization as a component of the process of scientific computing (Nielson et al., 1997)

Card and Mackinlay (1997) describe two types of data visualization. Scientific visualization includes scientific data with an inherent spatial component; for example, wind tunnel vector data or three-dimensional medical images. On the other hand, information visualization comprises abstract, non-spatial data, for example, financial data or document collections. The kinds of scientific and information visualization force a breakdown in the visualization field. Although this division has practical efficiency, it also has the downfall that research connecting the two fields may be intimidated.

There are certain steps that require to be taken to define a visualization of data. Keim & Grinstein (2015) discussing the design pipeline and illustrated the process of data to visual representation, and Figure 2.2 describe those steps.

There are certain steps need to be taken to define a visualization of data. Keim & Grinstein (2015) talking about design pipeline and it's illustrated the process of data to visual representation, Figure 2.2 describe those steps.

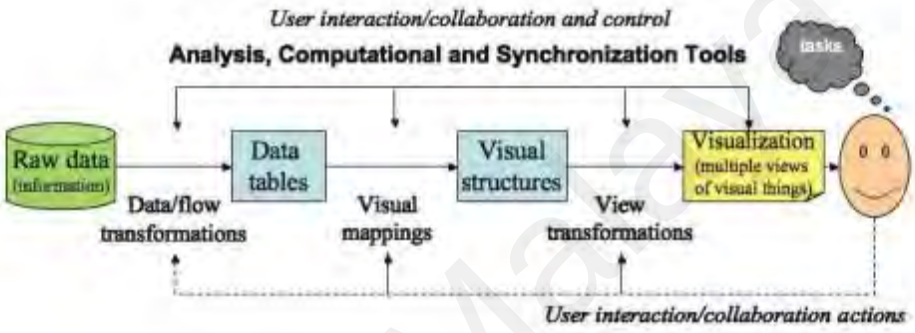

Figure 2.2: Design pipeline (Ward, Grinstein, & Keim, 2015)

User interaction can take place at any point of this pipeline. The starting point is to process the raw data into something that should be used for the visualization system. The first step is to transfer the unorganized data to some fundamental data types and also find out the missing data, or if the data is too large to find out the sample of data. (Ward et al., 2015). Once we clean the data, it is time to decide for specific visualization representation. This mapping requires color, sound, geometry and so on(Ward et al., 2015).

The final stage is to map from the geometry data to the image. This stage really depends on the underline library of the graphic (Ward et al., 2015).

2.3 Visualization Dashboard

Dashboards are one of the most popular use cases for data visualization; they are everywhere. Dashboards are designed and developed almost by every organization to help

data-driven decision making, practiced by students to track learning, and by the individual to observe personal health and energy expenditures.

Dashboard becomes prominent following the Enron scandal in 2001(Few, 2006b), but still, there is no standard definition for the dashboard, Due to it is ubiquitous, the definition of Visualization Dashboard also in flux. (Wexler, Shaffer, & Cotgreave, 2017) propose a more general definition:" a visual display of data used to monitor conditions and/or facilitate understanding." Few (Few, 2006a, p. 34) define the dashboard narrowly: "A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance.".

The dashboard thought has developed from one screen view to multiplies views and purpose, including learning, motivation communication, and decision support. Dashboard implementation interest growing day by day and (Negash & Gray, 2008) claims that dashboard is one of the most beneficial tools in Business Intelligence (BI). At the era of the information, the dashboard responds to the expanding complexity and diversity of the data faced by senior management. Managers mention the four reasons for the implementation of the dashboard (LaPointe,2005).

- The decision-relevant data is poorly organized in many pieces.
- Managerial preferences in information processing and decision making
- The accelerating needs for marketing accountability, given the coupled objective of companies to grow the top line while keeping down expenses for a healthy bottom-line
- The demand and need for various departments combination in performance reporting practices and resource allocation

There are numerous success stories reported that shows the importance of dashboard implementation. For example, (Schulte,2006) observed that the use of IBM's Business Objects Dashboard Manager at Edward Hospital raised its cash flow through the more reliable management of account receivables. Also, the Unisys' marketing dashboard, which was design for funds allocation, accountability, and performance management, directed the organization to further improvement (Miller & Cioffi, 2004).

(Sarikaya et al., 2019) and (Yigitbasioglu & Velcu, 2012) studied a cluster of the dashboard, and they identify and differentiate between two major types of design aspects of dashboards: Functional features and visual features. Functional features fit the purpose of the dashboard and describe what information dashboard presenting and what dashboard can do. Functional features are indirectly related to visualization. On the other hand, the visual features illustrate how efficiently and effectively information is displayed, and it belongs to the principals of data visualization. The main purpose of the dashboard is to support decision making. The main purpose of the dashboard is to support decision making. Besides that, the dashboard is also designed for communication, learning, and self-motivation.

(Sarikaya et al., 2019) also categorized dashboard based on the purpose. It also discusses three types of decision-making dashboard (strategic, tactical, operational), communication, and learning dashboard. Communication and learning dashboard instruct the reader, who may need the context encompassing the displayed data. Figure 2.3

presents four different kinds of the dashboard: Strategic Dashboard, Tactical Dashboard, Operational Dashboard, and Social Dashboard.

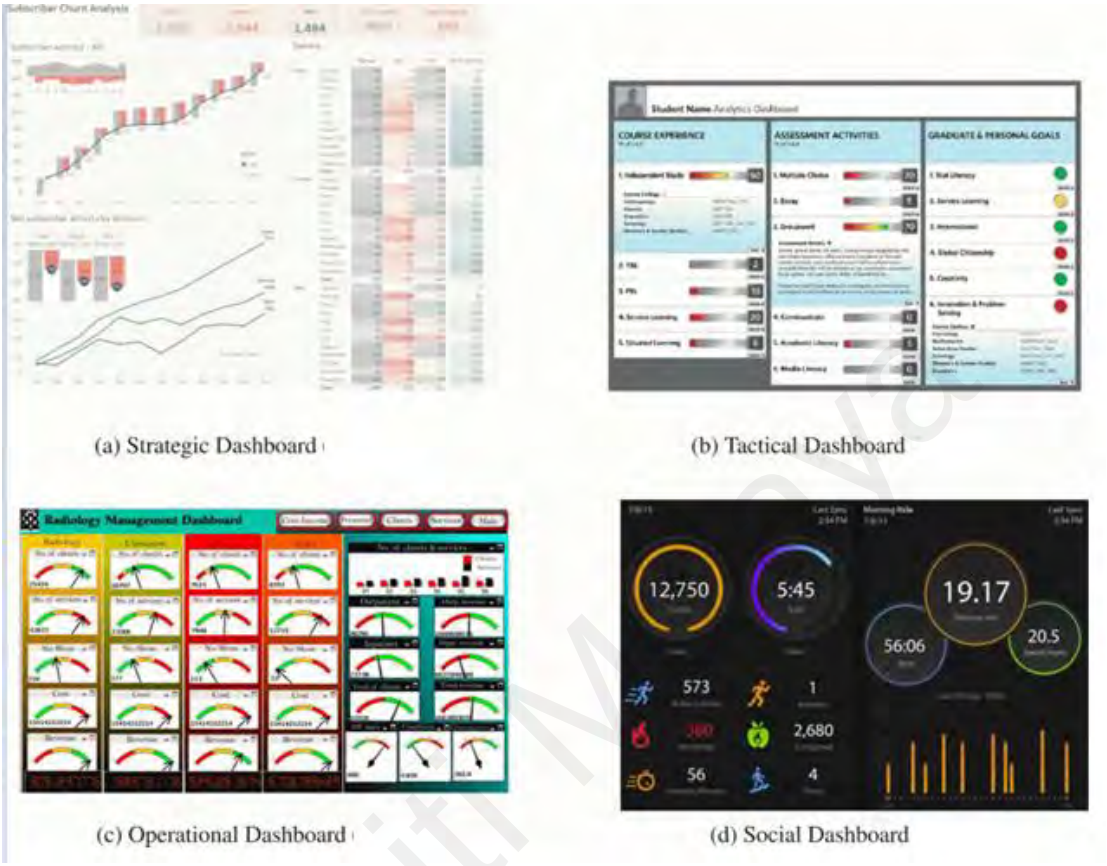

Figure 2.3: Types of the dashboard (Sarikaya et al., 2019)

2.4 Performance Dashboard

The performance dashboard derived from the balance score card concept, which was developed by Robert Kaplan and David Norton (Cleverley & Cleverley, 2005). In 2012, (Yigitbasioglu & Velcu, 2012) defined that a performance dashboard is a graphical user interface that includes a measure of business performance to facilitate managerial decision making. This definition highlights the purpose and structure of a performance dashboard. The use of a performance dashboard is to assist the manager in decision making and provide information about the key measurement of the business.

To structure the information in the dashboard (Eckerson, 2010) propose and describe the three layers structure. (Eckerson, 2010) uses the acronym of MAD for these layers,

which is stand for the monitor, analyze, and drill down the data. The logic behind this structure is, first monitor key metrics for exceptions and then analyze the information and to obtain the extra information and get a better picture of the exception and then check the details report before taking any action. The three layers are as follows:

- The outer layer contains the graphical and overall metric data, which are used to monitor performance. Often the out layer represented by charts, graphs, and alerts. Figure 2.23 shows an example of an outer layer of the performance dashboard.

- The middle layer will allow the user to analyze the users in many dimensions, usually, it consists of dimensional data. Figure 2.24 shows the second layer of the previous layer.
- The third or the inner layer consists of the details which usually presented as a list or report. This function also is known as drill-down. Figure 2.25 is the inner layer of the previous layer.

Rasmussen, Bansal & Chen (Rasmussen, Bansal, & Chen, 2009) and Person (Person, 2013) talking about three types of performance dashboard: strategic, tactical and operational. Organizations implement and utilize one or more of these types according to their needs.

Strategic dashboards are usually distributed on every level of an organization to ensure the strategic goals of the organization to seem to everyone. The purpose of this dashboard is to emphasize management rather than monitoring and analyzing. A useful example of a strategic dashboard was found (Tokola et al., 2016) study. The third dashboard for manufactory, which shows the prediction of on-time shipment, workers, lead time of

lines, demand information, manufacturing cost, and inventories. The time period of the dashboard to a month to a year.

Tactical dashboards track process and emphasis and highlighting the analysis. It also monitors performance and charts progress against budget and other goals (Information & Society, 2009). It used by departmental managers and updated periodically, normally on a daily or weekly basis (Karami, Safdari, & Rahimi, 2013). The tactical dashboard (Tokola et al., 2016) designed for production managers, which shows utilization details, the most important machines, the creation lead time for jobs, delivery reliability, line performance, and improvements. The time period of the dashboard is a day to a week

The operational dashboard usually works with the near real-time data. The time is a minute to an hour. The users of this dashboard often are workers. The performance dashboard proposed on the study of (Tokola et al., 2016) is a practical example of an operational dashboard that shows the situation of the factory floor and job queue.

After defining the organization and type of performance dashboard, the next move is to work through the process identifying what information will add in the dashboard, thus which KPI (key performance indicator) should be presented.

2.5 Design of Performance Dashboards

The concerns for designing and developing dashboards encompass the purpose of the dashboard, design features: visual and function features, data semantics, KPIs, and audience of the dashboard (Sarikaya et al., 2019; Yigitbasioglu & Velcu, 2012).

The intended use of the dashboard is called the purpose of the dashboard, and it may design for monitoring the performance, support decision making, and communication and learning (Sarikaya et al., 2019). Functional features fit the purpose of the dashboard and describe what information dashboard presenting and what dashboard can do. Functional

features are indirectly related to visualization. On the other hand, the visual features represent how efficiently and effectively information is displayed, and it relates to the principals of data visualization (Yigitbasioglu & Velcu, 2012). Besides, the design features dashboard can render valuable semantics about the data and processes that they visualize, for example, alter and notification to the viewer to take an instant action to correct the issue. KPIs are those metrics that dashboard is designed for the visualizations, for the details about the KPIs refer to (**Section 2.6**).

The audience is the end-users of the dashboard. Sarikaya (2019) studied clusters of the dashboard and generally cateogrized of the audience into four groups: public, social, organizational, individual. A public dashboard is designed for general consumption and may represent societally related data. In the social dashboard, Individual manages access to the dashboard to individuals of their selection, identifying situations of sensitive data or analysis. Dashboards for organizations are relevant for many different individuals within an organizational construct, such that these viewers share a mutual goal. Individual dashboards that quantify the Individual and are generally not shared, besides with trusted individuals (Sarikaya et al., 2019)

Many dashboards are not designed to be useful; they visualize as much data as possible to show the graphical abilities of the dashboard and want to impress the customers (Few, 2006a). In order to obtain a useful dashboard, two aspects are very important to give more attention. First, select the right data or metrics and second choosing the right visualization technique for the data (Brath & Peters, 2004; Janes et al., 2013).

Due to the recent emergence of the dashboards, design principles to the specific category are very rare. Few (2006) identified general principles: 1) dashboard information should achieve specific objectives; 2) A dashboard should fit a single screen; 3) Dashboard should monitor information at a glance. There is no guarantee that design principles from

one category neatly transformed into another category(Sarikaya et al., 2019). A very close study of public sectors finds some challenges for the design and development of a performance dashboard and recommends design principles for those challenges (Maheshwari & Janssen, 2014). Below is the illustration of each design principle with description.

Customizing metrics: The performance measurement metric should be relevant for the organizations and should be customized.

Using existing data resources and updating changing priorities: In order to speed up the process at a minimal cost, the currently available metrics should be used. All metrics can be updated continually, but consideration should be given to the metrics with priorities (DeBusk, Brown, & Killough, 2003).

Linking dashboard items/performance metrics: The metrics are usually inter-related, describing the overall process and procedures. Key metrics should be connected based on the perception of organizational strategies, viewpoints, business process, indirect effects, decision support systems, and managerial preferences (Eckerson, 2010; Johnston & Pongatichat, 2008; R. S. Kaplan & Norton, 2001).

Analyze the effect of alternative improvements: Besides visualizing the ongoing operations and process, the Dashboard should also enable the organization to analyze different scenarios and future conjectures (Eckerson, 2010; Maheshwari & Janssen, 2013).

Visual communication at a glance: Dashboards must visualize suitable, relevant information to monitor, analyze, and judge the performance at a glance (Baskett, LeRouge, & Tremblay, 2008; Edwards & Thomas, 2005).

Multi-level design: Dashboards should be usable by different stakeholders and represent their views. A multi-level design can enable organizations to use combined different dashboards connected to the one dashboard.

Data interpretation support: The relationships between performance metrics and organizational aspirations must be transparent and accurate (Velcu-Laitinen & Yigitbasioglu, 2012).

Learning and growth: Dashboard should record information overtime for training and growth purpose.

By applying the above design principles, they enable organizations to make sure that dashboards achieve what they are intended for (Maheshwari & Janssen, 2014).

For Information System (IS) development, Walls (1992) propose a package of three interrelated elements:1) A set of user requirements; 2) A collection of principles that guide the design of a system; 3) A set of principles that is sufficient for guiding the development process (Walls, Widmeyer, & El Sawy, 1992); In order to provide a complete package of guidance for design and development of performance dashboard a framework is required. Lempinen (2012) proposed a design framework for performance dashboard based on design challenges. The author divided these challenges into three phases: 1) What to measure; 2) Where and how to capture the data; 3) How to deliver performance information to the users (Lempinen, 2012).

Beside above related principles to each challenge, the researcher also proposes general principles include:

- Practice an agile, iterative development process.
- Apply a modular approach for the designing system.
- Facilitate communication between the interest groups and individuals.
- Ensure user engagement at each stage to fulfill their requirements.

Another study for developing dashboard templates proposes a data transition method. Figure 2.4 illustrates the proposed framework for analyzing and developing dashboard

templates. This method started from composing events and operations of business and organization follow by attributes of these events and operation than selecting appropriate visualization techniques and applying dashboard capabilities such as dashboard design, layout, and presentation (Noonpakdee et al., 2018).

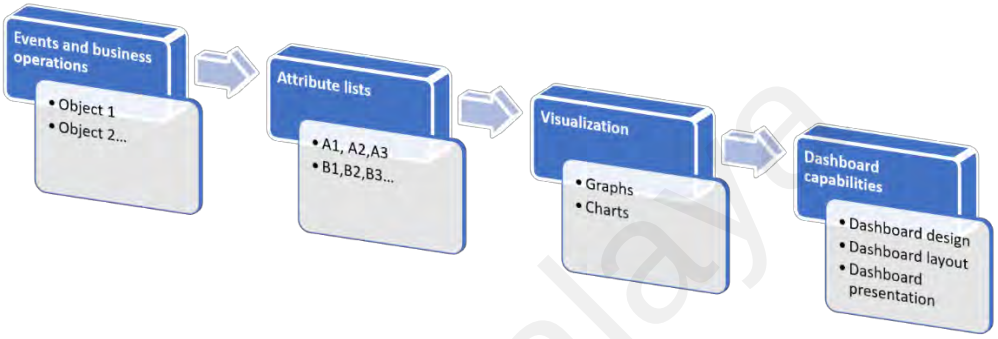

Figure 2.4: Framework for analyzing and developing dashboard templates

2.6 Key Performance Indicators (KPI)

Enterprises and organizations require to examine their activities to discover the degree to which their goals have been achieved. One most reliable way to take out this evaluation is to measure the performance. The evaluation should be taken on those metrics that organizations rely on and have an intense effect on organization performance known as Key Performance Indicators (KPI) (Domínguez, Pérez, Rubio, & Zapata, 2018). (Chen, 2012; Kirchner, 2012). The scorecard survey is one way to find out the KPI, which should be collected from the company or organization (R. Kaplan & Norton, 1995).

KPIs described as metrics that have an intense effect on the organization and assist the organization in measuring and determining progress towards organizational goals (Cynthia McKinney, FHIMSS, & Ray Hess, 2012). In another definition, KPIs indicate a set of measures concentrating on those aspects of the organizational performance that are

the most important for the current and future progress of the organization (Parmenter, 2015).

KPIs perform an essential role in transforming organizational goals into reality (Popova & Sharpanskykh, 2010). In addition, it is assisting organizations to learn how well they are performing concerning their strategic goals (Del-RíO-Ortega, Resinas, Cabanillas, & Ruiz-Cortés, 2013). More precisely, KPIs can give organizations valuable information to establish the basis for implementing their growth strategies (Popova & Sharpanskykh, 2010). Therefore, having an effective, appropriate KPI selection has become crucial and increasingly important in today's competitive business environment (Popova & Sharpanskykh, 2010).

Performance Indicators has different characteristics for example name, definition, type, owner, scale, source, time frame, threshold, hardness, and so on. The descriptions of these characteristics are addresses following (Popova & Sharpanskykh, 2010).

- Type: it might be continuous or discrete, for instance, if the indicator measure as a continuous number then its type specified as continuous and if the indicator measure in joined units such as packets, items, pieces or managing predefined concepts such as low/medium/high then it can be defined as discrete.
- Time: Time frame means which time frame the performance indicator limited; for example, yearly profit has the time frame year. Many scales can also be used for particular performance Indicators such as min value, max value.
- Source: The source may be internal or external to extract the performance indicators.

- Owner: It is means which Role/agent does it, measure/describe it. The threshold can have a precisely defined unit of measurement (e.g., measured in minutes, miles, number of persons or products, etc.).
- Hardness: The performance indicators may be hard or soft. A hard indicator means that it can be measured, for example, numbers of customers, time to produce a plan where soft means not directly measurable, for example, customer satisfaction, company reputation, employee motivation.

2.7 Data Visualization techniques

It is essential in the visualization process to consider the selecting of the best technique to be used in a particular application or situation. The inadequate use of visualization techniques can generate deficient or even incorrect results. The most important question to ask when creating a data visualization is " what is your point." and this is the primary reason for visualizing the data. Once we articulate the point, it generates an answer which derives nearly everything about visualizing the data (Evergreen, 2019). Most visualization techniques are based on the characteristics of the data such as data type, dimensionality (number of attributes) and scalability (number of records (Card & Mackinlay, 1997; Dias, Yamaguchi, Rabelo, & Franco, 2012). Besides, tasks that the user can perform during data exploration might be another factor when deciding for a data visualization technique (Keller, Keller, Markel, Mallinckrodt, & McKay, 1994).

Keller and Keller (1994) classify visualization techniques based on the type of data being analyzed and the user's task. A related classification proposed by Schneiderman (2003) is based on data types but his data types list was different from Keller and Keller. Another classification proposed by Keim (2002) is based on three dimension: data types, visualization techniques, and interaction/distortion methods (Keim, 2002).

The components of each classification listed below:

Classification based on data types (six types of data exists):

- One-dimensional data: temporal data, news data, stock prices, text documents
- Two-dimensional data: maps, charts, floor plans, newspaper layouts
- Multidimensional data: spreadsheets, relational tables 4. Text and hypertext—e.g., new articles, web documents
- Hierarchies and graphs: telephone/network traffic, system dynamics models
- Algorithm and software: software, execution traces, memory dumps

Classification on visualization techniques (5 classes of visualization techniques exist):

- Standard 2D/3D displays: e.g., bar charts, line graphs;
- Geometrically transformed displays: e.g., landscapes, scatterplot matrices, projection pursuit techniques, hyper slice, parallel coordinates;
- Iconic displays: e.g., Chernoff faces, needle icons, star icons, stick Figure icons, color icons, tile bars;
- Dense pixel displays: e.g., recursive pattern, circle segments, graph sketches;
- Stacked displays—e.g., dimensional stacking, hierarchical axes, worlds-within-worlds, tree maps, cone trees.

Classification of Interaction and Distortion Techniques (five classes of visualization techniques exist):

- Dynamic projection: e.g., grand tour system, XGobi, XLispStat, ExplorN;
- Interactive filtering: e.g., Magic Lenses, InfoCrystal, dynamic queries, Polaris;
- Interactive zooming: e.g., TableLens, PAD++, IVEE/Spotfire, DataSpace, MGV and scalable framework;
- Interactive distortion: e.g., hyperbolic and spherical distortions, bifocal displays, perspective wall, graphical fisheye views, hyperbolic visualization, hyperbox;

- Interactive linking and brushing: e.g., multiple scatterplots, bar charts, parallel coordinates, pixel displays and maps, Polaris, scalable framework, S-Plus, XGobi, XmdvTool, DataDesk.

Figure 2.5 show the overall classification of information visualization techniques based on three dimensions.

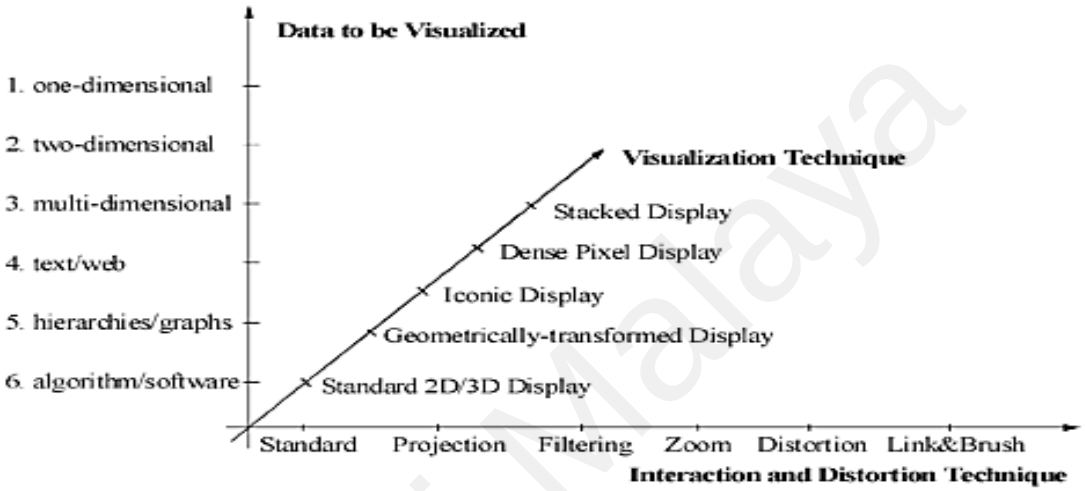

Figure 2.5: Classification of information visualization techniques (Keim, 2002)

All the above classification is very general, and it is used across all domains which are out of the scope of this study to discuss all of them. The most primitive visualization techniques are positional techniques that encompass 1D to 3D visualization techniques (Senay & Ignatius, 1994). For statistical and relational data different charts and graphs are the adequate visualization techniques (Shneiderman, 2003). Based on our observation in related works (refer to **section 2.8**), the performance dashboard mostly uses standard 2D/3D visualization techniques. Sections 2.7.1 to 2.7.15 describe each visualization technique and then categories it based on user tasks and data involved. The aim is to provide a clear understanding of each visualization technique first and might be one visualization technique used in different scenarios to fulfill a particular task.

2.7.1 Bar chart and Column graph

A Bar chart and Column graph look like each other, just rotated 90 degrees. Figure 2.5 and Figure 2.6 show Bar chart and Column graph respectively. Both are effective for comparing values because human beings are extremely good at seeing even small differences in length from a common baseline. One axis of the chart shows the specific categories being compared, and the other axis represents a measured value, it means that one type of data is categorical (nominal) and another type is quantitative(numeric). Beside comparison, it can also be used for analyzing and distribution purposes (Evergreen, 2019; Mackinlay, Hanrahan, & Stolte, 2007; Wexler, Shaffer, & Cotgreave, 2017).

When the categories labels are long and have more than ten items, in this case, the Bar chart is the best option and in the other case if the label is not long and items are less than ten, then the Column graph should be selected (Evergreen, 2019). By adding more variables, the colors can be used to differentiate among them and provide a better understanding.

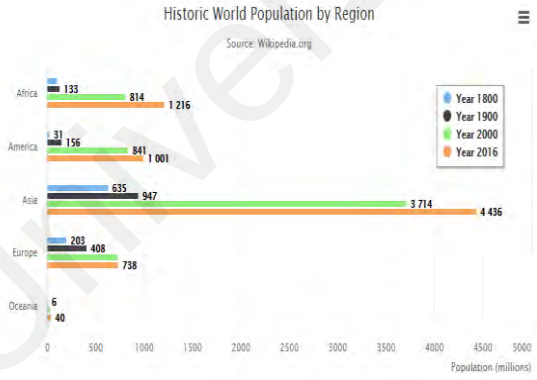

Figure 2.6: Bar chart

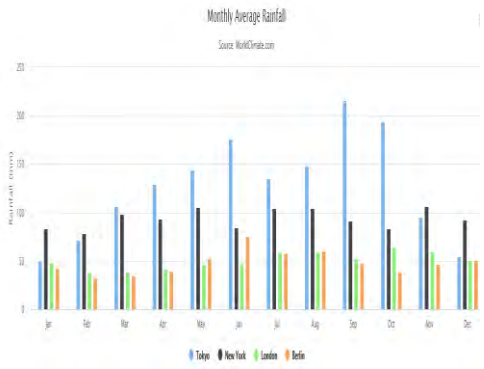

Figure 2.7: Column graph

2.7.2 Line Graph

The primary use of the line graph is to display a trend over a period of time and can be shown many different categories of data, it also shows the comparison, analyzing and

relationship among the different data. Figure 2.7 shows the basic example of a Line Graph. Time is represented by position on the horizontal x-axis and the measures are shown on the vertical y-axis. It means the x-axis data type is ordinal and the y-axis type is quantitative. When plots become more than four lines it causes visual distractions (Evergreen, 2019; Hardin, Hom, Perez, & Williams, 2012; Robertson, Fernandez, Fisher, Lee, & Stasko, 2008).

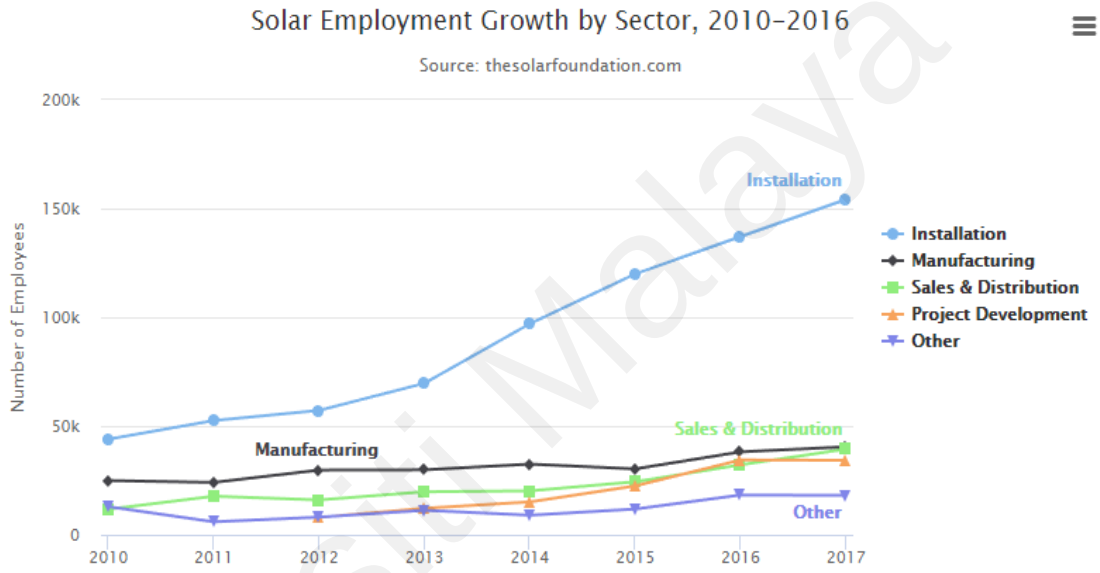

Figure 2.8: Line Graph

2.7.3 Scatter Plot

Scatter Plot is the most used technique for showing correlation and regression. Figure 2.9 shows a typical example of a scatter plot. It also shows comparisons between the two measurements. Each measure is encoded using the position of the horizontal and vertical axes. Scatter plots are an adequate way to give you a sense of trends, attention, and outliers that will direct you to where you want to focus your investigation efforts further (Hardin et al., 2012; Mackinlay et al., 2007; Wexler et al., 2017).

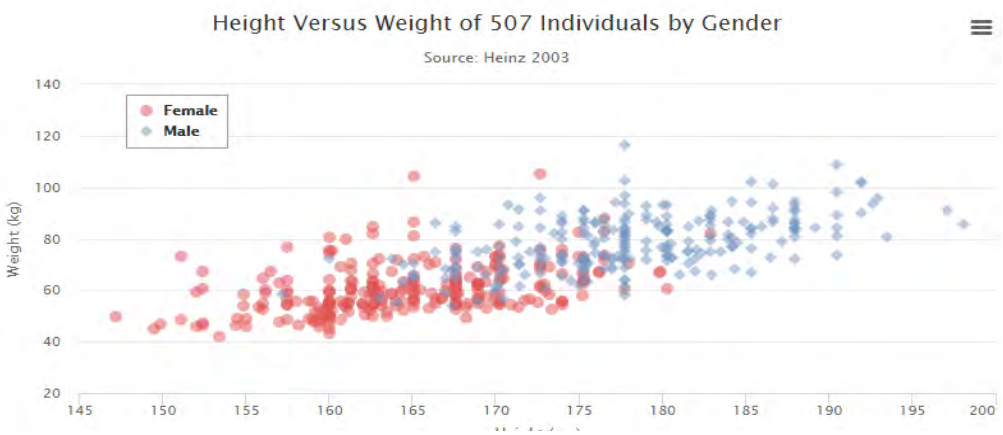

Figure 2.9: Scatter Plot

The typical scatter plot can be enhanced, for example recently news media using a technique called connected scatter plot. The first use of this technique in news graphics by the New York Times in February 2008 (Haroz, Kosara, & Franconeri, 2015), Figure 2.10 shows an example of an enhanced scatter plot.

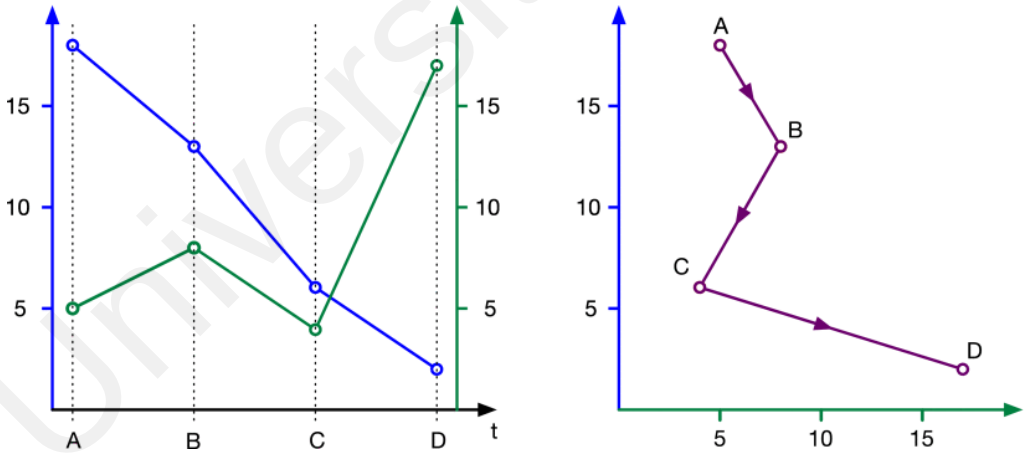

Figure 2.10: Connected Scatter plot (Haroz et al., 2015)

2.7.4 Pie chart

The pie chart is more than two centuries old. The diagram first appeared as an element of two larger graphical displays (Spence, 2005). The pie chart is effective technique while showing relative proportions or percentage of information. Some people trying to use for

comparing purpose which is misused of the pie chart (Evergreen, 2019; Hardin et al., 2012), Figure 2.11 shows an example of the pie chart.

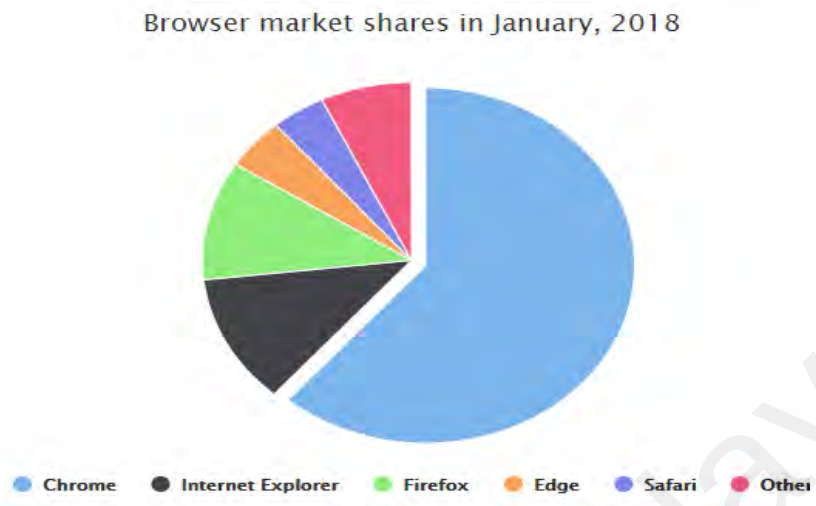

Figure 2.11: Bar chart

2.7.5 Histogram

A histogram is an adequate technique to show the distribution of data over a continuous interval or a certain time period across the groups. Basically, it is a combination of a column graph and a line graph. It is not recommended for more than three variables in a data set. Using consistent colors and labeling is best practice to identify relationships more easily (Evergreen, 2019; Hardin et al., 2012; Mackinlay et al., 2007; Wexler et al., 2017), Figure 2.12 shows an example of histogram.

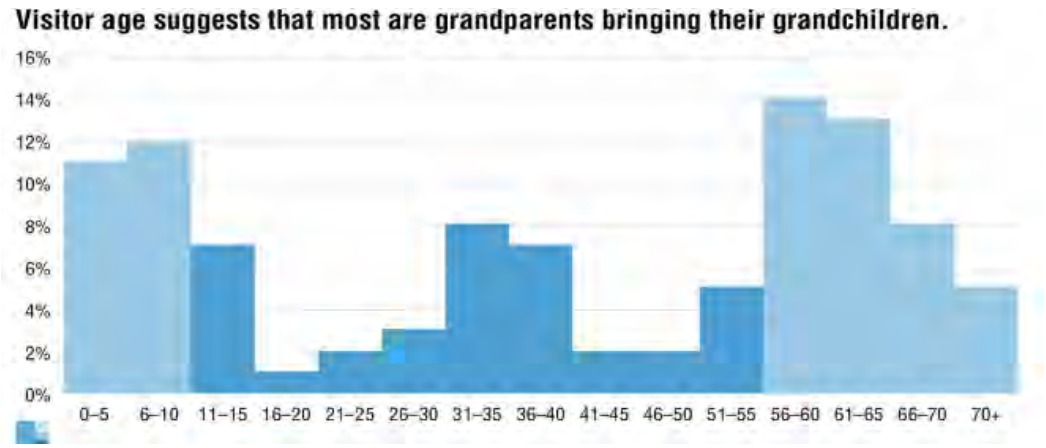

Figure 2.12: Histogram (Evergreen, 2019)

2.7.6 Area Chart

An area chart is essentially a line, with each segment stacked on top of one another. In this way, it also shows part of the whole. Each part of the area chart informs the viewer about the relative contribution that line contributes to the whole. It shows the composition and trends at the same time (Evergreen, 2019; Hardin et al., 2012; Wexler et al., 2017), Figure 2.13 shows an example of the area chart.

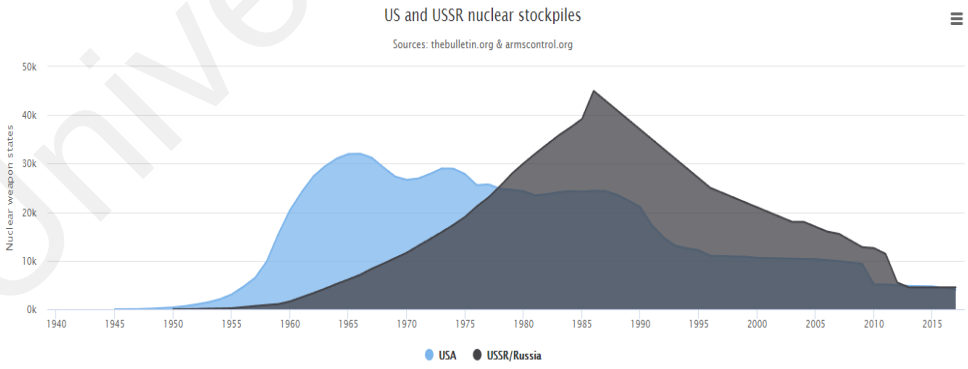

Figure 2.13: area chart

2.7.7 Stacked Bar chart

Stacked Bar is an effective technique while we have to show the percentage that makes up the whole alongside the comparison. It is the enhanced version of the Bar chart and

each bar can show the parts of the whole. It goes deep to analyze and answers multiple questions at once (Evergreen, 2019; Hardin et al., 2012), Figure 2.14 shows an example of a stacked bar chart.

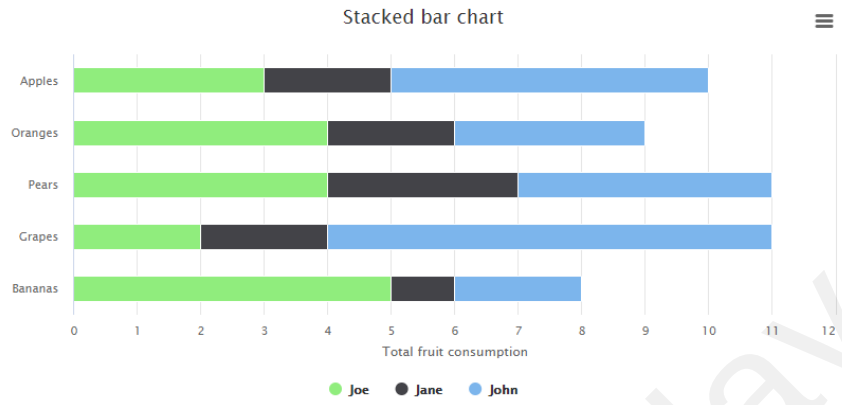

Figure 2.14: Stacked Bar Chart

2.7.8 Heat Map

Heat map visualization techniques represent the individual value of data in a matrix as colors. It is a nice way to summarize the whole story. Many people with finance background ask for a table but heat map provides better insight that you can't see easily with a text table (Evergreen, 2019; Wexler et al., 2017), Figure 2.15 shows an example of the heat map.

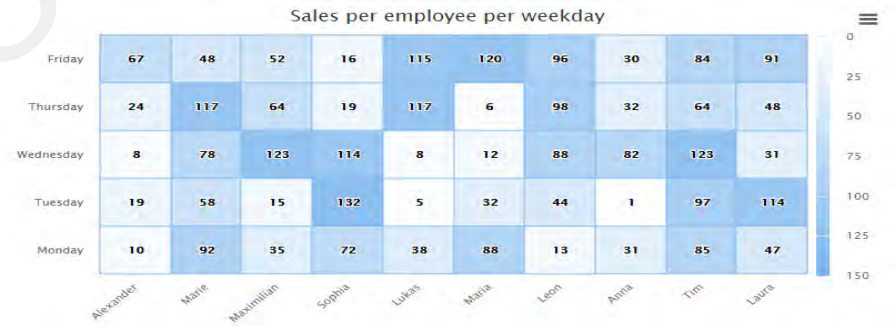

Figure 2.15: Heat Map

2.7.9 Waterfall Chart

A waterfall is a kind of visualization technique that helps in understanding the combined effect of sequentially introduced positive or negative values. These values can either be time-based or category-based values. The waterfall fall chart better visualizes the ongoing increase and decrease over time (Wexler et al., 2017), Figure 2.16 shows an example of the waterfall chart.

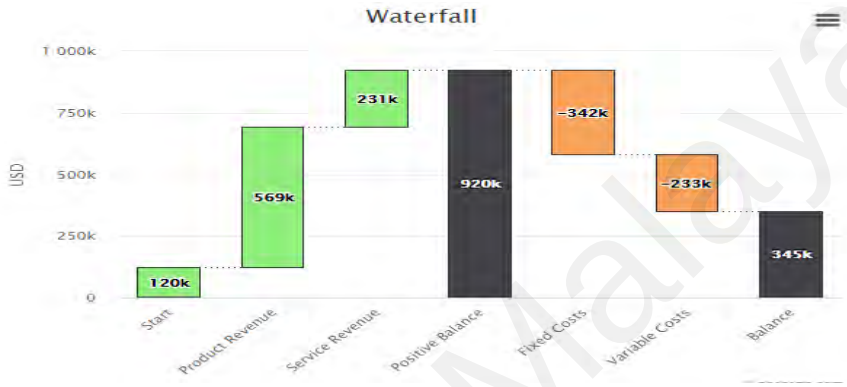

Figure 2.16: Water fall chart

2.7.10 Tree Map

There are many ways to display hierarchical data. In information visualization mostly it used nested figures in rectangle shapes. Hierarchical structures of information are everywhere: family trees, directory structures, organization structures, catalogs, computer programs and so on (Van Wijk & Van de Wetering, 1999; Wexler et al., 2017), Figure 2.17 shows a basic example of the tree map.

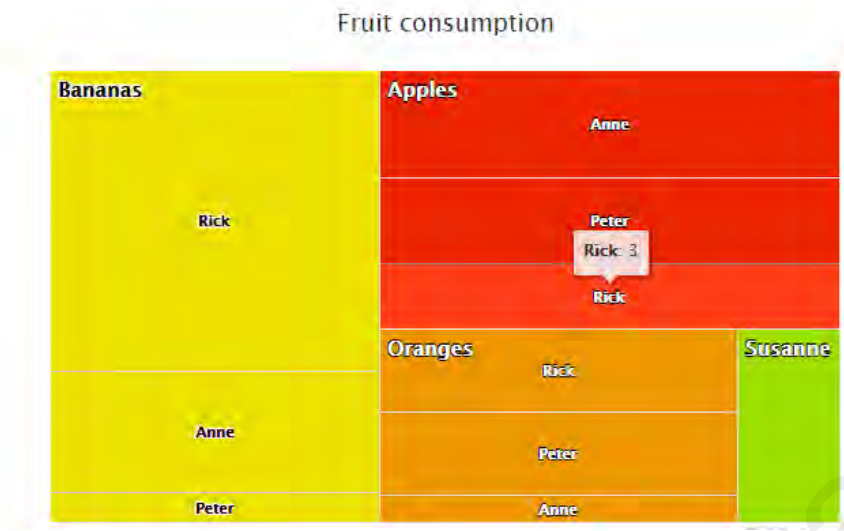

Figure 2.17: Tree Map

2.7.11 Bubble Chart

A bubble chart is a variation of a scatter chart in which the data points are replaced with bubbles, and it adds an additional dimension to the data which is the size of the data, and each bubble represents that size. Bubble charts can help to improve the understanding of social, medical, and other scientific relationships (Fortino, Alenius, & Greco, 2015; Wexler et al., 2017), Figure 2.18 shows an example of the bubble chart.

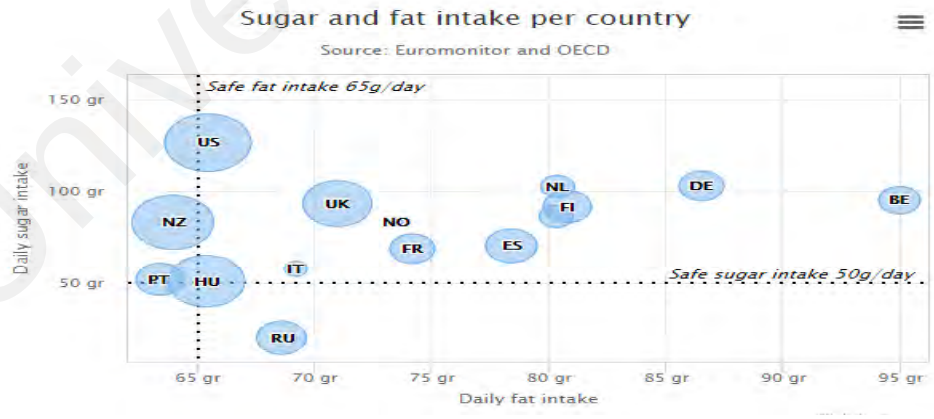

Figure 2.18: Bubble Chart

2.7.12 Gauges and Bullet chart

A gauge is typically used to visualize metrics having a single value, but it displays more than one just value. It can show the minimum, maximum and current value. A bullet

graph is a variation of a linear gauge that represents an actual value and a target value. It may also show ranges that identify if an amount is within a defined state. Bullet graphs convey meaningful information in a small space, making them ideal for dashboards (de Andrade & Sadaoui, 2017; Evergreen, 2019). Figures 2.19 and 2.20 show examples of Gauge and bullet chart respectively.

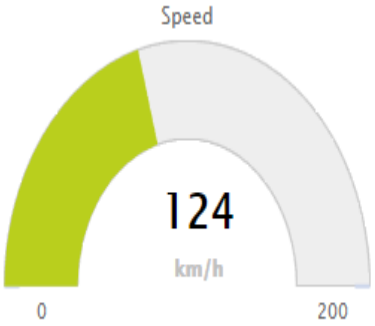

Figure 2.19: Gauge Chart

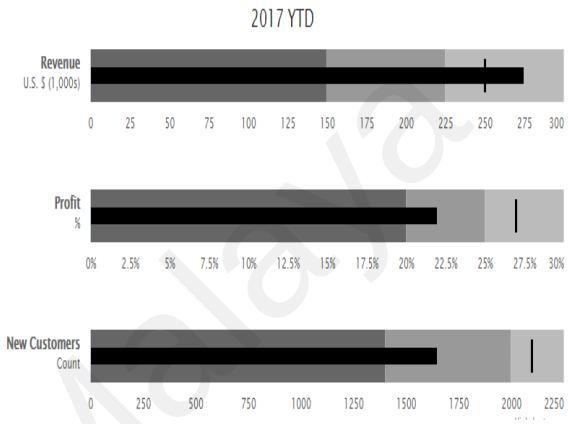

Figure 2.20: Bullet Chart

2.7.13 Map

Map visualization is used to analyze and display the geographically related data and present it in the form of maps. We can visually see the distribution or proportion of data in each region. It is convenient for everyone to mine deeper information and make better decisions (Evergreen, 2019), Figure 2.21 shows an example of map visualizations.

Figure 2.21: Map

2.7.14 Table

Tables are also a useful visualization technique when there is a need to extract specific values and combining them into an overall judgment (Umanath & Vessey, 1994; Vessey & Galletta, 1991). It is the default type of visualization that is used when first selecting data if you did not choose another type and it's also used when you there need to go inside for details by clicking a specific visualization (Khan & Khan, 2011).

2.7.15 Single Number Visualization

Sometimes, all we need is for people to remember this one number we calculated because of the number itself is impactful. For example, we served 125000 clients last year. The most effective way to show a single number is to show it in a big nice format text and a big number more likely to burn into audience brains, Figure 2.22 is an example of showing a Single number (Evergreen, 2019; Tokola et al., 2016).

Figure 2.22: Single number Visualization

2.8 Related Work

There are numbers of studies in different domains that are talking about performance dashboard and their characteristics. In this section, nine studies related to the performance dashboard are discussed and compared. This study selected related work from Manufacturing, Business, Industrial, Education and Healthcare domains. Table 2.2 compares the characteristics of the design of performance dashboards. The related works were chosen from the Business, Industrial, Manufacturing domain due to their most adjacent. This section first analyzes different aspects of the existing performance dashboards: purpose, target users, visual features, functional features, data semantics, KPIs and then it also compares the process model and development method that were used for the design and development of the performance dashboard. It was noted in the literature review that the general purposes of performance dashboards are: 1) To analyze the performance; 2) To monitor the performance; 3) To support decision making (Sarikaya et al., 2019). Table 2.1 gives an overview of the related studies (i.e. domain, year of publication and purpose of the dashboard). In section 2.8.1, Figure 2.23 to Figure 2.34 shows some screenshots of performance dashboards taken from the existing studies.

Table 2.1: Recent studies related to performance dashboard templates

No	Authors	Title	Year	Domain	Purpose
1	Tokola, Henri Gröger, Christoph	Designing manufacturing dashboards on the basis of a Key Performance Indicator survey	2016	manufacturing	To analyze, monitor manufacturing performance and support operational decision-making.
2	Shamsuzzoha, AhmHao	Dashboard User Interface for Measuring Performance Metrics: Concept from Virtual Factory Approach	2014	Business	Measuring the performance metrics and communication among the partners' organizations
3	Vilarinho, Sandrina Lopes	Developing dashboards for SMEs to improve the performance of productive equipment and processes	2018	Industrial	Monitoring, measurement, analysis, and improvement of production processes and equipment to achieve planned results.
4	Mahmoodpour, Medih	Role-based visualization of industrial IoT-based systems	2017	Industrial (IoT)	To monitor, analyze and Support Decision making
5	de Andrade, Paulo Roberto	Improving business decision making based on KPI management system	2017	Business	To monitor and support the decision-making process
6	Widjaja, Henry AE	University dashboard: An implementation of executive dashboard to university	2014	Education	To provide information about the status of any University
7	Karami, Mahtab Safdari, Reza	From Information Management to Information Visualization Development of Radiology Dashboards	2016	HealthCare	To analyze, Monitor and support decision-making
8	Kumar, SM Belwal, Meena	Performance dashboard: Cutting-edge business intelligence and data visualization	2017	Business	To track the metrics, Key Performance Indicators
9	Noonpakdee, Wasinee	A Framework for Analyzing and Developing Dashboard Templates for Small and Medium Enterprises	2018	Business	To track the metrics, Key Performance Indicators

A concise summary of the comparison and characteristics of these studies shown in Table 2.2. It was noted that the basic requirements of the performance dashboard are the characteristics of the dashboards which include target users, visual and functional features, Data semantics and KPIs. It was also observed that characteristics of the performance are different from each other and it depend on organization need and requirements. Target users are the user of the dashboard; visual features are features

related to how efficiently and effectively information is presented to the user; Functional features are the features that relate indirectly to visualization but describe what the dashboard can do. Other than visual and functional features, dashboards can provide valuable semantics about the data and processes that they visualize; KPIs are the Key Performance Indicators that are used in the related dashboard. S stands for the Strategic dashboard, T stands for the Tactical dashboard, and O stands for Operational dashboard.

Table 2.2: Comparison of the characteristics of design templates used in the related studies

No	Target Users	Visual Feature	Functional Features	Data Semantics	KPIs	S	T	O
1	Directors, Managers and operational staff	Modification of the data and views. Customization of the views. Single Page for each User type.	Allow users to drill down information to obtain further details.	Not implemented	99 KPIs from Sales, Costs, Quality, production, Environment	Y	Y	Y
2	Different users such as frontline workers	different colors used for a different meaning. Single page user-based design	Drill down information to obtain further details on various performance measures	Altering, notifications	Quality, Time, Flexibility and Cost KPIs	Y	Y	Y
3	The expected users are operators associated with productive areas	Presented information must respect principles of visualizing data, allowing that information can be quickly and easily understood by anybody. Single page Design for four Zones.	Information presented through trend charts and other graphics; quality tools; tables; images; white space; among others	Alerting, Benchmarking	KPIs about the technical and managerial performance	Y	Y	Y

Table 2.3: Comparison of the characteristics of design templates used in the related studies(continued)

No	Target Users	Visual Feature	Functional Features	Data Semantics	KPIs	S	T	O
4	Operator, Supervisor and Mangers	Dashboard allow users to modify the construction and composition of views, customize the views. Single page Dynamic, Role-based Visualization	Drill down information. Information presented through trend charts and other graphics; quality tools; tables; images;	Not mentioned	States of machines (i.e. idle and busy), errors, running hour, pending orders. Manufacturing costs, energy consumption.	Y	Y	Y
5	Employee, Manager, Board, Auditor, System Administrator	Information can be quickly and easily understood by anybody. Single page Dynamic, Role-based Visualization	Dynamic graphs, Divide KPIs into business units, User access control	Not mentioned	KPIs from Claim Rate", "Client Satisfaction" and "Sales Index	Y	Y	Y
6	Rector, Vice Rector and the Dean	Single page	Allow users to drill down information	Not mentioned	Not mentioned	Y	N	N
7	All Key Stakeholders	Toggling between tabular and chart views. Resizing, maximize/minimize, re-ordering of zones. Allowing different layouts. Visual intelligence to highlight areas and values. Single page based on user role	Drill-down features. Dimensional modeling with hierarchies and levels. Dependency analysis	Altering, notifications	KPIs related to patient safety and quality of care, medical imaging services, internal and external customers, financial performance, resource utilization and so on	Y	Y	Y
8	For a different type of users (not clearly mentioned)	Single page. Role-based multiple page view	Not mentioned	Not mentioned	The mission, vision, goals and objectives of an organization is considered to build the respective metrics	Y	Y	Y
9	Small Medium Enterprise (SME) users	Single page	Not mentioned	Not mentioned	Sale KPIs for business	Y	Y	Y

The dashboard design principles that were discussed in the Section 2.5 are also not fully considered in the related studies. Table 2.3 shows the abbreviation for each design principles (D-1 to D-8). Table 2.4 analyzes the design principles applied to design the performance dashboard in each study. Based on the analysis, none of the existing performance dashboards implemented design principle D-4, which is "Analyze the effect of alternative improvements". On the other hand, design principles (D-1, D-5, D-7) are implemented by all of the performance dashboards.

Table 2.4 Design Principles for performance dashboard (adopted from Maheshwari & Janssen, 2014)

NO	**Design principles**
D-1	Customizing metrics
D-2	Using existing data resources and updating changing priorities
D-3	Linking dashboard items/performance metrics
D-4	Analyze the effect of alternative improvements
D-5	Visual communication at a glance
D-6	Multi-level design
D-7	Data interpretation support
D-8	Learning and growth

Table 2.5: Related papers and their applied design principles

NO	Authors and Year	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8
1	Tokola, Henri Gröger, Christoph (2016)	✓	✗	✓	✗	✓	✓	✓	✓
2	Shamsuzzoha, AhmHao (2014)	✓	✓	✗	✗	✓	✓	✓	✗
3	Vilarinho, Sandrina Lopes (2018)	✓	✗	✗	✗	✓	✓	✓	✗
4	Mahmoodpour, Medih (2017)	✓	✗	✗	✗	✓	✗	✓	✗
5	de Andrade, Paulo Roberto (2017)	✓	✗	✓	✗	✓	✓	✓	✗
6	Widjaja, Henry AE (2014)	✓	✗	✗	✗	✓	✗	✓	✗
7	Karami, Mahtab Safdari, Reza (2016)	✓	✗	✓	✗	✓	✓	✓	✗
8	Kumar, SM Belwal, Meena (2017)	✓	✓	✗	✗	✓	✓	✓	✓
9	Noonpakdee, Wasinee (2018)	✓	✗	✓	✗	✓	✓	✓	✓

2.8.1 Analysis of the existing process in designing a performance dashboard

Besides the characteristics and design principle that recent studies applied, the design and development process model and method were also identified. Table 2.5 shows the process model for the related studies. All of them have some common steps by different names, some named it initial requirement gathering, collecting KPIs, or initial data

collection. Study 4 and study 8 also have a step to define the user roles for the dashboard. Study 6 included a step called "designing and mapping" to design a performance dashboard, but the research did not discuss the steps that should be taken to select an appropriate visualization technique.

Table 2.6: Designing process of related studies

No	Authors and Year	Development Process Model
1	Tokola, Henri Gröger, Christoph (2016)	Did not mention about specific process model or development method, based on our analysis below steps are taken. • Conducted a survey to find out the related KPIs • Discussed some design principles • Developed the dashboard for the collected KPI
2	Shamsuzzoha, AhmHao (2014)	The dashboard is developed by the traditional development method. Below two steps are taken. • Select the appropriate metrics for the dashboard • Develop the dashboard
3	Vilarinho, Sandrina Lopes (2018)	A method was proposed based on the classical product development process, this study defines four phases for dashboard development. • Diagnosis of productive areas. • Dashboard requirements assessment. • Dashboard layout development. • Dashboard implementation and improvement
4	Mahmoodpour, Medih (2017)	The following steps are taken for the Dashboard development: • Define the Roles and hierarchical structure of the organization. • Define the KPIs for each role. • Dashboard Development.
5	de Andrade, Paulo Roberto (2017)	This study has taken two main steps for dashboard development. • Define the KPIs • Dashboard Development.
6	Widjaja, Henry AE (2014)	This study has taken four major steps to develop the dashboard: • Initial data collection • Design and Mapping • The development of Executive Dashboard Prototype • The Implementation of Executive Dashboard

Table 2.7: Designing process of related studies (continued)

No	Authors and Year	Development Process Model
7	Karami, Mahtab Safdari, Reza (2016)	This study has taken below steps to develop the dashboard • Find out the KPIs • Determine the set of user interface requirement • Develop the prototype of the dashboard.
8	Kumar, SM Belwal, Meena (2017)	This study has taken two major steps and under each step, it has sub-steps for the development of the dashboard. **Define the Business Architecture** • Define metrics • Define users • Define data users • Define strategy **Define the technical architecture** • Data source • Data integration • Centralized data warehouse
9	Noonpakdee, Wasinee (2018)	This study combined fours steps for developing the dashboard • Event business operation Define. • Define Attribute lists. • Define visualization. • Define dashboard capabilities.

Figure 2.23: :Strategy dashboard (Tokola et al., 2016)

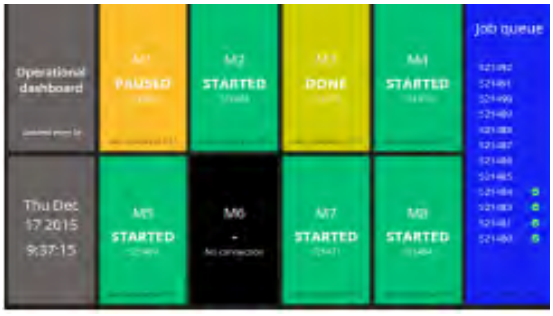

Figure 2.24: Operational dashboard (Tokola et al., 2016)

Figure 2.25: Tactical dashboard (Tokola et al., 2016)

Figure 2.26: Virtual factory dashboard (Shamsuzzoha et al., 2014)

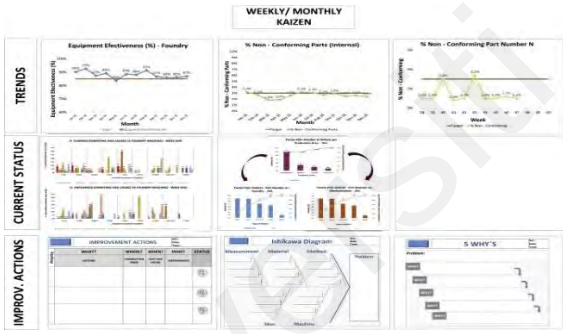

Figure 2.27: Dashboard detail page template for SME (Vilarinho et al., 2018)

Figure 2.28: Dashboard detail page for SME (Vilarinho et al., 2018)

(a) Operational dashboard for operator at factory floor

(b) Tactical dashboard for mid-level supervisor.

(c) Strategic dashboard for high-level manager

Figure 2.29: Three dashboards for different hierarchical roles (Mahmoodpour et al., 2018)

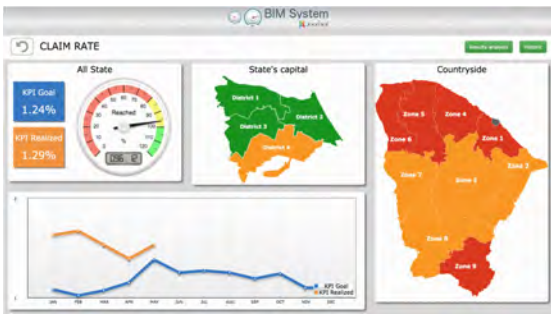

Figure 2.30: KPI detail page-overview (de Andrade & Sadaoui, 2017)

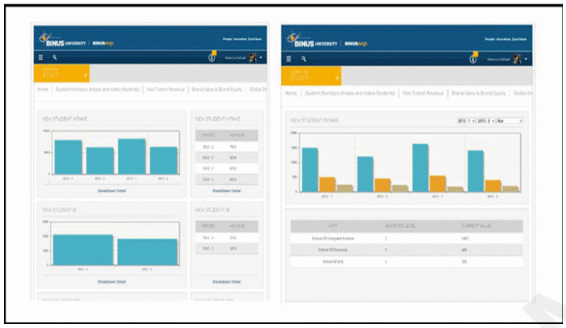

Figure 2.2.31: Dashboard application display for student intake (Widjaja & Santoso, 2014)

Figure 2.2.32: Radiology management dashboard (Karami & Safdari, 2016)

Figure 2.33: Analysis report (Kumar & Belwal, 2017)

Figure 2.34: Analysis report (Kumar & Belwal, 2017)

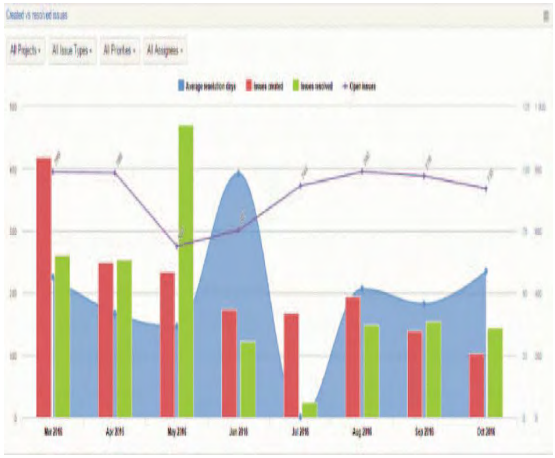

Figure 2.35: Analysis report (Kumar & Belwal, 2017)

Figure 2.36:Performance dashboard (Noonpakdee et al., 2018)

2.9 Summary

This chapter discussed all aspects that closely related to the design of a performance dashboard. It covers data visualization, dashboards, dashboard design, performance dashboard, KPIs, Visualization techniques that were used in performance dashboards. Besides the comprehensive background, the recent related studies are analyzed based on characteristics, processes, and applied design principles at the end of the chapter. Up to data the existing studies only design a performance dashboard with limited characteristics and sample steps.

The next chapter will discuss the research methodology used to achieve the objectives of this study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology for conducting this study. The overview of the research methodology is presented in Section 3.2. The overview briefly describes all steps that has been taken to conduct this study. The details of each step are presented from Section 3.3 to Section 3.7. A summary is presented at the end of the chapter.

3.2 Overview

This study deals with the design and development of the performance dashboard, several steps carried out as presented in figure 3.1 to achieve the objective of the study

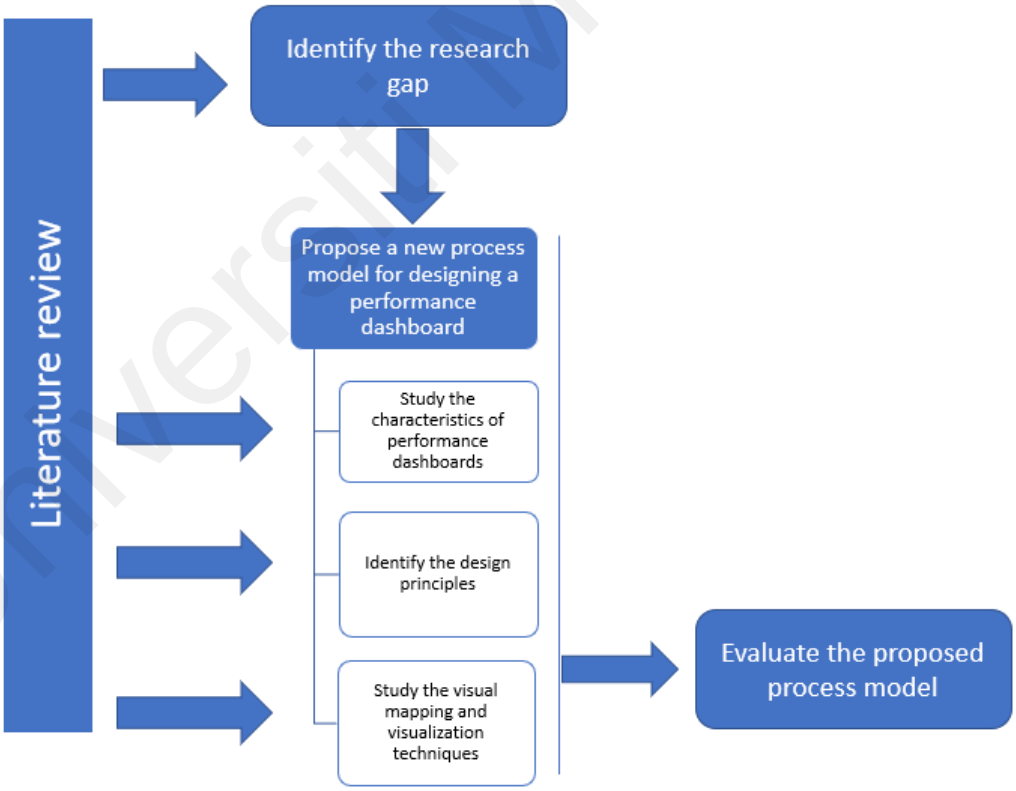

Figure 3.1: Research methodology

The steps that carried out for conducting this study as following:

a) Step 1: Literature review (Section 3.3)
b) Step 2: Identify research gap (Section 3.4)
c) Step 3: Propose a new process model for designing a performance dashboard (Section 3.5)
    i. Step 3a: Study the characteristics of performance dashboards.
    ii. Step 3b: Identify the design principle of the performance dashboard.
    iii. Step 3c: Study the visual mapping and visualization techniques
d) Step 4: Evaluate the proposed process model (Section 3.6)

3.3 Literature review

The literature review is conducted to obtains the information in related areas, which is carried out by previous researchers. Information related to the dashboard, performance dashboards, characteristics of the dashboards, dashboard design, design principles, visual mapping, and visualization techniques were thoroughly gathered. Related studies were reviewed to understand all these areas how they implemented while designing and developing a performance dashboard in the respective domain.

The search has performed in several digital libraries to conduct the research. This study conducted a literature review on journal articles, technical reports, book chapters, and books to understand all areas related to the performance dashboard and then propose a new process model for designing a performance dashboard. The search is conducted based on the following digital libraries:

A. ACM.
B. Science Direct.
C. Web of Science.
D. IEE Explore.
E. Springer Link.

F. Google Scholar.

3.3.1 Search Method

Different keywords were used to find out various aspects of the performance dashboard development. The keywords that were used includes the dashboard, performance dashboard, visualization dashboards, visualization techniques, dashboard design, visual mapping, and data visualization.

3.3.2 Inclusion criteria

The selection criteria were based on the various aspect of the performance dashboards, which includes characteristics of the dashboards, visual mapping, design principles, visualization techniques, and taxation data.

3.3.3 Exclusion criteria

All other aspects that are not related to the performance dashboard design and development were removed. The study focuses on studies related to the performance dashboard and their aspects.

3.4 Identify Research Gap

From the literature, the research problem is identified through reviewing, analyzing and exploring existing studies. The problem statement is explained in the Introduction chapter of this study (refer to Section 1.2).

3.5 Proposing a new process model for designing performance dashboard

All the aspects of the design and development of the performance dashboards were identified and analyzed from the existing studies, the example of performance dashboards, and related books to propose a new process model for designing performance dashboards. Different criteria were identified which has a significant role in developing

the performance dashboards, which include the characteristics of the dashboard, design principles to apply and visual mapping to transform the data to appropriate visualization techniques.

3.5.1 Study the characteristics of the dashboard

Characteristics of the dashboards are the requirements of the dashboard which includes purpose, visual and function features, KPIs, data semantics and target audiences. Figure 3.2 shows the characteristics of the dashboard that were identified from the literature.

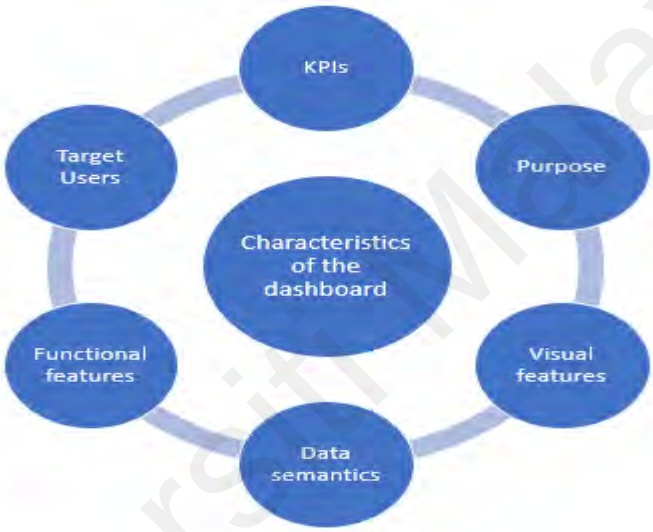

Figure 3.2: Characteristics or requirements of the dashboard

3.5.2 Identify the Design principles

Design principles are the guidelines to support the development process, Different design principles are studied, this study has chosen the six out of eight design principles proposed by Maheshwari and Devender (2014) to be included in the new process model for designing the performance dashboard. Two design principles which are difficult to be applied in designing a performance dashboard were excluded since it required a large number of performance records and the use of machine learning algorithms for analyzing

effects of alternative improvements, learning, and growth. The six design principles adopted in the process model are as follows:

- Customizing the organization metrics
- Utilizing existing data resources and updating changing priorities
- Connecting dashboard metrics among the departments.
- Visual presentation at one glance for the user
- Multi-level design of the dashboard
- Data interpretation and analyzing support

3.5.3 Study visual Mapping and visualization techniques

The process of transformation of the data to appropriate visualization technique is called visual Mapping, there are certain steps are required to be taken to define a visualization technique. Keim & Grinstein (2015) discussed the design pipeline and it is illustrated the process of data to visual representation, refer to Figure 2.2 of the general steps of the design pipeline. The most important question to ask when creating a data visualization is "what is your point". and this is the primary reason for visualizing the data. Once we articulate the point, it generates an answer which derives nearly everything about visualizing the data (Evergreen, 2019)

Beside the point or reason, the data characteristic (data types, numbers of variables, numbers of records) is another factor while selecting an appropriate visualization technique (Card & Mackinlay, 1997; Dias et al., 2012).

This study identified several visualization techniques, their usage, importance, and their data characteristics from the existing studies, books and performance dashboards.

3.6 Evaluate the Proposed Process Model

This phase represents the evaluation of the proposed process model for designing a performance dashboard. A case study was conducted with Afghanistan Revenue Department to design and develop a taxation performance dashboard. Dashboard characteristics and requirements include KPIs, visual and functional features were collected from the Afghanistan Revenue Department. A prototype of the performance dashboard was developed based on the proposed process model. A questionnaire-based survey and follow-up interviews were conducted to evaluate the effectiveness and usability of the taxation performance dashboard. The results of the survey were used to evaluate the functional suitability and usability f applying the proposed process model to design an effective and usable performance dashboard.

3.7 Summary

This chapter discussed the research methodology for conducting this study. The research methodology, which consists of four (4) main steps. Each step and sub-step are discussed and justified to explain the process of conducting this research.

The next chapter will discuss the proposed process model for designing a performance dashboard.

CHAPTER 4: PROPOSED WORK

4.1 Introduction

Chapter 4 describes the proposed work to solve the research problem highlighted in Chapter one. This chapter starts with the overview of the proposed work, a new process model for designing a performance dashboard. The subsequent sections describe each phase of the proposed process model with details. A summary is given in Section 4.7 to conclude this chapter.

4.2 Overview

This section introduces the proposed work, Process Model for Designing a Performance Dashboard (PM-DPD). This process model combines all aspects which are required for the design of a performance dashboard. Figure 4.1 illustrates the proposed process model. PM-DPD consists of four main phases:

- Phase 1: Define characteristics of the performance dashboard
- Phase 2: Customize the KPIs,
- Phase 3: Visual mapping, and
- Phase 4: Design dashboard user interface (UI).

Phase 1 starts from defining the purpose of the performance dashboard. Once the purpose is defined, the next step is to define the main features of the performance dashboard. The three main types of features include the visual, functional and data semantics features, which are very important requirements to analyze the business or organization performance. After defining the features of the dashboard, it is crucial to identify and select the set of KPIs that will be used to measure and determine progress and performance towards organizational goals.

In phase 2, the set of KPIs that are defined earlier need to be customized in order to ensure that the collected KPIs are measured and analyzed accurately to evaluate the performance. The perspective, strategy, measurement and performance metrics are defined to assess each KPI. After that, the visual mapping process is performed in Phase 3 to define each point of KPIs by considering data types and the reason to select appropriate visualization techniques and map performance data for information visualization.

In the last phase, the dashboard UI is designed into multi-level and incorporate all the levels into one dashboard. It starts from selecting a point from each perspective for the first level design, followed by the design of second level for analysis purpose and third layer for presenting the details of each KPI. After completing the multi-level design, a prototype of performance dashboard is developed using appropriate development techniques to demonstrate the performance analysis using appropriate visualization techniques.

The following six design principles are adapted from the study conducted by Maheshawar and Janssen (2014) and applied throughout the four main phases of the process model:

- **Using existing data resources and updating changing priorities:** In order to design a performance dashboard in a timely manner, the existing data resources (e.g. database) should be analyzed to select and prioritize a set of metrics that can be used to measure the performance (Phase 1).
- **Customizing metrics:** A set of general KPIs relevant for assessing the performance of organizations should be identified and selected to meet the purpose of the performance dashboard (Phase 1). Performance metrics are customized to align with different perspective, strategy and measurement of KPIs (Phase 2).

- **Linking dashboard items/performance metrics:** The performance metrics are often inter-related. It is crucial to link the key performance metrics using visual mapping to select the visualization by considering the points, data types and reason of visualization (Phase 3).
- **Multi-level design:** A multi-level design can enable organizations to drill-down the information into different levels in order to get a deeper understanding. Different levels of dashboard is designed to present the performance analysis from the high level overview to more detailed information (Phase 4).
- **Data interpretation support:** The relationship between performance metrics and organizational needs are interpreted and presented in different levels using appropriate visualization techniques (Phase 4).
- **Visual communication at a glance:** Every level of the dashboard UI is designed to visualize appropriate, relevant, exact and accurate information in order to monitor, analyze, and assess the performance at a glance on a single page of the dashboard (Phase 4).

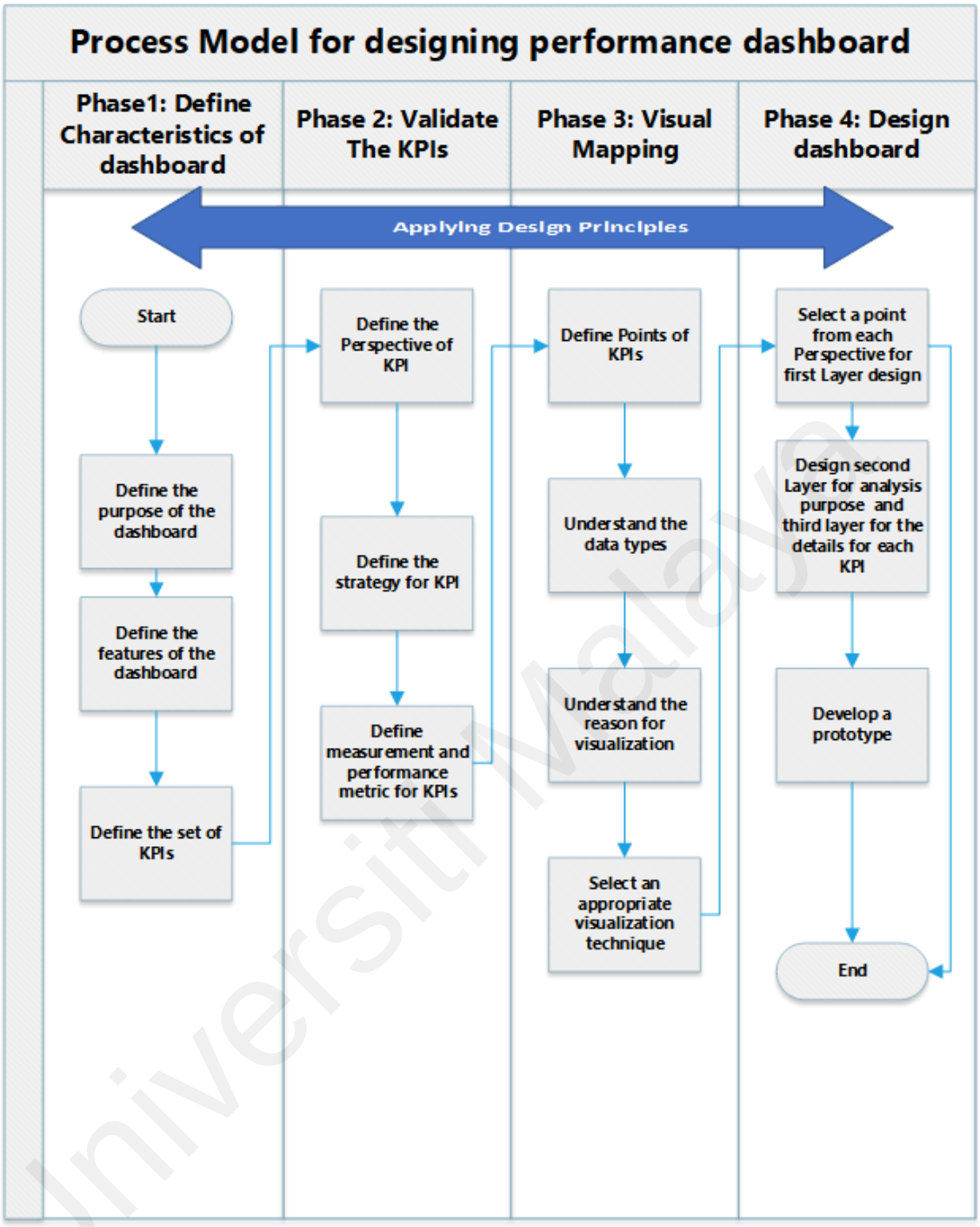

Figure 4.1: Overview of the proposed work, PM-PDP

4.3 Phase 1: Define characteristics of the performance dashboard

Phase 1 of the process model consists of three main activities as described in Section 4.3.1 to Section 4.3.3 to define the main characteristics of a performance dashboard.

4.3.1 Define the purpose of the performance dashboard

It is essential to know the intentions and level of users of performance dashboards. The dashboard can help to monitor the performance of an organization to plan strategies for improving performance.

To define the purpose of the performance dashboard, firstly, the level of decision-making and the target users need to be identified. There are three levels of decision making: strategic, tactical, and operational. Table 4.1 shows the performance dashboard types and their corresponding level of users.

Table 4.1: Performance dashboard type and users level (adopted from (Pauwels et al., 2009; Sarikaya et al., 2019)

No	Performance Dashboard Type	Level of Users
1	Strategic	Executes/Board
2	Tactical	Mangers/Analysts
3	Operational	Operational staff

4.3.2 Define features

The visual and functional features are two essential features of the dashboard. Visual features are the features associated with how efficiently and effectively information is presented to the user. On the other hand, functional features are the features that link indirectly to visualization but describe what the dashboard can do. Literature review was conducted to analyze the common visual and functional features of a performance dashboard

Table 4.2 shows the common visual and functional features implemented in different performance dashboards from the existing studies (Pauwels et al., 2009;

Sarikaya et al., 2019). The visual and functional features should be defined based on the needs and requirements of the organization.

Table 4.2: Common visual and functional features of a performance dashboard

No	Visual Features	Functional features
1	Single page: Allow viewers to have an all-in-one view in a single page	The dashboard should define Role-based security
2	Multipage: Allow viewers to switch between pages for different components of decision-making or context.	The dashboard should have the drill-down feature
3	The dashboard allows the users to maximize/minimize the visualization techniques.	Visualization technique should be print in different formats.
4	The dashboard allows consumers to modify the construction and composition of views.	The dashboard allow users to choose presentation format type (e.g. Graphs vs Tables).
5	The dashboard provides control panels to modify data.	The dashboard helps users to identify performance measures that need immediate attention by alerts.

Besides visual and functional features, the data semantics feature is also vital for a performance dashboard. Performance dashboards can render helpful semantics about the data and processes that they visualize. Table 4.3 shows four common data semantics features that was identified from the literature review (Sarikaya et al., 2019).

Table 4.3: Common data semantics features

No	Data Semantics
1	Alerting - identify anomalies and highlight them for awareness and alerting purposes.
2	Notification - Identify anomalies and indicate warning and critical scenarios.
3	Benchmarks - Add indications of breaking user- or model-defined thresholds (e.g. green up arrows ad red down arrows).
4	Updateable - Accommodate changing data when the datasets/databases are updated

4.3.3 Identify the set of KPIs

KPIs are defined as metrics that have an intense effect on the organization and assist the organization in measuring and determining progress towards organizational goals (Cynthia McKinney et al., 2012). In another definition, KPIs designate a set of measures focusing on those aspects of the organizational performance that are the most critical for the current and future success of the organization (Parmenter, 2015). The ways to identify and select a set of KPIs for assessing performance of an organization is to analyze the existing data resources and discuss them with the top management (e.g. conduct meeting and interview). Feedback should be collected from the stakeholders and target users (e.g. conduct interview and survey) to identify a set of general KPIs. To refine, prioritize and select the KPIs, this process of discussion should be iterative until finalize the set of KPIs. Figure 4.2 shows a sample process to define the set of KPIs for a performance dashboard of an organization.

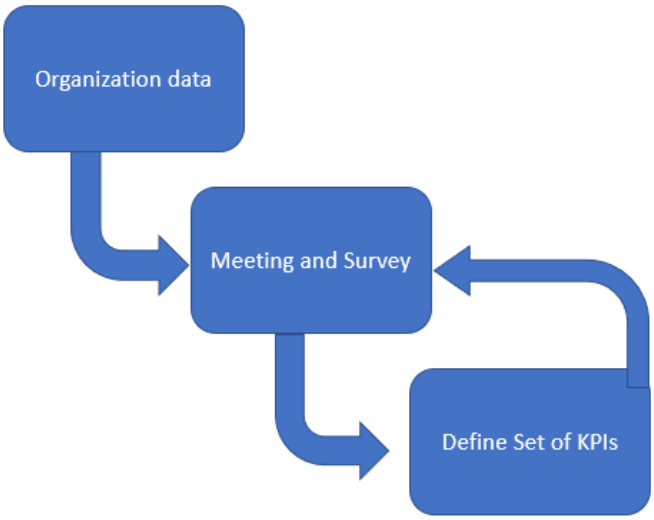

Figure 4.2: Process of defining the set of KPIs

4.4 Phase 2: Customize the KPIs

Phase 2 includes the activities to customize the set of KPIs by considering different perspectives. Strategies and measurements are defined to measure the KPIs using appropriate performance metrics.

4.4.1 Define the perspective, strategy, measurement and metrics

To make a performance dashboard that includes all critical metrics and also helps the organization in decision making, it is important to select, validate, and prioritize performance measurement (Kokina, Pachamanova, & Corbett, 2017). In the previous phase, a set of KPIs are identified. This phase focuses on customizing each KPI based on different perspectives and define a strategy to achieve the goal for each KPIs. Next, the performance measurement to assess the KPIs are defined. For example, based on the finance perspective, a strategy is defined to increase the revenue of an organization; the measurement for this strategy is the rate of revenue growth which can be measured using the metrics such as revenue increase rate over a period of time. Figure 4.3 shows the overall picture of the customizing the set of KPIs based on perspective, strategy,

measurement and performance metric, which is adapted from the balance scorecard concept applied in Kokina and Pachamanova's research (2017).

Figure 4.3 :Customization process for the KPIs

4.5 Phase 3: Visual Mapping

Visual mapping is the process of transformation of the organizational KPIs to data visualization techniques. In order to convert the related KPIs to visualization, there is a need for visual mapping. Figure 4.4 shows the steps taken to select the appropriate visualization (Vz) technique. It starts from mapping each KPI into one or more points to describe and analyze that specific KPI from a specific perspective. After confirming the points, the points are matched with the data types of the related data variable. Next the reason for visualization (e.g. comparing, distribution, analyzing relationship) are determined to select the appropriate visualization technique(s) in order to present the performance analysis of each KPI visually.

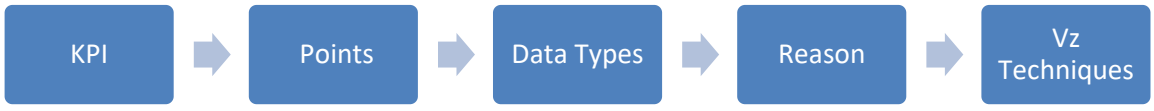

Figure 4.4: The visual mapping process

4.6 Phase 4: Design dashboard UI

The last phase of the process model emphasizes on designing the UI of a performance dashboard to ease the visual communication by presenting appropriate, relevant and precise analysis of performance information.

4.6.1 Multi-level design

In order to have a useful performance dashboard, this study suggests MAD design, which adopted from Eckerson (2010). MAD stands for Monitor, Analyze, and Detail. To limit the viewpoint of different users and avoid information overloading, multi-level design can be applied to design the UI of a complex performance dashboard. In the top layer, it is recommended to give a high level view of KPIs based on the points from each perspective, and the second layer should present the analysis of the correspondence KPIs or point. The third layer should consist of the details of KPIs (e.g. present the details in the structured table format).

4.6.2 Developing the prototype of performance dashboard

A prototype of the performance dashboard is developed to demonstrate the UI design. Appropriate programming languages, scripting languages, development framework, libraries and tools need to be selected to implement the dashboard design and visualization techniques. A prototype will allow the top management and target users to review the performance dashboard and identify the limitations of the dashboard. The design of the performance dashboard can be refined and finalized by addressing the identified problems and suggestions for improvement.

4.7 Summary

This chapter explains the proposed process model, PM-DPD. This chapter began with an overview of the proposed work. After the overview section, each phase are broken-down into steps to further describe the process of designing a dashboard in each phase.

This process model can be used as a general step-by-step process to assist the development teams of an organization for designing any performance dashboard.

The next chapter will discuss a case study to evaluate the functional suitability and usability of applying PM-DPD by designing a taxation performance dashboard.

CHAPTER 5: CASE STUDY

5.1 Introduction

This chapter discusses the case study conducted to evaluate the functional suitability and usability of applying proposed process model, PM-DPD. Section 5.2 outlines the case study design. Section 5.3 explains the case selection. Section 5.4 describes the data source and methods used to collect data. Section 5.5 describes the process of applying PM-DPD to design a taxation performance dashboard. Section 5.6 presents the results of survey data analysis. Section 5.7 discusses the results and functional suitability and usability of applying PM-PDP for real-life context. This chapter ends with the summary section to conclude the case study.

5.2 Caste Study Design

The case study design in this study is adapted from the guidelines proposed by Runeson and Höst (2008). They have presented a detailed guideline and checklists for conducting software engineering case studies. The adapted process to conduct this case study is shown in Figure 5.1.

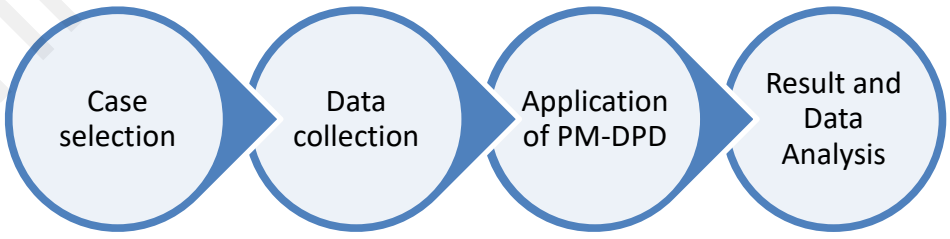

Figure 5.1: Case study procedure to evaluate the PM-PDP

As shown in Figure 5.1, the case study for this research begins with selecting a domain and real-life context for the case study, followed by data collection and application of the proposed process model, PM-PDP. Next, a survey is conducted after demonstrating the prototype of performance dashboard to collect the feedback in terms of the effectiveness and usability of the dashboard. The survey data is analyzed and the results is presented and discussed to evaluate the functional suitability and usability of applying PM-DPD.

5.3 Case selection

It is crucial to have good planning for a case study. At the planning stages, there are some elements that need to be organized such as case study objective, case selection strategy (where to seek the data) and methods (how to collect the data) (Runeson & Höst, 2009). The main objective of this case study is to evaluate the functional suitability and usability of applying the proposed process model, PM-DPD for designing a performance dashboard in a real-life context using data visualization techniques.

The case study has chosen the taxation domain and the data was collected from the Afghanistan Revenue Department (ARD). Standard Integrated Government Tax Administration System (SIGTAS) developed by Sogema Technologies are used by more than twenty countries around the world (Sogema-Technologies, 2019) including ARD. This system comprises modules that cover the main taxation process which starting from taxpayer registration, following by Tax forms, Assessments, Caching, Tax Collection, Objections, Cross-checking, Audits, Payments Agreements, Accounting, Documents and File Handling. This study used the KPIs related data extracted from ARD's SIGTAS system. Section 5.3.1 gives a background of the case domain, taxation.

5.3.1 Taxation

Taxation is the imposition of compulsory levies on individuals or entities by governments. Taxes are levied in almost every country of the world, primarily to raise revenue for government expenditures, although they serve other purposes as well (Charles E. McLure, 2018). Taxation has a long history, taxes on consumption were levied in Greece and Rome, for example, early Roman practices of taxation included consumption taxes, customs duties, and certain "direct" taxes. In the modern tax system the greatest amount of revenue coming from income tax (individual and corporation), payroll tax, general sale tax, property tax and so on (Charles E. McLure, 2018).

Due to continuous advancements in Information and Communication Technologies which has caused major and rapid changes in the daily life of people, could not leave governments unaffected. They also transformed into a new form of government namely electronic government or e-government (Akman, Yazici, Mishra, & Arifoglu, 2005). Taxation which is an important sector of government also adopted contemporary technology to provide better services for taxpayers, avoid tax evasion and to increase the revenue of the government. A recent transformation through information and communication technology (ICT) is electronic tax payment or e-tax filing which reduces cost and enhances services levels (Stafford & Turan, 2011).

5.4 Data collection

To consider the ethics of the research, a formal request was submitted to ARD for data collection. ARD has approved the request and extracted KPIs related data from SIGTAS system. The shared the data was used to implement the prototype of taxation performance dashboard. The letter of authorization to access the data is presented in

Appendix A. Besides this, two surveys were conducted to collect data for this case study. In the first survey, two meetings were conducted and one questionnaire was distributed to collect data that can be used to apply PM-PDP to design of a taxation performance dashboard for ARD. After the development of prototype of taxation performance dashboard, another survey was conducted to collect the feedback in terms of the effectiveness and usability of the performance dashboard. Based on the feedback, the functional suitability and usability of applying PM-PDP can be evaluated.

5.4.1 Survey 1

Two meetings were held with ARD top management, to narrow down the scope to the tactical dashboard. The questionnaire was designed to collect the basic requirements of the dashboard. The first section was to identify purpose, visual features, functional features, and data semantics features of the performance dashboard. The second part of the questionnaire collected responses from participants to rate the priority of each KPI according to their level of importance to be presented in the taxation performance dashboard using this Likert scale: 1=Not important at all, 2=Slightly important, 3=Important, 4=Fairly important and 5=Very important. There are six categories of KPIs for the taxation department: taxpayer information, revenue collection and target, audits, arrears, objection and enforcement cases. Most participants of the questionnaire were the mangers of the different tax centers. The meeting reports and detailed analysis of the questionnaire are presented in the Appendix B.

5.4.2 Survey 2

After presenting the prototype of the taxation performance dashboard to ARD, a survey was conducted to evaluate the dashboard in the term of visual features, functional features, data semantics and effectiveness. A questionnaire and follow-up interview were

conducted to collect the feedback. The questionnaire consists of the following seven sections:

- Fulfillment of the purpose,
- Effectiveness of performance dashboard,
- Visual features,
- Functional features,
- Data semantics,
- Usability – questions were designed based on the Technology Acceptance Model (TAM) created by Davis (1989),
- Problem faced and suggestion for improvement.

Most of the participants of the survey were the managers of the tax centers, who are the target users of the taxation performance dashboard. The details of the survey and the feedback analysis are presented in Section 5.6 of this chapter. Based on the analysis of the questionnaire results, follow-up interview was conducted to clarify the problems and suggestions.

5.5 Applying PM-DPD to design a taxation performance dashboard

This section presents the. Section 5.5.1 to Section 5.5.4 describes the application of PM-DPD for designing a taxation performance dashboard for ARD, starting from Phase 1 to Phase 4.

5.5.1 **Phase 1:** Define characteristics of the performance dashboard

During phase 1, Survey 1 was conducted to collect data that can be used to define characteristics of the performance dashboard.

5.5.1.1 Define the purpose of the taxation performance dashboard

To define the purpose of the taxation dashboard, firstly, the level of decision-making and the target users need to be identified. Two meetings were held with the top management, managers and programmers from ARD to narrow down the scope to design the performance dashboard at tactical level and target users of the dashboard are managers of the ARD's tax centers. The details of the meeting are presented in Appendix B.

5.5.1.2 Identify the features

To identify the features of the taxation dashboard, a questionnaire was conducted as part of the Survey 1 to collect responses from the taxation department of Afghanistan. Below are the visual and functional features that they requested for the taxation performance dashboard.

Visual features of the taxation performance dashboard:

- The dashboard should be a single screen, with no scrolling.
- The dashboard allows users to maximize/minimize the visualization techniques.
- The dashboard supports interactive interface for users to focus their analysis on data items that re relevant to them

Functional features of the taxation performance dashboard:

- The dashboard should have a drill-down feature.
- Visualization techniques should be presented in different formats.
- The dashboard should define Role-based security.

Data semantics features of taxation performance dashboard:

- The dashboard identifies anomalies and highlights them for awareness and alerting.
- The dashboard identifies anomalies and indicates warning and critical scenarios.

- The dashboard adds indications of breaking user- or model-defined thresholds (e.g. Green up arrows ad red down arrows).
- The dashboard accommodates changing data when the datasets/databases are updated.

5.5.1.3 Identify the set of KPIs in taxation

To identify the set of KPIs from taxation department, a meeting and a questionnaire were conducted with taxation departments of ARD. In the first survey, KPIs were refined with the iterative communication with the stakeholders. The result of questionnaire related to KPIs is presented in Appendix B. The refined and selected set of KPIs are organized into six categories and presented as follows:

a) Taxpayer information

- Taxpayer Registration: It shows registered taxpayer (exclude the close taxpayers).
- Non individual Taxpayer: It shows How many of registered taxpayers are Non individual (Legal) taxpayers.
- individual Taxpayer: It shows How many of registered taxpayers are individual (Natural) taxpayers.
- Annual Tax Returns Filed: Number of tax returns filed (Corporate Income Tax, Personal income tax).
- Active Taxpayers: It shows how many of filed annual tax returns have gross receipts and expenses.
- Inactive Taxpayers: It shows how many filed Annual tax returns do not have gross receipts and expenses.
- Non-Filers: Number on taxpayers did not file an annual tax return.

b) Revenue collection and target

- Annual Targets: It shows the target of each tax centers.

- Revenue Collected: Total of tax revenue collected by tax centers.
- Income Tax: Income tax collected by the tax center.
- Business Receipt Tax: Revenue collected from Business Receipt tax by tax center.
- Withholding Taxes: Revenue collected from withholding taxes (Total of Wages withholding tax, Contract withholding tax, rent withholding tax, Royalties, Dividend, Gift, interest withholding taxes) by tax center.
- Fixed Taxes: Revenue collected from Fix taxes (e.g. Small Business, Properties).
- Others: Revenue collected and unallocated tax or unclassified taxes.
- % Revenue Collected to Target: Percentage of revenue collected by target.

c) Audits

- Number of Audits in Process: It shows the Number of Open Audit cases.
- Number of Audits Completed: It shows the Number of Audit cases completed.
- Tax Assessed - Completed Audits: Tax assessed from the assessment which is Linked with the completed audit cases.
- Self-Assessed Tax Reflected on Tax Original: Self-assessed tax which linked with completed audit case.
- Revenue Collected Audits: Total revenue collected from reassessed tax return with auditors.
- % Change Audit Assessment to Self-assessment.
- Average Time per Audit Case: Average time spent on the audit of cases audit is completed by Day.
- % Audit Completed to Registered Taxpayer.
- % Audit Completed to Active Taxpayer.

- % No Change Rate assessment.

d) Arrears

- Arrears: Total tax arrears.
- Income Tax: Total Arrears from Income taxes (Personal and corporate income taxes).
- Business Receipt Tax: Total arrears from Business receipt tax.
- Withholding Taxes: total arrears of withholding taxes (Total of Wages withholding tax, Contract withholding tax, rent withholding tax, Royalties, Dividend, Gift, interest withholding taxes) by the tax centre.
- Fixed Taxes: total arrears of Fix taxes (e.g. Small Business, Properties).

e) Objections

- Objection cases in progress: It shows open objection cases.
- Objection case completed: Total Objection cases closed.
- Objection cases refer to the court.
- % Audit Case Appealed: Check appealed cases and compare with audit case. If it exists, then apply this formula: Audit case appealed/ Total Appealed cases*100.
- % Appealed Cases Sustained: Count all appeal case with sustained step, then apply this formula: Appealed Case Sustained/Total Cases Appealed.

f) Enforcement

- Number of Enforcement Cases in Process: Number of cases under enforcement.
- Number of Enforcement Cases Completed: Number of Enforcement cases completed during this period.

5.5.2 Phase 2: Customize the KPIs

5.5.2.1 Define the perspective, strategy, measurement and performance metric

To make a performance dashboard that includes all critical performance metrics and also helps the organization in decision making, it is important to select, validate, prioritize performance measurement (Kokina, Pachamanova, & Corbett, 2017). Table 5.1 shows the visual mapping based on perspective, strategy, measurement and performance metrics defined for the taxation performance dashboard. Six perspectives were defined based on the six categories of KPIs for taxation.

Table 5.1: Customize KPIs based on perspective, strategy, measurement and metric

No	Perspective	Strategy	Measurement	Performance Metric
1	Taxpayer Information	Acquire and retain taxpayers	Numbers of registered, Individual, Non-Individual, active, Inactive, filers and nun-filers taxpayers	Number of new register taxpayers/new registered taxpayers last period
2	Revenue collocation and target	Increase in Revenue	Revenue Growth	Total of Revenue increase/Revenue last period (month, quarter, year)
3	Audits	Increase in Revenue (completed audits)	Revenue Growth from audits cases	Total of Revenue growth from audits cases/Revenue growth from audit cases from last period
4	Audits	Achieve timely audit process	Average time to complete an audit case	Duration of Time per audit case = end - starting
5	Arrears	Increase of collection of arrears	Revenue Growth of collection of arrears	Revenue growth of collecting of arrears/revenue growth of the collection of arrears from last period
6	Objections	Improve efficiency in handling objection cases	Number of completed cases relative to total cases	Number of objection case completed / total objection cases
7	Enforcement	Improve efficiency in handling enforcement cases	Number of enforcement cases completed relative to the total number of enforcement cases per tax center	Number of enforcement cases completed / total number of enforcement cases

5.5.3 Phase 3: Visual Mapping

Visual mapping is the process of transformation from taxation data to visualizations using the visualization techniques. To convert the taxation department related KPIs to visualization, there is a need for visual mapping. Figure 5.2 shows the steps taken to select the appropriate visualization technique. It starts from KPIs and each KPI has one or more points to describe and analyze that specific KPI from different perspectives. After confirming the points, it is needed to know the data and then know the reason. Once the data and reason are cleared that is easy to select the appropriate visualization technique based on the literature review that discussed different visualization techniques based on different reason and data.

Figure 5.2: Visual mapping process

The most important thing after knowing KPIs is the point. Why you visualize, what is your point? Articulating the point generates an answer which drives nearly everything about visualizing that data. Table 5.2 shows the KPIs related to taxpayer's information and their different points. Taxpayer information category has five KPIs and each of them have seven points to know the performance with details and from a different perspective.

Table 5.2: Taxpayer information KPIs

NO	KPI	Points
KPI-TI-1	Taxpayer Registration	**p-1.** Show the comparison of registered taxpayers with previous period **p-2.** Show the registered taxpayers based on month, year and quarter. **p-3.** Show the registered taxpayer based on top five sectors. **p-4.** Show the registered Taxpayers Subtypes (Individual, non-Individual, Filers, Non-filers, Active, Inactive) **p-5.** Show the registered Taxpayers based on each day **p-6.** Show the Percentage of change based on Months, Year, and quarterly.
KPI-TI-2	Filers	**p-1.** Show the comparison of Filers taxpayers with Pervious period **p-2.** Show the Filers taxpayers based on Months, Year and quarter. **p-3.** Show the top 100 Filers that files on time. **p-4.** Show the numbers of Active and Inactive Filers from all sectors **p-5.** Show the Filers Taxpayers based on each day **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.
KPI-TI-3	Active Taxpayers	**p-1.** Show the comparison of Active taxpayers with Pervious period **p-2.** Show the Active taxpayers based on Months, Year and quarter. **p-3.** Show the top 100 Active taxpayers based on Investment and Years. **p-4.** Show the top 100 Active taxpayers based on Investment and sector **p-5.** Show the Active Taxpayers based on each day **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.
KPI-TI-4	Inactive Taxpayers	**p-1.** Show the comparison of Inactive taxpayers with Pervious period **p-2.** Show the Inactive taxpayers based on Months, Year and quarter. **p-3.** Show the top 100 Inactive taxpayers based on Investment and Years. **p-4.** Show the top 100 Inactive taxpayers based on Investment and sector **p-5.** Show the Inactive Taxpayers based on each day **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.
KPI-TI-5	Non-Filers	**p-1.** Show the comparison of Non-Filers taxpayers with Pervious period **p-2.** Show the Non-Filers taxpayers based on Months, Year and quarter. **p-3.** Show Non-Filers taxpayers based on Top five sectors. **p-4.** Show the top 100 Non-Filers taxpayers based on Investment and Year **p-5.** Show the Non-Filers Taxpayers based on each day **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.

Table 5.3 shows KPIs related to Revenue collection and target. It has one KPIs which is collected Revenue toward the target. It has six points that give more details about the collected revenue.

Table 5.3: Revenue collection and Target KPIs

NO	KPI	Points
KPI-RT-1	Collected Revenue.	**p-1.** Show the Target and Actual collected revenue for ARD and related Tax center. **p-2.** Show the Target and Actual revenue based on months, quarter and Years. **p-3.** Show the collective revenue based on Tax Type. **p-4.** Show the top 100 taxpayers based on tax payment. **p-5.** Show the collective revenue based on each day **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.

Table 5.4 shows the points of KPIs related to Audit Revenue, it has two KPIs which measure the total revenue collected from reassessment, and audits cases which shows the numbers of process and completed audit cases.

Table 5.4: Audits KPIs

ID	KPIs	Points
KPI-AD-1	Audit Revenue	**p-1.** Show the Audits Revenue of current fiscal Years based on Months. **p-2.** Show the Audits Revenue based on months, quarter and Years. **p-3.** Show the Audit Revenue based on Tax type. **p-4.** Show the Audit revenue based on each day **p-5.** Show the Percentage of Change based on Months, Year, and quarterly.
KPI-AD-2	Audit Cases	**p-1.** Show the numbers of the process and completed audits cases based on time

Table 5.5 shows the KPIs related to the arrear's category. It has one KPI and six points to give more details from every aspect of the arrears and find out those taxpayers that have more arrears or did not pay for a long time.

Table 5.5: Arrears KPIs

No	KPIs	Points
KPI-AR-1	Tax Arrears	**p-1.** Show the Arrears from the Last six months and tax types. **p-2.** Show the Arrears based on months, quarter and Years and tax type. **p-3.** Show the taxpayers that have arrears from the last five years. **p-4.** Show the top 100 taxpayers that have more arrears based on sector **p-5.** Show the arrears based on each day **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.

Table 5.6 shows the KPIs related to the Objection category. It has three KPIs, process, completed and refers to the court objections. Each of it consist six points to find out the details from each perspective about objections.

Table 5.6: Objection KPIs

NO	KPIs	Points
KPI-OB-1	Process objection cases	**p-1.** Show the process objection cases from last six months. **p-2.** Show the process objection cases based on month, quarter and yearly **p-3.** Show the number of process objections cases based on sector. **p-4.** Show the number of process objections cases bases on Tax type. **p-5.** Show the process objections cases based on each day. **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.
KPI-OB-2	Completed objection cases	**p-1.** Show the Completed objection cases from last six months. **p-2.** Show the Completed objection cases based on months, quarter and Years **p-3.** Show the number of completed objections cases based on sector. **p-4.** Show the number of completed objections cases bases on Tax type. **p-5.** Show the objections cases based on each day. **p-6.** Show the completed Percentage of Change based on Months, Year, and quarterly.
KPI-OB-3	Refer to the court cases	**p-1.** Show the Completed objection cases from last six months. **p-2.** Show the Completed objection cases based on months, quarter and Years **p-3.** Show the number of completed objections cases based on sector. **p-4.** Show the number of completed objections cases bases on Tax type. **p-5.** Show the objections cases based on each day. **p-6.** Show the completed Percentage of Change based on Months, Year, and quarterly.

Table 5.7 shows the KPIs related to the enforcement category. It has two KPIs, process enforcement cases and completed enforcement cases, each of them has sixpoints to find out the details from different perspectives.

Table 5.7: Enforcement KPIs

No	KPIs	Points
KPI-ENF-1	Process enforcement cases	**p-1.** Show the process enforcement cases from the last six months. **p-2.** Show the process enforcement cases based on months, quarter and Years **p-3.** Show the number of process enforcement cases based on sector. **p-4.** Show the number of process enforcement cases bases on Tax type. **p-5.** Show the process enforcement cases based on each day. **p-6.** Show the Percentage of Change based on Months, Year, and quarterly.
KPI-ENF-2	Completed enforcement cases	**p-1.** Show the Completed enforcement cases from last six months. **p-2.** Show the Completed enforcement cases based on months, quarter and Years **p-3.** Show the number of completed enforcement cases Revenue based on sector. **p-4.** Show the number of completed enforcement cases revenue bases on Tax type. **p-5.** Show the enforcement cases revenue based on each day. **p-6.** Show the completed Percentage of Change based on Months, Year, and quarterly.

Table 5.8 shows the example of mapping the first few KPI points to visualization (Vs.) techniques based on data types and reason for visualization.

Table 5.8: Mapping from point of KPIs point to visualization technique

KPIs & Points	Data Type	Reason for Visualization	Vs Technique
KPI-TI-1-P1	• Number of registered taxpayer's • current period • Previous period. • Percentage of change	Compare registered taxpayers with the previous period and show the Percentage of change	Table
KPI-TI-1-P2	• Number of registered taxpayers • Period (Month, quarter, Year)	Compare the registered taxpayers based on a period (month, quarter, Year)	Column Graph
KPI-TI-1-P3	• Number of registered taxpayers • Sector • Period (Month, quarter, Year)	Show the trend of top sectors that have high registered taxpayers based on a period (month, quarter, Year) and sector	Line Chart
KPI-TI-1-P4	• Subtypes of registered taxpayers. • Numbers of each type	Show the hierarchy and subtypes of registers taxpayers and their numbers	Tree Map
KPI-TI-1-P5	• Number of registered taxpayers • Period (day)	Show the registered taxpayer based on each day.	Heat Map
KPI-TI-1-P6	• Period (Month, quarter, Year) • Percentage of change	Compare the percentage based on a period (month, quarter, year)	Table
KPI-TI-1-P7	Different variables.	Show the detail Report of registered taxpayers	Table
KPI-TI-2-P1	• Number of filers taxpayer's • current period • Previous period. • Percentage of change	Compare Filer's taxpayers with the previous period and show the Percentage of change	Table

Table 5.9: Mapping from point of KPIs point to visualization technique(continued)

KPIs & Points	Data Type	Reason for Visualization	Vs Technique
KPI-TI-2-P2	• Number of filers taxpayers • Period (Month, quarter, Year)	Compare the Registered taxpayers based on a period (month, quarter, Year)	Column Graph
KPI-TI-2-P3	• Number of filers taxpayers • Sector	Show the top 100 filers that filed on specified time	Bubble chart
KPI-TI-2-P4	• Numbers of each of filers taxpayer • sectors	Show the numbers of filers taxpayers from each sector	Sunburst
KPI-TI-2-P5	• Number of registered taxpayers • Period (day)	Show the filers taxpayer based on each day.	Heat Map
KPI-TI-2-P6	• Period (Month, quarter, Year) • Percentage of change	Compare the percentage based on a period (month, quarter, year)	Table
KPI-TI-2-P7	Different variables.	Show the detail Report of filers taxpayers	Table
KPI-TI-3-P1	• Number of Active taxpayer's • current period • Previous period. • Percentage of change	Compare Active taxpayers with the previous period and show the Percentage of change	Table
KPI-TI-3-P2	• Number of taxpayers • Period (Month, quarter, Year)	Compare the Active taxpayers based on a period (month, quarter, Year)	Column Graph
KPI-TI-3-P3	• Number of Active taxpayers • Investment • Year	Show the top 100 Active taxpayers based on investment from the last five years	Zoom bubble chart

Table 5.10: Mapping from point of KPIs point to visualization technique(continued)

KPIs & Points	Data Type	Reason for Visualization	Vs Technique
KPI-TI-3-P4	• Number of Active taxpayers. • Sectors	Show the top 100 Active taxpayers based on sector	Bubble Chart
KPI-TI-3-P5	• Number of Active taxpayers • Period (day)	Show the registered taxpayer based on each day.	Heat Map
KPI-TI-3-P6	• Period (Month, quarter, Year) • Percentage of change	Compare the percentage based on a period (month, quarter, year)	Table
KPI-TI-3-P7	Different variables.	Show the detail Report of registered taxpayers	Table
KPI-TI-4-P1	• Number of Active taxpayer's • current period • Previous period. • Percentage of change	Compare Active taxpayers with the previous period and show the Percentage of change	Table
KPI-TI-4-P2	• Number of taxpayers • Period (Month, quarter, Year)	Compare the Active taxpayers based on a period (month, quarter, Year)	Column Graph
KPI-TI-4-P3	• Number of Active taxpayers • Investment • Year	Show the top 100 Active taxpayers based on investment from the last five years	Zoom bubble chart
KPI-TI-4-P4	• Number of Active taxpayers. • Sectors	Show the top 100 Active taxpayers based on sector	Bubble Chart

Table 5.11: Mapping from point of KPIs point to visualization technique(continued)

KPIs & Points	Data Type	Reason for Visualization	Vs Technique
KPI-TI-4-P5	• Number of Active taxpayers • Period (day)	Show the registered taxpayer based on each day.	Heat Map
KPI-TI-4-P6	• Period (Month, quarter, Year) • Percentage of change	Compare the percentage based on a period (month, quarter, year)	Table
KPI-TI-4-P7	Different variables.	Show the detail Report of registered taxpayers	Table

5.5.4 Phase 4: Design dashboard UI

5.5.4.1 Multi-level design

The taxation performance dashboard was designed in three levels. At the first level, one point or story is selected from each category and overall performance is also presented in the first layer. Figure 5.3 shows the first level of design for each category of KPI.

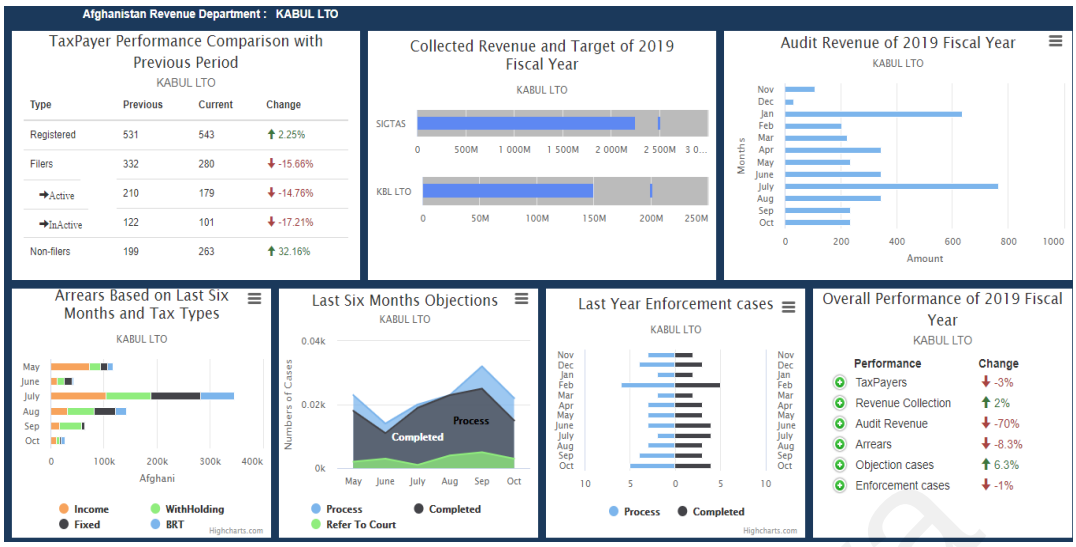

Figure 5.3 :First level of the designed taxation performance dashboard

The second layer consists of the analysis of each KPIs from the first layer, each KPI has one or more points to understand and analyze the KPIs in different points. Figure 5.4 shows an example of the second layer.

The third level is performance information presented as structured table format, which shows the details of each point of the second layer. Figure 5.5 shows an example of the third level.

The complete screenshots of the taxation performance dashboard are presented in the Appendix D.

Figure 5.4:An example of the second level of the designed taxation performance dashboard.

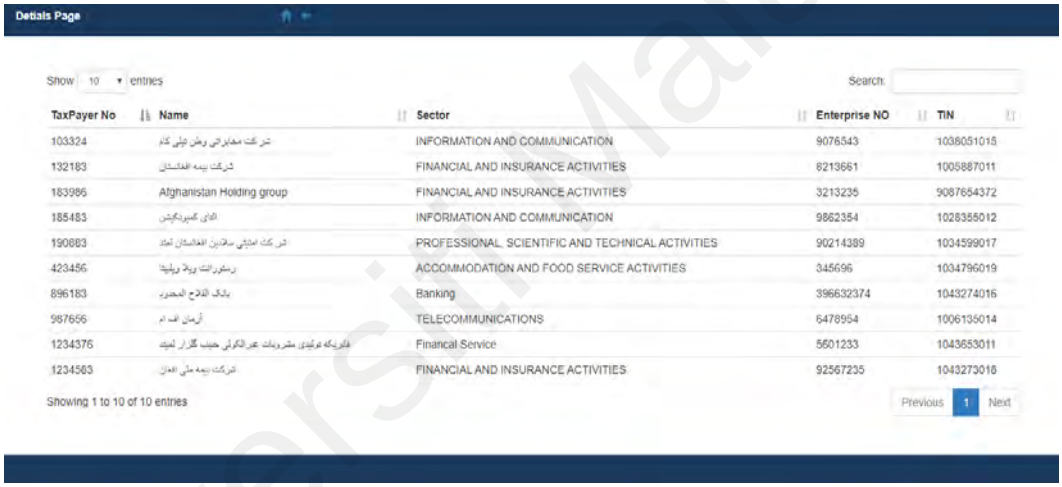

Figure 5.5: An example of third level of the designed taxation performance dashboard.

5.5.4.2 Developing the Prototype of Performance Dashboard

Previous steps in this study identified main purpose, targets users, visual and functional features, data semantics, KPIs, and also mapped the KPIs to appropriate visualization techniques. The last step is to develop the taxation dashboard using the appropriate web development technologies. Based on the requirements specified by ARD, ASP.NET MVC framework was selected for server-side development, Highcharts JavaScript library

was chosen to customize and demonstrate the analysis of performance data using the visualization techniques. The following technologies were selected to develop the taxation performance dashboard:

- ASP.NET MVC framework
- JQuery
- Bootstrap framework
- Highcharts JavaScript charting framework

5.6 Results

After designing and developing the performance dashboard, Survey 2 was conducted to evaluate the dashboard in term of effectiveness and usability. The survey questionnaire consists of seven sections as described in Section 5.4.2. Fifteen responses were collected from different positions. Figure 5.6 shows the percentage of different positions that participated in the survey. The majority of them were department managers (80%), for whom the taxation performance dashboard was designed. A five-level Likert scale was used to collect the level of agreement or disagreement from the participants. On the Likert scale, 1 represents strongly disagree, 2 represents disagree, 3 represents Neutral, 4 represents agree and 5 represents strongly agree.

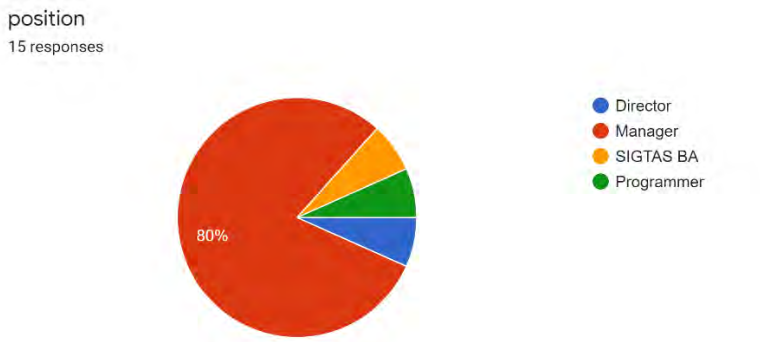

Figure 5.6: Percentage of survey participants

The first section of the questionnaire was to evaluate the fulfillment of the purpose of the dashboard. Figure 5.7 shows the fulfillment of the purpose of the end-users of the taxation performance dashboard.

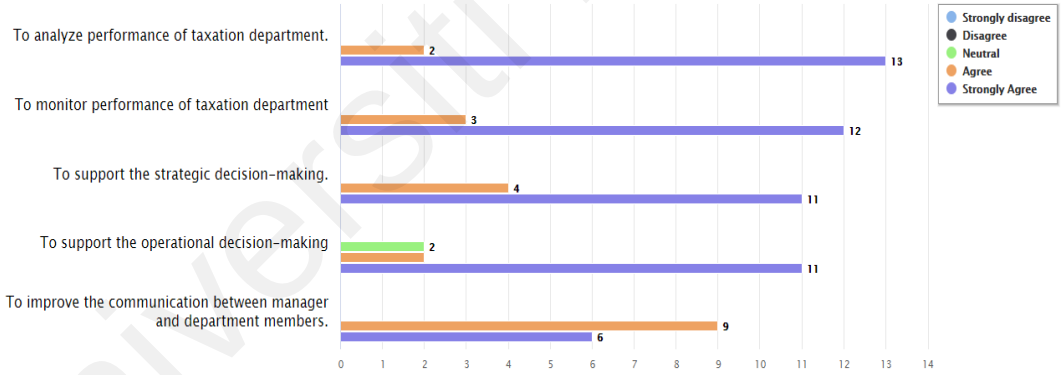

Figure 5.7:Result of the purpose fulfillment

Table 5.9 summarizes all responses of the end-users for the first section of the survey. The last three rows of the table show the mean, median and standard deviation calculated for the rating scores of all responses regarding the fulfillment of the purpose of the taxation performance dashboard. In Table 5.9, P-1 to P-5 stand for the five main purposes in the questionnaire (refer to questions in Appendix C). The mean scores are more than 4, which show that the participants either strongly agree or agree that the dashboard has fulfilled the five purposes.

Table 5.12: All responses for the fulfillment of the purpose and their mean, median and standard deviation

Respondent	P-1	P-2	P-3	P-4	P-5
1	4	5	4	3	4
2	5	5	5	5	4
3	5	5	5	4	4
4	5	5	5	3	4
5	5	5	5	4	4
6	5	4	5	5	4
7	5	5	5	5	5
8	5	5	4	5	5
9	5	4	4	5	4
10	4	4	5	5	5
11	5	5	5	5	5
12	5	5	5	5	4
13	5	5	4	5	4
14	5	5	5	5	5
15	5	5	5	5	5
Mean	4.86	4.8	4.73	4.6	4.4
Median	5	5	5	5	4
Standard deviation	0.351	0.414	0.457	0.736	0.507

Second part of the first section consists of questions to evaluate whether the dashboard fulfills the purpose to monitor the KPIs of the taxation department which were requested by ARD or not. Figure 5.8 shows all the responses to each category of the KPIs.

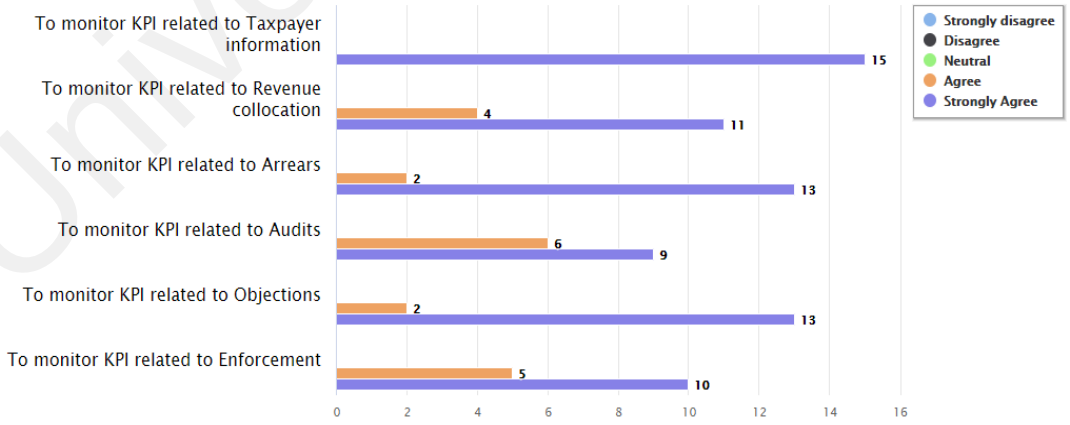

Figure 5.8: Result of the fulfillment of KPIs

Table 5.10 highlights all responses of the end-users for the second part of the first section of the survey. The last three rows of the table show the mean, median and standard

deviation calculated for the rating scores of all responses to evaluate the dashboard implemented all KPIs which was requested from the ARD. In Table 5.10, KPI-C stands for Key Performance Indicator category (refer to questions in Appendix C). The mean scores are more than 4, which show that the participants either strongly agree or agree that the dashboard has fulfilled the purpose of monitoring KPIs of taxation department.

Table 5.13: All responses to evaluate the implementation of KPIs and their mean, median and standard deviation.

Respondent	KP-C-1	KP-C-2	KP-C-3	KP-C-4	KP-C-5	KP-C-6
1	5	5	5	5	5	5
2	5	5	5	4	5	5
3	5	5	5	4	5	5
4	5	5	5	5	5	5
5	5	5	5	5	5	5
6	5	4	5	5	4	5
7	5	4	5	5	5	5
8	5	5	5	5	5	5
9	5	4	5	5	5	4
10	5	5	5	4	5	5
11	5	5	5	5	5	5
12	5	5	5	4	5	4
13	5	4	4	4	4	4
14	5	5	5	4	5	4
15	5	5	4	5	5	5
Mean	5	4.73	4.86	4.6	4.86	4.73
Median	5	5	5	5	5	5
Standard deviation	0	0.457	0.351	0.507	0.351	0.457

The second section of the survey consists to evaluate the effectiveness of the performance dashboard. Figure 5.9 shows the feedback of the respondents. Table 5.11 highlight all responses of the participants for the second section of the survey. The last three rows of the table show the mean, median and standard deviation calculated for the rating scores of all responses to evaluate the effectiveness of the designed taxation performance dashboard. In Table 5.11, EP stands for Effectiveness Point (refer to questions in Appendix C). The mean scores are more than 4, which show an effective taxation performance dashboard was designed based on the PM-DPD.

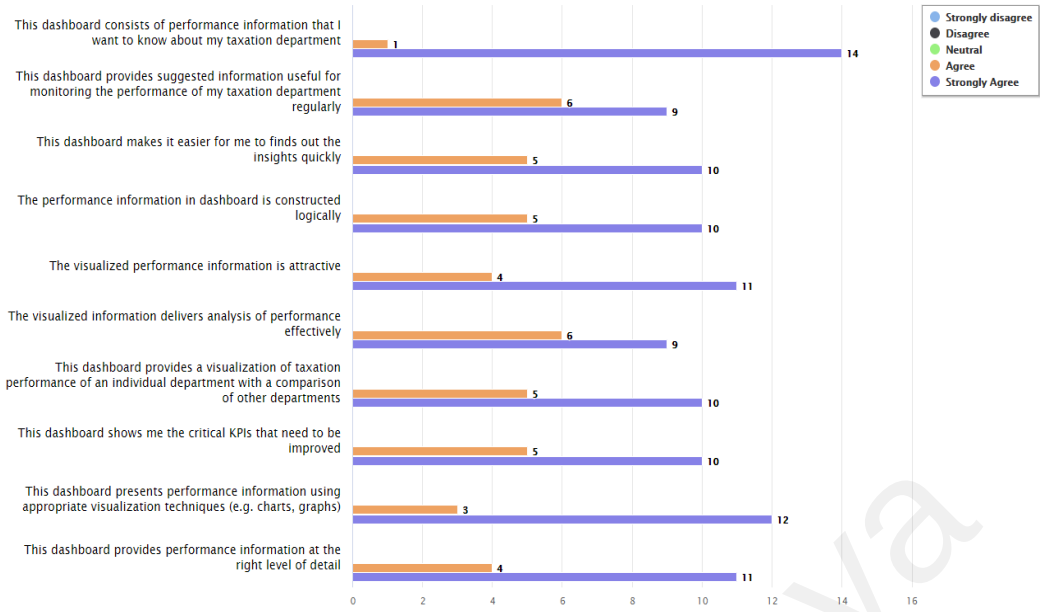

Table 5.14: All responses to evaluate the effectiveness of the dashboard and their mean, median and standard deviation.

Respondent	EP-1	EP-2	EP-3	EP-4	EP-5	EP-6	EP-7	EP-8	EP-9	EP-10
1	5	4	4	4	5	4	4	5	5	5
2	5	5	4	4	5	5	5	5	5	5
3	5	4	5	5	5	5	5	5	5	5
4	5	5	5	5	5	5	5	5	5	5
5	4	5	5	5	5	5	5	5	5	5
6	5	5	5	4	4	4	5	5	5	5
7	5	4	4	5	5	5	5	4	5	5
8	5	4	5	4	5	5	5	4	5	4
9	5	5	4	5	4	4	5	4	4	4
10	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	5	4	4	4	4	5
12	5	4	4	4	4	4	4	4	4	4
13	5	4	5	5	5	5	4	5	5	5
14	5	5	5	5	4	4	4	5	5	5
15	5	5	5	5	5	5	5	5	5	5
Mean	4.93	4.6	4.66	4.66	4.73	4.6	4.66	4.66	4.8	4.8
Median	5	5	5	5	5	5	5	5	5	5
SD*	0.258	0.507	0.487	0.487	0.4577	0.507	0.487	0.487	0.414	0.414

The third section consists of visual features that requested from the end-users. Figure 5.10 shows the fulfillment of the users from the visual feature that they requested.

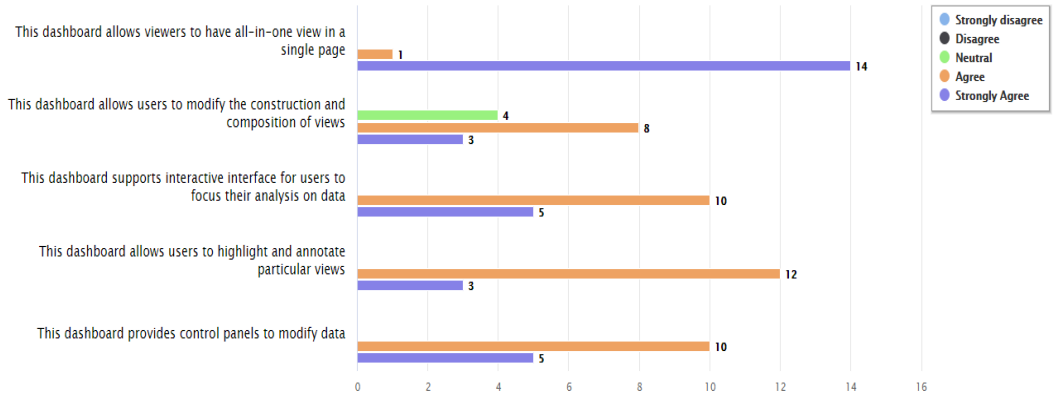

Figure 5.9: Result of the fulfillment of the visual features

Table 5.12 highlight all responses of the participants for the third section of the survey. The last three rows of the table show the mean, median and standard deviation calculated for the rating scores of all responses to shows the fulfillment of the visual features that was requested from ARD. In Table 5.12, VF stands for Visual Feature (refer to questions in Appendix C). The analysis results show that the dashboard has designed the required visual features.

Table 5.15: All responses of the fulfillment of the visual feature and their mean, median and standard deviation.

Respondent	VF-1	VF-2	VF-3	VF-4	VF-5
1	5	3	5	5	4
2	5	3	4	4	4
3	5	4	4	4	4
4	5	3	4	4	4
5	5	4	5	5	4
6	5	4	4	4	4
7	5	5	5	4	5
8	5	4	4	4	4
9	4	4	4	4	4
10	5	5	5	5	5
11	5	4	4	4	4
12	5	4	4	4	4
13	5	5	5	4	5
14	5	4	4	4	4
15	5	3	4	4	5
Mean	4.93	3.93	4.33	4.2	4.26
Median	5	4	4	4	4
Standard deviation	0.258	0.703	0.487	0.414	0.457

The fourth section of the survey consists of functional features of the dashboard, Figure 5.11 shows the fulfillment of the end-users that they were requested, and it was implemented in the dashboard.

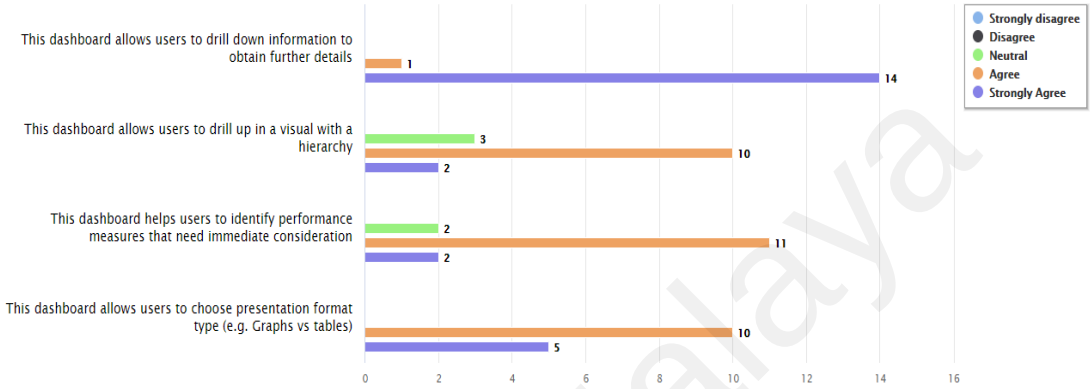

Figure 5.10: Result of the fulfillment of the functional features

Table 5.13 highlight all responses of the participants for the fourth section of the survey. The last three rows of the table show the mean, median and standard deviation calculated for the rating scores of all responses to shows the fulfillment of the functional features that were requested from ARD. In Table 5.13, FF stands for Functional Feature (refer to questions in Appendix C). The analysis results show that the dashboard has designed the required functional features.

Table 5.16: All responses of the fulfillment of the Functional feature and their mean, median and standard deviation.

Respondent	FF-1	FF-2	FF-3	FF-4
1	5	4	4	5
2	5	4	4	5
3	5	5	4	5
4	5	4	4	5
5	5	4	4	4
6	5	4	4	4
7	5	4	4	5
8	5	4	5	4
9	4	4	4	4
10	5	5	4	4
11	5	3	3	4
12	5	3	3	4
13	5	3	4	4
14	5	4	4	4
15	5	4	5	4
Mean	4.93	3.93	4	4.33
Median	5	4	4	4
Standard deviation	0.258	0.593	0.534	0.487

The fifth section consist of data semantics requirements, ARD requested data semantics but they did not mention clearly which data semantics they actually need. After analyzing the questionnaire results, follow-up interview was conducted with them to clarify the improvement related the data semantics, and the requested data semantics feature is added to the dashboard design. Figure 5.12 shows the fulfillment of the user from data semantics.

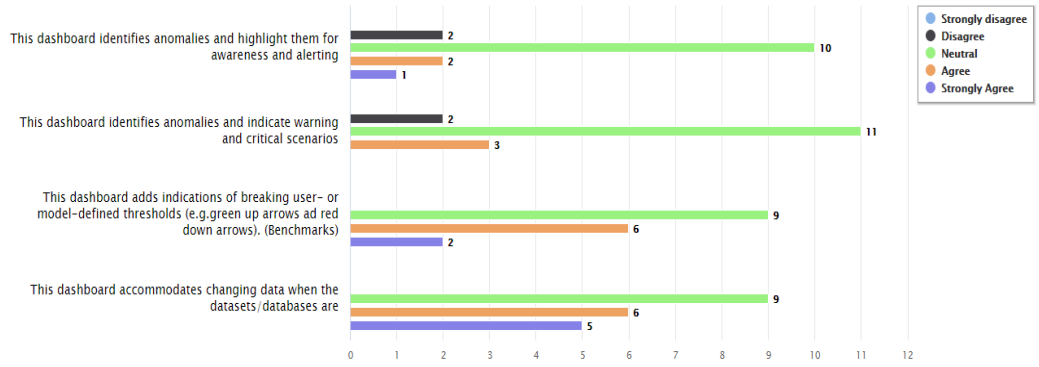

Figure 5.11 :Result of the fulfillment of the data semantics

Table 5.14 highlight all responses of the participants for the fifth section of the survey. The last three rows of the table show the mean, median and standard deviation calculated for the rating scores all responses to shows the fulfillment of the data semantics that was requested from ARD. In Table 5.14, DS stands for Data Semantics (refer to questions in Appendix C). The mean scores of the data semantics features are less than 4, it shows that the design of the performance dashboard have not satisfied the user needs in alerting, notification, benchmarking and updateable.

Table 5.17: All responses of the fulfillment of the Data Semantics and their mean, median and standard deviation.

Respondent	DS-1	DS-2	DS-3	DS-4
1	3	2	4	4
2	2	3	4	4
3	3	2	4	4
4	3	3	4	4
5	3	3	4	4
6	3	3	4	4
7	3	3	4	4
8	3	4	4	3
9	3	3	3	3
10	5	4	4	4
11	3	3	3	3
12	3	3	3	3
13	4	3	3	3
14	4	3	3	3
15	3	3	3	4
Mean	3.2	3	3.6	3.6
Median	3	3	4	4
Standard deviation	0.676	0.534	0.507	0.507

The sixth section consists of questions to evaluate the usability of the taxation performance dashboard. It is adopted the Technology Acceptance Model (TAM) proposed by Davis (1989). Figure 5.13 shows the responses of the participants based on their experiences using the taxation performance dashboard.

Table 5.15 shows all responses of the participants for the fifth section of the survey. The last three rows of the table show the mean, median and standard deviation calculated for the rating scores of all responses to shows their experiences using the taxation performance dashboard. In Table 5.15, UP stands for Usability Point (refer to questions in Appendix C). The mean scores of usability are more than 4. This shows that the design of performance dashboard has fulfilled the usability aspects.

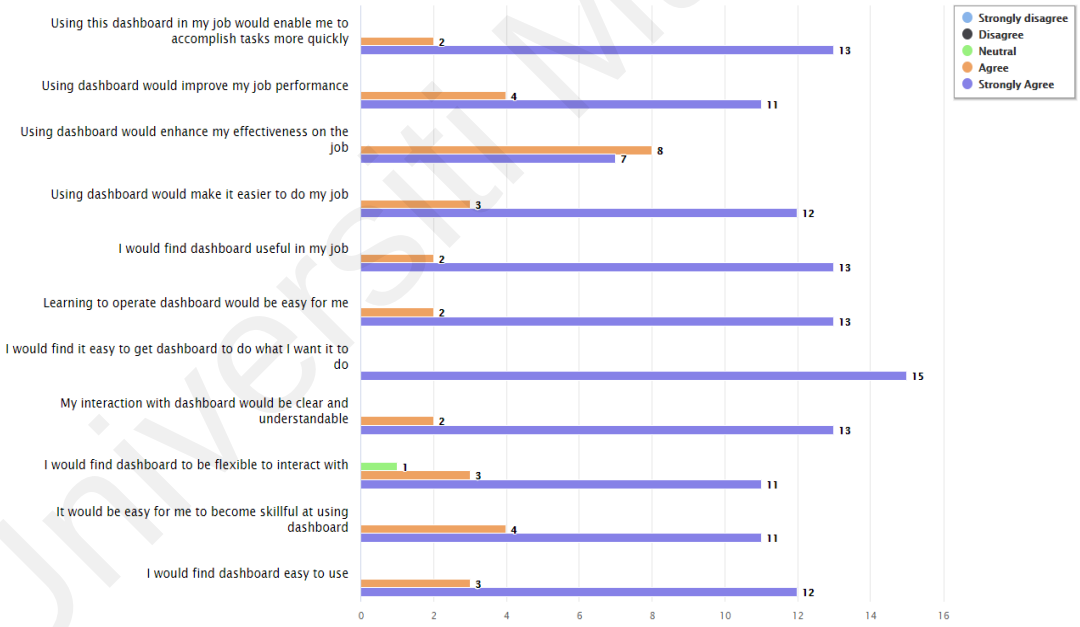

Figure 5.12: Result of the fulfillment of the usability

Table 5.18: All responses of the evaluation of the usability of dashboard and their mean, median and standard deviation.

Respondent	UP-1	UP-2	UP-3	UP-4	UP-5	UP-6	UP-7	UP-8	UP-9	UP-10	UP-11
1	4	4	4	5	5	5	5	5	3	4	5
2	4	5	4	5	5	5	5	5	4	4	5
3	5	5	4	4	5	4	5	4	5	4	5
4	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5	4	4
6	5	5	4	5	5	5	5	5	4	5	4
7	5	4	4	5	5	4	5	4	4	5	4
8	5	5	5	5	5	5	5	5	5	5	5
9	5	5	5	5	5	5	5	5	5	5	5
10	5	4	4	5	5	5	5	5	5	5	5
11	5	5	5	4	4	5	5	5	5	5	5
12	5	5	5	5	5	5	5	5	5	5	5
13	5	4	4	4	4	5	5	5	5	5	5
14	5	5	4	5	5	5	5	5	5	5	5
15	5	5	5	5	5	5	5	5	5	5	5
Mean	4.86	4.73	4.46	4.8	4.86	4.86	5	4.86	4.66	4.73	4.8
Median	5	5	4	5	5	5	5	5	5	5	5
SD*	0.351	0.457	0.516	0.414	0.351	0.351	0	0.35	0.61	0.45	0.41

*SD = Standard deviation

The last section of the questionnaire comprises two questions to collect the problem faced when using the dashboard and suggestions for the improvement of the taxation performance dashboard. Some suggestions to address the problems were collected from the conducted survey. Table 5.16 shows the problems faced by participants and suggestion that were received for the improvement of the taxation performance dashboard.

Table 5.19: Problem faced and suggestion for the improvement of the taxation performance dashboard

Respondent	Problem that faced	Suggestion for the improvement
1	Dashboard does not have analysis of the employee performance.	If possible, add the employee performance in the dashboard, for example, which employee doing lots of jobs in which department.
2	The resizing feature is not found.	Each analysis has a full screen, it would be better if it has the resizing feature.
3	No problem	No suggestion
4	No problem	Add more analysis in future.
5	I cannot find charts for the network of the ARD.	Add the status of all the network connectivity of tax centers with the central system in future.
6	I cannot find the admin panel link.	If the dashboard is designed in such a way that new analyzing is add easily it will be very good.
7	I cannot find the notification part.	It will be very good if notification and alert are added.
8	No problem	No suggestion
9	No problem	To add some more things to the dashboard.
10	Need to implement the resizing library too.	It will be very good if the resizing library of JavaScript is added to each box.
11	Some calculation is not correct	I think some statistics and calculation are incorrect. It should show the statistics and calculation correctly.
12	No problem	No suggestion
13	Labels need to be changed	Some labels need to be changed.
14	No problem	It is designed in a very effective way.
15	The calculation of the statistic is not correct.	Some statistics are not shown correctly. It needs to double-check.

5.7 Discussion

This section discusses the results presented in the previous section.

5.7.1 Effectiveness and Usability of the Performance Dashboard

The results of Survey 2 show that the taxation performance dashboard was an effective and usable dashboard. Among the three main features, visual and functional

features are well designed, except for data semantics features. A follow-up interview was conducted to collect feedback from the participants to redesign and improve the data semantic features. Figure 5.13 shows the screenshots of data semantics parts of the dashboard that were redesigned based on the feedback. Notifications and alerting were added to highlight the data semantics.

Figure 5.13:Taxation performance dashboard after post case study survey.

The improved data semantics features were presented to ARD again. A follow-up questionnaire was conducted to collect feedback related to the data semantics features after redesigning the taxation performance dashboard. Table 5.17 shows the result of their feedback, DS stands for Data Semantics (refer to questions in Appendix C). The participants from ARD were satisfied with the new design improvements of data semantics.

Table 5.20: All responses of the fulfillment of the Data Semantics

Respondent	DS-1	DS-2	DS-3	DS-4
1	5	5	5	4
2	5	5	5	4
3	5	5	4	5
4	4	5	4	5
5	4	5	4	4
6	5	5	4	4
7	5	5	4	4
8	5	4	5	4
9	5	5	5	5
10	5	4	4	4
11	4	5	5	5
12	5	5	5	5
13	4	5	5	5
14	4	5	5	5
15	5	5	5	4
Mean	4.66	4.86	4.6	4.466
Median	5	5	5	4
Standard deviation	0.488	0.351	0.507	0.516

The main suggestions for improvement that was to add some KPIs such as employee performance, and network performance. This is out of the scope of this case study since it is agreed earlier that this is a tactical performance dashboard which focus on department KPIs. Additionally, the employee performance data was not shared by ARD.

Additionally, some suggestion to add some more features to the dashboard is also received. For example, adding a resizing library, that everyone can resize their dashboard, based on how everyone wants to view the dashboard. This will be implemented in future since this is only the prototype to evaluate the design of the dashboard. Nevertheless, some suggestions highlights that statistics and calculations shown in the dashboard is incorrect. The reason is because the limited data was shared by ARD and the statistics and calculations were implemented as proof of concept of the design, not to show the accurate results. Accurate statistics and calculation can be implemented in future when

the dashboard is linked to the SIGTAS system and get the direct queries from the SIGTAS system. The development team of ARD will take over the prototype to modify the query for the development of actual performance dashboard.

5.7.2 Functional suitability and usability

All steps of the proposed process model were accordingly taken for designing the taxation performance dashboard in this case study. The dashboard design has fulfilled all the purposes, visual and functional features defined for this performance dashboard. Based on the results analyzed for effectiveness and usability aspects, it can prove that it is feasible to apply the PM-DPD to design an effective and usable performance dashboard in a real-life context. The proposed process model provides a systematic approach to support the design of a performance dashboard by considering the characteristics of the dashboard, customization of the KPIs, visual mapping between KPIs and visualization techniques.

In the case study, three issues were identified that need to have deeper consideration during the design of a performance dashboard. First issue is design of data semantics features. Although common data semantic features were defined for alerting, notification, benchmarking and updateable, it is crucial to discuss with the stakeholders to elicit more specific requirements for data semantics. Second issue is selecting the right KPIs for the performance dashboard. In Survey 1, a set of KPIs were identified. However, in the process of customizing the KPIs based on perspective, strategy, and measurement, the set of KPIs defined earlier need to be reduced and merged to have a more meaningful performance analysis. The third issue is found during the phase of visual mapping, different factors need to be considered to select appropriate visualization techniques based on points, data types and reason for visualization. The visualization techniques can be finalized during the phase of designing dashboard UI to make sure that the integration of

different visualization techniques in a single page can fit the size of the dashboard for each level.

5.8 Summary

This chapter explains the case study conducted to evaluate the functional suitability and usability of the proposed process model for designing a performance dashboard. This chapter starts with the design of the case study, which illustrates the whole process for conducting the case study. Following each section describe precisely each step of the case study that was taken for doing this case study. Result and discussion of the case study were presented in the last two sections of this chapter. The evaluation results show that it is feasible to apply PM-DPD to design an effective and usable performance dashboard.

The next chapter will present the conclusion and future work of this study.

CHAPTER 6: CONCLUSION

6.1 Introduction

This chapter discusses a conclusion of this research to highlight the achievement of the research objectives, research contribution, limitations and future work of this research.

In this research, firstly, a thorough literature review was conducted to identify main aspects of a performance dashboard and analyze common characteristics of a performance dashboard from the existing studies. During the literature review, characteristics of the dashboard, design principles and visual mapping were three main aspects identified in this study. Based on the three main aspects and common characteristics, a new process model, PM-DPD was proposed. PM-DPD consists of four main phases which are define characteristics of the performance dashboard, customize the KPIs, visual mapping, and design dashboard UI.

To evaluate the proposed process model, a case study was conducted to evaluate the functional suitability and usability of applying PM-DPD to develop a performance dashboard for monitoring the performance of taxation departments. The case study results show that it is feasible to apply the four phases proposed in the PM-DPD process model to design effective and usable performance dashboards.

6.2 Fulfillment of the Research Objectives

This study discussed three (3) research objectives in chapter one. Throughout this research, each research objective was achieved sequentially.

Objective 1: To identify the existing processes of designing a performance dashboard.

This study conducted literature review to identify the existing processes and steps that can taken for designing a performance dashboard. The existing processes are presented in Section 2.9. By referring to the existing processes, a new process model, PM-DPD is proposed.

Objective 2: To propose a process model for designing a performance dashboard using visual mapping approach

A new process model is proposed for designing a performance dashboard using data visualization techniques. This new process model can assist the development team of an organization to design and develop an effective and ease of use performance dashboard. The details explanation of the proposed process model is presented in Chapter 4.

Objective 3: To evaluate the functional suitability and usability of the proposed process model in designing a performance dashboard.

To evaluate the functional suitability and usability of the proposed process model, a case study was conducted to design and develop a taxation performance dashboard. This case study had taken each phase and step that was proposed in PM-DPD to design a performance dashboard. The evaluation results show that it is feasible to apply PM-DPD to design an effective and usable performance dashboard. The details explanation of the case study is presented in Chapter 5.

6.3 Research Contributions

In this study, a new process model, PM-DPD was proposed for designing a performance dashboard using data visualization techniques. The main contributions of this research are as follows:

- This research contributes to improve the process of designing a performance dashboard using visualization techniques by considering purpose, visual and functional features and selecting set of KPIs.
- This study reviewed visualization techniques with a detail description to map the KPIs with type of the data, and the reason for the usage of a specific technique for visualization.
- All steps recommended in the PM-DPD are useful to support development teams for design of a performance dashboard.

6.4 Limitations

Every research project encounters various limitations in the development period. Similarly, this study also faced with some limitations.

- As discussed in the literature review, there are three types of performance dashboard (Strategic, Tactical, Operational). This research only conducted a case study to design a tactical performance dashboard to support the performance monitoring by the manager of the organization and department. Additionally, the proposed work was evaluated using the performance data from one organization and one domain (i.e. taxation).
- There is a limitation in the process of eliciting the requirements for data semantics features. A more detailed steps need to propose to get more specific requirements for data semantics features.

6.5 Future Work

As part of the future work of this research, the PM-DPD can be further improved. The data semantics can be improved by adding some sub-steps that can help to collect the precise data semantics requirements for a performance dashboard. To further evaluate the

functional suitability and usability of PM-DPD, it needs to conduct more case studies in different domains (e.g. healthcare, business) and levels of performance dashboard (e.g. strategic and operational performance dashboards).

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