Czech University of Life Sciences Prague

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Diploma Thesis

User experience testing of online visualization tools

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DIPLOMA THESIS ASSIGNMENT

Ing. B.Sc. Carruthers Kofi Kodzitsey

Systems Engineering and Informatics
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Thesis title

User experience testing of online visualization tools

Objectives of thesis

The main objective of this thesis is to analyze, evaluate and test user experience with a set of online visualization tools in different use cases.

The partial goals are:

1. Analyze issues hindering UX related to online data visualization tools.

2. Identify areas of progress, weaknesses and evaluate key issues.

3. To propose how to address long-term issues affecting the adaptation of online data visualization tools in multinational companies.

Methodology

The Methodology of the thesis will be emphasized in the study, analysis, and expert testing methods such as formal usability inspection, consistency Inspection, or cognitive walkthroughs of a set of online visualization tools in different use cases. The user experience testing defined and evaluated based on a case study and upon the synthesis of knowledge and results that will be gathered on proposed long-term issues affecting the adaptation of online data visualization tools in multinational companies. Analysis and results will be derived and concluded with recommendations formulated.

The proposed extent of the thesis

60 – 80 pages

Keywords

User experience, accessibility, adaption, experience evaluation, evaluation methods, information system, reliability, usability, UX visualization tools.

Recommended information sources

Helen, Petrie., and Nigel Bevan. (2009). The evaluation of accessibility, usability and user experience. The Universal Access Handbook, C Stepanidis (ed), CRC Press, (2009).

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Vermeeren, A., et al. (2010). User experience evaluation methods: Current state and development needs.

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Declaration

I declare that I have worked on my diploma thesis titled "User experience testing of online visualization tools" by myself with the help of expert consultation and the use of credible sources of information, and I have used only the relevant sources mentioned in the references at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break the copyrights of any person.

In Prague on 06. 04.2020 ______________________________

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User experience testing of online visualization tools

Abstract

The study shows that the knowledge derived to understand UX of online visualised tools, user preference, facial expressions and reaction, novelty with aesthetics of such tools, and the subjective experience time between the user and the online visualised tool need to be considered to address such issue better. Analysis based on this subject matter hindering UX were identified with areas of progress, weakness in other to evaluate such key issues to deliver long-term resolutions affecting the use and adaptation of online visualized tools.

The study is based on qualitative approaches with the incorporation of quantitative questionnaires, a method and system for measuring the overall subjective UX time, facial reactions of users when working on a scenario task using the online visualized tools. These subject matters and objectives validate the user's knowledge, preference, behaviour, and perceptions to adapt and use the online visualised tool. Also, it incorporates observational and physiological measurements in addition to the translation of the findings, which are measured by different scenarios and concluded by highlighting the need to address these issues for users' long-term use and adaptation of the online visualized tools.

Keywords: User experience (UX), accessibility, reliability and adaptation, experience evaluation methods, information system, subjective experience time, usability, UX visualization tools, User experience measurement, Facial expressions

Table of content

List of figures

List of tables

List of graphs

1 Introduction

The fast advancing global computer networks, information technologies and the design of the computer program system and product make it unlikely to think of any instances that a product or design does not have a human interface. The acceptance given to products all over the world has flourished intensively with accomplished and exceptional evaluated user experience and perspective. These developments have considered products from a user experience perspective given that there are some types of the interface between the design, system or product and the user. (Tullis and Albert 2013)

The ease of product use emphasises the proper achievement of task specifically settings of utilization. Yet, with new advancements, for instance, the Web and versatile media streams and players, for example, iPods, clients are not looking to only accomplish a task as users, yet in addition to divert and engage themselves in the form of entertainment. (Petrie and Bevan 2009) Hence, the term user experience as initially popularized by Norman (Norman 1998), has appeared to address the components of users' interactions with, and responses to, eSystems that go past effectiveness, efficiency, and conventional explanations of satisfaction.

The user experience according to Tullis and Albert comprises of three key essential characteristics: A user is involved, That user is interacting with a product, system, or anything with an interface and the users' experience is of noticed and of utmost important, observable or measurable and in the absence of a user undertaking a task or something, one might just be calculating attitudes and preferences. (Tullis and Albert 2013)

Usability is usually considered the ability of the user to use the thing to carry out a task successfully. In contrast, user experience takes a broader view, looking at the individual's entire interaction with the thing, as well as the thoughts, feelings, and perceptions that result from that interaction. In any casual conversation about usability, most people would agree that it's good to have something that works well and isn't confusing to use. (Tullis and Albert 2013)

2 Objectives and methodology

The main objective of this thesis is to analyse, evaluate and test user experience with a set of online data visualization tools in different use cases.

2.1 Objectives

Further objectives include:

1. Write a comprehensive literature overview on the subject
2. Analyse issues hindering UX related to online data visualization tools
3. Identify weak areas of the progress and evaluate key issues
4. Write a proposal on how to address long-term problems affecting the adaptation of online data visualization tools in multinational companies

2.2 Methodology

The dissertation mainly focuses on analytic data and incorporating qualitative data. It utilizes a research method on a descriptive analytics report on the selected online data visualization tool based implemented with a qualitative method of research.

The research was undertaken in a usability lab with a small group of 5 participants, with individual scenarios and tasks to be performed on each of the online visualised tools. In the process, there were video recordings on each of the online visualised tools to capture the facial behaviour and reactions with the visualised tools. This was followed by questionnaires for the participants to provide their responses based on the scenario task on the tools. Further literature reviewed together with the survey method to elaborate a broad understand of the study. Finally, detailed coverage of the qualitative method to dive deep into the study and confirm the survey result.

2.3 Analytic Study

Analytics is specifically valuable in areas with indispensable documented information the researcher can code from research findings. Analytics are grounded on the simultaneous content of the methods applied and the application of descriptive breakdown from hypothesis scenarios and narrative examination to support the operations of the research of the online visualized tools. The dissertation compiles data two online visualized tools to understand the knowledge of the human-machine interface, which will result in better future design to organisations on business data with needs that improved and satisfies, predict, and improve business performance on the user interface. Moreover, this UX analyst plays a massive part in the investigation of users' behaviour, preferences and interactions with online visualised tools. This enables measuring the interaction between a user and a user interface on the application or the design. Likewise, implementing facial recognition to detect the reactions and user's mode of expressions when struggling with online visualised tools. Collecting data on user's interaction with the tools provides an excellent for future development.

2.4 Qualitative study

This section of the study incorporates requests for informational analysis in which documents are interpreted by the researcher to give voice, understanding and meaning around an assessment subject. Additionally, analysis of such documents via incorporating descriptive coding content into themes comparable to how an emphasis on a group or interview transcripts is investigated.

However, the main purpose is to examine further in-depth literature review relating to the true implications of the questionnaire responses on the online visualised tools.

Moreover, the author's assessment with the participant's interaction with the scenarios will be noted and further enlightened in the analysis part as well as the results and discussion part of this dissertation. The extraordinary influence of qualitative analysis of UX and UI is considered as it is the senses and reactions of the design field of human-computer interaction, Literature will be backed on the space where interactions between humans and machines occur with researchers first-hand knowledge on the assessment on the users with the online visualised tools. The level of involvement with the product, acceptance and adaptation, which comes with better understanding and use of the tools and with efficiency, effectiveness and limited error rates are impeccable, which sees a high retention rate of users on the product.

2.5 Quantitative study

The data collected by means of a questionnaire that users accessed via mail electronically to provide their details and understanding during the scenarios performed on the online data visualization tools. The quantitative data which comprises of three sections. The first section consists of the user's personal information (e.g., age, gender, work position, organisation). The second section entails the metrics that investigate performance, user happiness, engagement, user adaptation, retention and task success rate and measures on user struggles and hindrances when performing a task on the online visualised tools.

Section 3 consists of questions covering some of the variables related to factors affecting the user interface with the online visualised tools.

The questionnaire part comprised of the knowledge base on the users' interactions with the online visualised tools. Specifically, the questionnaires were designed to accumulate evidence of the practical knowledge and skill of the users.

All metrics in the section employed a Likert scale with endpoint ranging from; 1= Poor, 2= Fair, 3 = Average, 4 = Good and 5 = Excellent. Measurement on the product design based on the metrics stated above with the study focused on the practical knowledge and skills exhibited to authenticate the connection between user's task success rate, adoption and with a solid recommendation of the product design the intention of the user to use it frequently.

3 Literature Review

3.1 User experience (UX)

User experience, which is widely known and abbreviated by UX, can be well-defined in numerous ways. The numerous means developed in the field of Human-Computer Interaction (HCI) over the years has become increasingly concerned with user experience (UX) meant to describe the practice of utilizing user research and design techniques including usability testing, user personas, and user-centred and design to make items usable, useful, and enjoyable. (Beasley 2013) Thus, there is the issue of having no common definition for user experience. As a result of the challenges related to the topic, quite a lot of methods for measuring or otherwise evaluating user experience have been developed to fit the many contexts and research areas. (Allaboutux.org 2014) A user's subjective opinion about (or answer to) a certain statement (or a question) about the system (or modality, interaction, or any other specified target) in a certain context at that time. (Keskinen 2015)

Moreover, elaborated definitions that involve comparing usability and user experience arguing on that unlike the more traditional usability, user experience is somewhat purely subjective and therefore, cannot be evaluated by observation or expert evaluation alone. Nevertheless, "Usability" and "user experience" are still used almost synonymously surprisingly often when evaluating the design and especially in industry. (Hassenzahl 2008)

Although usability can, to some level, be assessed in a more objective manner by experts, the user experience involves something only the users themselves can evaluate and determine. (Keskinen 2015)

According to Roto and his colleagues, the augment of usability and user experience is defined as a clear, fit-for-all-fields definition for "user experience" is still missing which perhaps due to this, the terms "usability" and "user experience" are constantly interchanged especially among people who are not directly working with the issue. Additionally, when it involves individual interrogations asked from users regarding UX, however, it is unquestionable that even the most experienced UX or usability expert is not always able to elaborate on whether the question concerns usability or user experience. (Roto, Law et al. 2011)

In view of observation and findings by Roto, Obrist and Väänänen the question "How can we observe how users feel, i.e., observe the user experience?". (Roto, Obrist et al. 2009)

However, the basis for evaluating user experience, as the truth of user experience cannot be based on observation data alone can lead only to educated assumptions and cannot be used as is only within the user.

User experience, to some level, involves more human-machine interaction with a core understanding of how the knows the tool and feels, not on how the user performs or would be able to perform with a system of a certain "usability level." Despite the fact, usability can, to some extent, be evaluated in a more objective manner by experts. For instance, user experience is a relative term; only the users themselves can evaluate and determine. Noticeably, something about user responses can be said based on observing the users. For example, the interacting phase with users whether the users give the impression of extremely happy or very disappointed when interacting with a system which indicates if the system is well received. (Keskinen 2015)

However, educated speculation on a design cannot be used as the basis for evaluating user experience based on observation data alone, as the truth of user experience is only within the user. Likewise, "user response" or even "user reaction." is a better term for observed reactions. Still, the term "user experience" is used in observations and findings where nothing has been asked from the users themselves. (Vajk, Coulton et al. 2008)

In addition, to maintain simplicity, the abbreviation UX is used in this dissertation. The complexity around the term and its definition, as seen in the literature, undoubtedly only increased by using the abbreviation "UX." Thus, the term "user experience" is interpreted here: an individual using an object (user) plus his or her feeling about the object (experience) = user experience. (Keskinen 2015)

3.1.1 UX evaluation method from design

The connection between usability and UX is intertwined. Attempts have been undertaken to demarcate or even dismiss the boundary between them, conceptually and operationally. Researchers turn to take the stance that usability is subsumed by UX. The implication is that UX evaluation entails the augmentation of existing methods for usability evaluation. Usability tests tend to focus on task performance, whereas UX focuses on lived experiences. As further explained, a user's motivation and expectations contribute to a stronger part in UX than in traditional usability. (Kankainen and Suri 2001) The differences between evaluation cases and various methods, i.e., the objectives, system, and features, context, user group, and so forth, have most undoubtedly contributed to the formation of many methods as well. Regularly, readily available methods that are suitable for evaluation cases as such are difficult or impossible to find. Thus, put researchers in a position to be forced to create new methods or questionnaires, or at least discrepancies of existing methods. (Keskinen, Hakulinen et al. 2013)

Moreover, there are many user experience evaluation methods that include self-reported quantitative ratings. This involves data gathered with questionnaires, user experience can be assessed, or at least has been, or the more subjective information can be enhanced with.

For instance, the following data collection methods: interviews, observation, focus groups, journals, and investigations. (Bargas-Avila, Hornb et al. 2011) A relatively wide, although not comprehensive, list of existing methods for evaluating user experience can be found through All about UX—methods. (Allaboutux.org 2014)

One obstruction in the evolution of the evaluation questionnaires, for example, more often the content of self-created questionnaires remains unknown, as found by Bargas and his colleagues in their evaluation and assessment based on the appraisal of empirical user experience studies from 2005 to 2009. (Bargas-Avila, Hornb et al. 2011) This secrecy probably goes partly together with the lack of clear literature on how to evaluate user experience in practice.

3.1.2 Accessibility and usability

The research of usability plays a significant component in ensuring a quality user experience, which is still an essential part of the broad and multidisciplinary field of human-computer interaction. The accessibility and usability of design are about getting users past the technology and focusing on getting things done for work. Equally, it is about designing the technology as an extension of human capabilities to accomplish something and to be as transparent as possible in the process. For instance, help boost this unexplained imperious, “make it transparent,” into more than a nice platitude. Deliberate on how a writer or an artist works or perform a task of writing with pencil and paper. The writer’s emphasis is all about capturing expressions to convey content and meaning.

Much mental energy can be directed toward organizing the thoughts and finding the right words to express them. No thought at all should be necessary toward the writing tools, the pencil and paper, or computer-based word processor. These tools are simply an extension of the writer. Perchance the lead of the pencil breaks or a glitch occurs in the word processor software. In this instance, the writer must turn attention away from the writing and reflect on how to get the software to work, making the tool that was transparent to the writer in the writing task become the focus of a breakdown recovery task. (Weller and Hartson 1992) Similarly, interaction design that causes usability breakdowns for users turns attention away from the task to the computer and the user interface.

Moreover, in these days of extreme competition among different products, usability becomes an essential part of making technology transparent and creating greater consumer awareness, that is not already enough. Thus, while usability engineering is still a foundation for UX, it does not stop there. Subsequently, the focus is still entirely on designing for the human rather than focusing on technology, "user-centred design" is still a decent description. Thus, a new term or reference to express such concern beyond impartial usability: "user experience". (Hartson and Pyla 2012)

The concept of user experience, which entails more conjures a broader image of what users reflect on with inviting comparisons with Quesenbery. (Quesenbery 2005) Understanding further the old acronyms, for instance, What You Experience Is What You Get (WYXIWUG) (Lee, Kim et al. 2005), makes it much relevant for user experience to be a pivotal part of UX. Additionally, the traditional usability attributes, which emphasize user experience comprising of social and cultural interaction, value-sensitive design, and emotional impact on how the interaction experience includes "joy of use," fun, and aesthetics for the user.

3.2 Evaluating user satisfaction and user experience

Evaluating user satisfaction and user experience move beyond performance-based measures that have traditionally been in the case of every design, which has been the focus of user-based evaluations. These aspects of the evaluation of various eSystems can be assessed in numerous ways. For example: using Kansei techniques from consumer product development. However, the simplest way is with rating scales and questionnaires.

Psychometrically designed questionnaires, for example, SUS for usability (Brooke 1995), for user experience, it will give more reliable results than ad hoc questionnaires (Hornbæk 2006), which gives examples of other validated questionnaires.

3.3 User experience research, usability and UX evaluation

The evaluation feedback enables designers/developers to fix this experiential problem of usability and UX evaluation. Designers and developers can know that their fix works (i.e., downstream utility) when the emphasis is put on conducting UE in the early phases of any development lifecycle with the use of low dependability models, in so doing enabling feedback to be comprehensively combined before any such design becomes too late or costly to make any changes. (Hertzum 2006)

Recently, research efforts on evaluating and UX evaluation methods have been undertaken to collect, consolidate and categorize such methods. (Vermeeren, Law et al. 2010) Nevertheless, it is envisaged that classifications of UX qualities, which can ease the assortment of UX approaches and measures, will come to completion from these ongoing endeavours. Usability of any design ensuring the smoothness of observed feedback determines its worth. Previous study showed that for a design, the development squad needs to be convinced about the urgency and necessity of recognizing and fixing usability issues. Moreover, the nature of UX evaluation feedbacks not as much of persuasive than usability feedback. (Nørgaard and Hornbæk 2009)

The resolution of such significant findings will have an impact on UX evaluation be weaker. The acknowledgement of the software engineering community recognized the importance of usability research and findings, consequently playing a huge role for developers in any design. Efforts are focused on explaining the consequences of usability for requirements gathering, software architecture design, and the selection of software components. (Juristo, Moreno et al. 2007) This said as UX evaluation procedures and measures could prove to be very different (e.g., artistic performance) recognition and implications need not be taken for granted for UX, usability and UX evaluation. Even though there is no fundamental difference between measures of usability and measures at a point in time, the difference in emphasis between task performance and pleasure leads to different concerns during development.

3.4 Web interactions and analysis

According to Beasley, web interactions and analytics is a technique of learning how the users interact with websites and mobile apps by repeatedly recording various characteristics of users' performance and then merging and transforming the performance into data that can be studied and evaluated. (Beasley 2013) Additionally, web scrutiny and studies depend exclusively on the user's data derived from the day to day interaction with a specific web page or app. Knowledge discovery from a large amount of database through processes of extracting useful, implicit, and previously unknown knowledge from data is referred to as knowledge discovery in databases (KDD). (Lara, Lizcano et al. 2014)

Additionally, traditional research methods by UX professionals have typically involved observing the performance of small samples of representative users and seek to understand what users do and why they do it. UX professionals often ask questions such as: "What problems do users encounter when performing this task?" "How do users understand the way information is organized?" "Why do people click on this button rather than that other button on the same page?" Web analytics data tell you what large numbers of users have done on your website. These tools capture data on nearly every user who comes to your website and allows you to answer "what" questions rather than "why" questions. (Beasley 2013)

This said, an individual can learn what the most and least viewed pages on the website are and what the people who ended up buying something on that website typed in that search box. What web analytics can't tell you is why users did or didn't view those pages and what those users meant when they entered a particular search query. (Beasley 2013)

3.4.1 Current Visualization Methods

The state of current visualization approaches can be summarized in three categories: static visualization (graphs, infographics, etc.), interactive visualization (network views, relational data displays) and dynamic visualization (timelines, animations, etc.) Software applications can display visualizations that are based on manual data entry, generators for static graphics and word clouds ("use") and dynamic visualization. (Luther 2017) Dynamic visualizations are based on the code that is relational to the syntax of databases in a diverse range of data formats. Luther is of the view that software used in qualitative data analysis is often referred to as Computer-Assisted Qualitative Data Analysis Software (CAQDAS). (Luther 2017) These programs are largely used as desktop applications that contribute to the examination of qualitative data. Atlas. Ti, MaxQDA and Nvivo are three examples of prominent desktop applications for qualitative data analysis; all three allow manual data visualizations (drawing) and generator (use) through a software inherent network tool. (Luther

2017) The user interface (UI) and user experience (UX), in contrast to current trends in data visualization, vary in three key points: design of data, accessibility of information and the freedom to represent thoughts through the dynamic performance of restructured data. Moreover, data-driven documents (D3) is an example that shows possibilities to provide good UI and UX in dynamic data visualization and information mapping. The data-driven documents are a novel representation-transparent method to visualization.

3.4.2 Data input and structure

The process of data input can be provided by copying and pasting into a text box or by uploading two file formats, it can also have separations that can be hyphenated or with a comma, i.e., comma-separated values (CSV) or XLS(X) (Excel) format. Several delimiters (comma, tab, semicolon, space) are recognized. (Wilson, Bryan et al. 2017)

There are various types, structures of data that may exist in different formats. (Wilson, Bryan et al. 2017) The native structure that data exist and uses is the “tidy” format (Wickham 2014), and this data structure is accepted as input. However, the spreadsheet-type is often stored in a raw data structure, which is done in a wide space, in which each column reflects a condition. (Postma and Goedhart 2019)

3.4.3 User experience and usability

There is some contradiction as to whether usability is part of user experience, asserting that “User experience consists of all the users’ emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours and accomplishments that occur before, during and after use.” Nevertheless, if user experience comprises of all the above behaviour, it presumably includes the user’s effectiveness and efficiency. This seems consistent with the approaches designated by many people in the industry. (Ketola and Roto 2008) Roto and colleagues presented the idea to have incorporated usability within the user experience. (Roto, Obrist et al. 2009) In contrast, researchers working in the field consider user experience to be entirely subjective, e.g. “The objective measures in a UX research such as task which involves the execution of time and the number of clicks or errors are not valid measures for UX, but we need the critical understand on how the user feels about the system” . (Roto, Obrist et al. 2009) Moreover, user experience can be conceptualised in different ways: Primarily, an elaboration of the satisfaction component of usability. (Bevan 2009) Secondly, the historical emphasis on user performance needs to be distinct from usability. (Roto, Obrist et al. 2009) Lastly, an overall term for all the user's observations, sensitivities and responses, whether measured subjectively or objectively. (FDIS 2009) Likewise, notwithstanding the terminology used; optimising human performance and user satisfaction which are two distinct objectives in UX with achieving both practical and satisfaction goals. The relative importance of using methods to support such goals above will depend on the specific product and design objectives. Furthermore, procedures for optimising user satisfaction with achieving both pragmatic and hedonic goals can be categorised as the hedonic approaches which outline the evaluating and design for the goals of stimulation, identification and recreation and associated emotional responses of users. Additionally, approaches to evaluate and strategize an appropriate design for the user's perception of accomplishment of pragmatic goals associated with task success. Lastly, approaches that provide the design of the user's experience, which should include setting requirements and understanding the context of us. Although Bevan elaborated on the fundamentals and significance of UX and UI, there is no fundamental difference between measures of usability and measures of user experience at a specific point in time, the difference in emphasis between the task performance of the user and pleasure leads to different concerns during progress. (Bevan 2009)

In the context measurement of user-centred design, typical usability and UX concerns are outlined in Figure 1 below. There are categories involving usability measures such as designing for and evaluating overall UX effectiveness and efficiency. Furthermore, designing is meant for assessing and evaluating user comfort and satisfaction. Also, designing makes the product easy to use and to assess the product to categorise and fix usability problems. To conclude, when relevant, the progressive aspect leads to a concern amid at learnability. (Ketola and Roto 2008)

Measurement category	Measurement type	Measure	Area measured
Anticipation			
Pre-purchase	Anticipated use	The impact of expected UX to purchase decisions	UX lifecycle
Overall usability			
First use	Effectiveness	Success of taking the product into use	UX lifecycle
Product upgrade	Effectiveness	Success in transferring content from old device to the new device	UX lifecycle
Expectations vs. reality	Satisfaction	Has the device met your expectations?	Retention
Long term experience	Satisfaction	Are you satisfied with the product quality (after 3 months of use)	Retention
Hedonic			
Engagement	Pleasure	Continuous excitement	Retention
UX Obstacles	Frustration	Why and when the user experiences frustration?	Breakdowns
Detailed usability			
Use of device functions	How used	What functions are used, how often, why, how, when, where?	Use of functions
Malfunction	Technical problems	Amount of "reboots" and severe technical problems experienced.	Breakdowns
Usability problems	Usability problems	Top 10 usability problems experienced by the customers.	Breakdowns
Effect of localization	Satisfaction with localisation	How do users perceive content in their local language?	Localization
Latencies	Satisfaction with device performance	Perceived latencies in key tasks.	Device performance
Performance	Satisfaction with device performance	Perceived UX on device performance	Device performance
Perceived complexity	Satisfaction with task complexity	Actual and perceived complexity of task accomplishments.	Device performance
User differences			
Previous devices	Previous user experience	Which device you had previously?	Retention
Differences in user groups	User differences	How different user groups access features?	Use of functions
Reliability of product planning	User differences	Comparison of target users vs. actual buyers?	Use of functions
Support			
Customer experience in "touchpoints"	Satisfaction with support	How does customer think & feel about the interaction in the touch points?	Customer care
Accuracy of support information	Consequences of poor support	Does inaccurate support information result in product returns? How?	Customer care
Innovation feedback	User wish list	New user ideas & innovations triggered by new experiences	New technologies
Impact of use			
Change in user behaviour	How the device affects user behaviour	How are usage patterns changing when new technologies are introduced	New technologies

Figure 1 Categorisation of usability measures, Source: (Ketola and Roto 2008)

Measures on design to fit user's needs on user-centred design, typical user experience concerns comprise: 1. Understanding and designing the user's experience with a product specifically in the way people interact with a product over time i.e., what they do and why. 2. Make the best use of the achievement of the hedonic goals of stimulation, identification and elicitation, which is associated with the emotional responses. From time to time, the above sets of issues are contrasted as usability and user experience. Nonetheless, some organisations would include both under the common category of user experience. (Bevan 2009)

3.4.4 Data visualization

Data visualization defined as the presentation of data in a pictorial or graphical format. Information visualization enables decision-makers to understand analytics presented visually, so they can identify difficult concepts or identify new patterns. Since we have been living in an era of big data whereby large amounts of a structured, unstructured and semi-structured dataset that has the possible means to be mined for information. (Rouse 2019)

Furthermore, data visualization allows to clarity of the appearance of data in a pictorial or graphical format and a data visualization tool that also has software that generates such a presentation. Data visualization delivers users with spontaneous means to explore and analyse data interactively, enabling them to effectively identify interesting patterns, making available infer correlations and causalities, and provisions sense-making activities. (Bikakis 2018)

In addition, Big data is often characterized by the extreme volume of data, the wide variety of data categories and the velocity at which the data must be processed. These characteristics were primarily identified by Gartner analyst Douglas Laney published in a report published in 2001. (Laney 2001) More recently, several other Vs. have been added to descriptions of big data, including veracity, value and variability. Although big data doesn't equate to any specific volume of data, the term is often used to describe terabytes, petabytes and even exabytes of data captured over time. (Rouse 2019)

3.4.5 Evolution of Big Data Visualization

Visualization in big data emphasises on the basic concepts related to big data visualization. (Bikakis 2018) He further elaborated on traditional systems of data visualization operate in an offline way, limited to accessing pre-processed sets of static data. Moreover, the traditional systems of large data visualization cannot handle the magnitude of many contemporary datasets. As a result, they limit themselves to dealing with small dataset sizes, which can be handled without difficulty and analysed with conventional data management and visual explorations techniques.

A large amount of available information makes it difficult for users to explore and analyse data manually. Modern systems should provide mechanisms that assist the user and reduce the effort needed on their part, considering the diversity of preferences and requirements posed by different users and tasks. Recently, several approaches have been developed in the context of visualization recommendation.

In recent times, the big data era has enabled the availability of large numbers of very big datasets that are often dynamic and characterized by high variety and volatility. For instance, in several cases like scientific databases, new data constantly arrive on a daily/hourly basis. In other cases, data sources suggest interrogation or API endpoints for online access and updating. Additionally, in the present time, an increasingly large number of diverse users include; users with different preferences or skills with the indulgence to explore and analyse data in an overabundance of different circumstances. (Bikakis 2018)

Modern systems should be able to efficiently handle large dynamic datasets, which operating on machines with inadequate computational and memory resources (e.g., laptops). However, the dynamic nature of the current streams of data hampers the application of a pre-processing phase, such as the out-dated database loading and indexing. Moreover, in concurrence with performance issues, recent systems must address challenges related to visual presentation. The process of visualizing a large number of data objects is a challenging task that involves modern systems performing the action of "squeeze a billion records into a million pixels". (Shneiderman 2008)

3.5 Significant perspective on data visualization

The great potential of data visualization to enhance humanity in analysing the large volume data sets enhancing the effective predicting and trends of massive data. (Ravishankar 2014) Such data is vital for a good and timely decision for business advantage. The field of data visualization is an active research field concentrating on different procedures and equipment for qualitative exploration in conjunction with the quantitative analysis of data. The high-quality nature of the data visualization process with underlying data established can often cause an information overload from a very large data set, which means that the user can get lost in irrelevant detail. Methods have been developed to increase readability by decreasing detail in the image and data visualization, which has high quality if the underlying data can be established from the image. (Jänicke, Weidner et al. 2011) In many practical cases, data visualization serves the purpose to develop and serve for domain-specific tasks and knowledge in which the user gains a quick overview of the recent problem, circumstances and spontaneously prioritize the different problems. (Rosenthal, Pfeiffer et al. 2013) Besides, the purpose of the data visualization tool is to provide a reference library that can be used by professionals to establish the appropriate visualizations in order to allow their data to be understood and implemented in decision making. (Wills 2012)

Many current data visualization tools support displaying time-varying data sets in order to deal with the enormous size of time-varying data in the interactive visualization. (Wolter, Assenmacher et al. 2009) The recent complicated nature of data visualization tools makes it problematic for users to learn the communication categories of human-machine interface with appropriate sequence to data visualization tools which get more complicated as users find it difficult to learn the interaction sequences with the ability to remember the past queries and interpret the visual states. (Nafari and Weaver 2013) Graphs form an effective visual analysis which requires the appropriate visual appearances in combination with user interaction facilities and graph analysis algorithmic. (von Landesberger, Kuijper et al. 2011) Likewise, there are areas of significance with the simultaneous visualization of multiple and continuous data characteristics in a single visualization task. (Khlebnikov, Kainz et al. 2012)

Over a long period, there is a significant process to resolve such a task by utilizing the procedural quality synthesis toward creating the zoom-independent visualizations of three scalar information attributes. The method is constructed on the random-phase Gabor noise, whose regularity is improved for the visualization of the first data attribute. Text-based data visualizations have been used on the World Wide Web and the Internet. (Shalin 2015) Text analysis has proven to be one of the most powerful ways to add context to data visualizations. A short sentence or fragment that contains a combination of static text and dynamic values that designate one or multiple visualizations by integrating dynamic text analysis into data visualization to enable data intelligence. Similarly, if a clear, text-based interpretation of what visuals portray saves user's time since they no longer must stare at the visualization thoroughly to gain a deeper understanding of the data. Such distribution of salience over the visualization image is an essential measure of the quality of the text visualization. (Jänicke and Chen 2010)

However, as salience detection is regularly studied in the context of the visual system, there are similar mechanisms which operate in other sensory systems. For instance, letters for human subjects can become salient by training salience detection, which is a principle mechanism to facilitate visual attention. A good visualization can capture the observer's attention to the relevant aspects of the representation. The large amount of data displayed by pixel-based visualizations is popular because it can display huge amounts of data that can provide many details. (Oelke, Janetzko et al. 2011)

Nevertheless, regarding the pixel-based visualized tools, the effective means of pixel-based visualizations are well-thought-out only if the data set is not sparse and the data distribution not haphazard. Therefore, single pixels, no matter the positions, that is; if they are in a blank area or the centre of a large area of differently coloured pixels, they are perceptually tough to discern and may be missed. In many scientific communities, there are efforts to develop the approaches that quantify the uncertainty related to spatial data fragments focused within many scientific communities. (Bauer and Rose 2015) Hence, uncertainty is a feature that can prove to be both useful and problematic in data visualization, and it is valuable to develop the information visualization method with a facility for visual uncertainty analysis. (Dasgupta, Chen et al. 2012) The tendency of uncertain data values at different spatial positions to contrarily modify as a means of visualizing their correlations allows inferring on the discrepancies of structures in the data. (Pfaffelmoser and Westermann 2012)

3.6 Types of data visualization tools

Constructing an interactive data visualization takes a bit of creativity. It involves as much science as an art. Nearly all data visualization software is required to work via converting mysterious data set or information into great visualizations to interconnect the undisclosed intelligence in the data set to the target audience. (Kasemsap 2017)

According to Murray, data visualization tools are required to have the ability, process and display of the data in an understandable fashion. (Murray 2013) The need for it to be efficient in creating reliable data reports and dashboards by integrating and aggregating massive and complex data from different sources.

3.6.1 Examples of Applications

Over the years, visualization techniques have proven to be of great importance in a wide range of application areas in the big data era. The capacity, velocity, heterogeneity and complexity nature of obtained and accessible data make it extremely tough for individuals to explore and analyse such information. Consequently, data visualization enables users to accomplish a series of analyses on large data tasks that are not at all times, possible with common data analysis techniques. (Keim 2010)

The large size of data set has made it possible for major application domains, for instance, in physics and astronomy for data visualization, accessibility and analytics. Satellites and telescopes accumulate daily massive and dynamic streams of data. Using traditional analysis techniques, astronomers and other scientists are able to recognise noise, patterns and resemblances of data set. (Bikakis 2018) There are high volumes of data collected in the other application domain, such as atmospheric meteorology and climatology sciences. In this domain, there are high volumes of data collected from devices of big data visualization equipment and satellites daily. The storage process of these data over the years results in enormous amounts of data to be examined. Core tasks that include event predictions, climate factors and correlation analysis in visual analytics have proven so useful in assisting scientists understanding the collected data. (Keim 2010) Yet, in order to capture real-time phenomena, for instance, fires, tsunami, flood and hurricane, the domain access visualization systems are used in several scenarios in order to capture those events. Also, in bioinformatics, visualization techniques are exploited in numerous tasks. Biologists have used the visual techniques to obtain insight and identify fascinating parts of genes allowing them to experiment with the gene sequences. For instance, studying the large amounts of biological data produced by DNA sequencers, which is tremendously challenging, became much easier using the visualisation techniques. (Bikakis 2018)

In the big data visualization systems and techniques are extensively accessed and used in the business intelligence domain. The business and finance markets are one application part where visual analytics are often permitted to learn, display and monitor markets, clarify market trends and perform predictions in market research. Nevertheless, diverse sources that depend and analyse with visualized tools such as marketing agencies and in-house marketing departments (e.g., finance data, customer behaviour, social media) depend on the nature of display on the visualized tools to indicate market nature. Thus, these visual techniques are exploited to understand tasks such as identifying trends, finding emerging market opportunities, finding influential users and communities, optimizing operations (e.g., troubleshooting of products and services), business analysis and development (e.g., churn rate prediction, marketing optimization). (Bikakis 2018)

3.6.2 Tableau

Tableau Desktop is an application, which is used by individual data scientists, analysts, and people who generate and work on data visualizations. It resides on the desktop and is designed as per individual user. It can use public data or data that is specific to the enterprise or the individual. More collaborative organisations will probably use Tableau Desktop along with Tableau Server, which is an innovativeness solution aimed at the collaboration of data visualizations. (Rouse 2019) The data can be taken from anywhere and shared within the organization through the desktop or mobile browsers. The set-up tableau server is an on-premise solution. Moreover, Tableau Online is an accommodated version of the tableau server. It is accessible, secure and suitable for a variety of use cases from start-ups who need to share data fast to large global establishments who need the ability to scale. However, the Tableau Public is a free, online version of Tableau, which is aimed at community bloggers and people who create data visualizations to share online. The data and workbooks are completely public and available. (Rouse 2019)

Tableau has the best visualization functionality. It is far ahead of the competition in terms of completeness of vision and features. According to Gartner, Tableau is one of the most advanced business intelligence and data visualization tools in the business. (Gartner 2019) Based on Francois's analysis, Tableau is a complete, easy-to-use analytics solution and can view details in a few clicks. (Francois 2018)

3.6.2.1 Tableau model characteristics and interface

Tableau software has an interface that enables non-technical users to instantly and quickly build reports with their most rated user-friendly dashboards to present beautiful insight into a wide display of practices. (Kemal 2019)

Based on Kemal, Tableau's scalability is highly accessible, protected and its extensibility together with a process of drag-and-drop abilities of the software secure Tableau in the preferred best of data visualizations. (Kemal 2019)

The user-friendly nature with a drag and drops interface makes it a flexible licencing structure that permits multiple users to partner and share. It provides high-performance real-time visualisation and supports communication with other tools, languages and database sources such as CSV files, SQL databases and R-Easy Deployment. The accessibility and availability of Tableau on multiple devices such as phones, tablets, computers and laptops make it much contusive too. Besides, its seamless web publishing and renowned characteristics making it much preferred by users. However, Tableau does not support custom visual imports, and it does not provide scheduling or report notification, there is limited data processing as it supports straightforward data pre-processing techniques and high costs of licensing with poor after-sales support that make it expensive to smaller businesses. (Kemal 2019)

3.6.3 Microsoft Power BI

Microsoft Power BI is a business intelligence platform that provides such a collection of nontechnical business users with tools for accumulating, analysing, visualizing and sharing data. Such collection of services and online features focus on Power BI's user interface, which is intuitive for users familiar with Excel and its deep integration with other Microsoft products. This makes it a very versatile self-service tool that requires little upfront training. Likewise, with its desktop and online service whereby users can quickly develop dashboards, share reports and connect directly to all important works. (Negru 2018)

Tableau remains a formidable solution for advanced visualizations compared to Microsoft Power BI, which is broadly competitive with Tableau in basic visualizations as identified by Town and Thabtah. (Town and Thabtah 2019)

Microsoft developed Power BI out of several “Power” add-ons for Excel, beginning with the 2013 edition. (Kline 2014) The foundational layer for Microsoft Power BI is the tool Power Query tool, which has been entirely integrated with Excel as the “Get and Transform” commencement in 2016 (Microsoft, n.d.a). Power Query provides functions for accessing tabular data in a wide variety of formats, ranging from large-scale databases to simple text files. These tables can then be reformatted and combined before being loaded to Excel as tables or as part of a “data model” that can be manipulated with a pivot table and graphing tools. Other add-ons (Power Pivot and Power View) added capacity for mathematical calculations on tables without the spreadsheet grid reference system and for interactive visualizations based on those calculations. (Becker and Gould 2019) The pivot table system, together with basic charting functions, remains a part of recent Excel releases. The Power View system has become the visualization engine of Power BI. Power Query fully replaces the text import functions of Excel in 2016 and newer versions, allowing significantly more control over data types and delimiters along with more advanced transformations. (Becker and Gould 2019)

3.6.4 Microsoft Power BI models

Microsoft Power BI is an online SaaS service offer from Microsoft that is exhibiting communicating dashboards that users can create and update from many different data sources. The four main concepts of Power BI are: data, dashboards, reports and data sets

In Microsoft Power BI, users can create dashboards and gather data that are important for all assembled information. The visualization of graphical information can significantly enable users in the interpretation of complex data imported from excel tables, visual stimuli and provide a strong effect on individuals day to day work, helping in the decision making the process of small and complex data. (Pavel 2014) In Microsoft Power BI, data is based on reports, and reports are derived and generated from data sets formed in Power BI or Power BI Desktop. (Negru 2018)

Microsoft Power BI is an excellent business analysis tool that can deliver fast and reliable analysis on data set and large information for a decision via its software in desktop by demonstrating visualized data onto excel. (Kemal 2019).

According to Chua, Microsoft has backed in a large standard list of visualizations in addition to its front-end layer, which makes Power BI a formidable choice for the non-technical user to pick a start and develop in a short learning curve. (Chua 2016)

Table 1 Key Components of Power BI, Source: (Chua 2016)

Power Query	**Power Pivot**	**Power View**	**Power Map**
Search organizational and Public (Cloud) data	Create in-memory data model	Analyze, visualize and display data	Create maps and tours of data
Import, merge, shape and cleanse Data	Create hierarchies and KPI's	Interactive data visualization tool	Enables storytelling using 3-D data
Manage Shared Queries and Certify Queries	Create derived fields and calculations	Delivers intuitive ad-hoc reporting for business users	Uses ''Bing Map Service''

3.6.5 Qlik Sense visualization tool

Qlik Sense is a powerful tool for visualizing data within a business or an organization. Mastering the skills that are needed to develop Qlik Sense apps effectively will let users work quickly and make great data visualizations. According to Kemal, Qlik Sense provides the most value regarding data manipulations and data modelling. The associative data model allows for unique analyses to be showcased to business users.(Kemal 2019)

Table 2 Comparison of Power BI, Qlik Sense, and Tableau, Source: (Alainia 2019)

	Power BI	**Qlik Sense**	**Tableau**
Visualization Capabilities	Easy-to-use Platform	Self-service Analytics Tool	Perfect Graphics and Visualisation Capabilities
Advanced Analytics Capabilities	Supports R Language-based Visualisations	Does not support R or Python-based objects.	Provides fully integrated support for R and Python
Cloud Capability	Compatible with Microsoft Azure	Offers a SaaS cloud product	Compatible with robust cloud platforms like, Azure, AWS, etc.
Big Data Integration	Places the solution above Tableau and Qlik	Lets you access and manage all your data, big and small, within a single environment	Connect to nearly any data repository, ranging from MS Excel to Hadoop clusters

4 Practical and analytical part

In this section, we mainly describe the theoretical framework and provide findings related to some important knowledge differences discovered. The theoretical framework was developed from the themes recognised in the investigated outcomes. The analysis provides a detailed understanding of the various outcomes of the research.

This chapter deals with the various scenarios implemented in the research studies and the background information of the respondents. The completed scenarios and questionnaires were recorded, coded, revised, modified and computed via statistical analysis system.

The knowledge, adoption and UX of online visualised tools by various users as well as the role and impact on the task performed on such online visualised tools connected with a survey in the form of a scenario task to be performed by the users was developed among five users selected for the online visualised tools. Out of the five users, only one user was familiar with the online tools, the others with no knowledge about the tools.

The Scenario task was followed up with questionnaires to understand the know-how of the respondents. The scenarios with task performance are set up to capture the user's interaction connected with their facial expressions when working with online visualised tools which provides an understanding of the task, proper navigation of the tools, hindrances in performing such key issues and task via assessing the user’s strength and feebleness in the know-how process. This is followed by another performance task to identify and understand how well the user can work and accomplish a task as well as categorise, follow a routine, navigate and sort out key components and directories of the online visualised tools.

The questionnaire part comprised of personal information of the respondents, some of the variables related to UX with online visualised tools. Specifically, the questionnaires were designed to accumulate evidence of the practical knowledge or skills of the users. Such expertise or ignorance will come to light in the analysis section.

Moreover, this section also outlines some of the variables related to user’s familiarity, clarity, usefulness, preference amongst the tools, performance in response to features, frequency, the visualisation of the design, the novelty of the tool, design and simplicity of the tool and obstacles encountered in their experience with the tool. Most of the variables in this section employed a Likert scale with endpoint ranging from 1= Poor, 2 = Fair, 3 = Average, 4 = Good and 5 = Excellent. The rest had a single answer option, or it only required the user to provide a phrase or written answer.

Additionally, the UX lab is equipped with a facial recognition tool on the top of each monitor that the users are working on in the research. This tool captures the facial expressions on the users' faces with their reactions on each task performed on the various tools in the lab. The certainty and uncertainty, response and reactions with facial gestures made by the user in the navigation process related to the task performed were taken into consideration with the variables.

4.1 Scenarios for the various task performed

A lab test for two different scenarios, for Microsoft Power BI and Tableau, was set up for users to have a practical workaround on the tools. The tasks of scenarios performed by the user to identify the user’s familiarity, experience and the user’s overall interaction with the various online visualised tools. The User can perform the scenario task with stepwise guidance from an instructor (Author) for a better understanding of the user’s interaction with the various tools as per the different tools.

Additionally, there was video footage captured in the UX lab for the entire procedure to be able to understand the user’s facial expression and behaviour when performing a specific task. Analysis of the facial expression footage to identify whether it affects the user’s decision, user’s understanding of the task and the use of the tools.

4.1.1 Scenarios for Microsoft Power BI

The scenario-based on this visualisation tools were set in the daily administrative office of an HR manager that needs to analyse hiring statistics. The user’s task was based on part A and B. The task from Part A was based on how best users can access the Human Resource page, how well they can classify the various sections in each chart using the Likert chart from 1 = poor and 5 = Excellent.

Furthermore, the ability to rate the display of the dashboard from a Likert chart from 1 = poor and 5 = Excellent, emphasising on UX characteristics such as Colour, Clarity and Usefulness.

Part B comprises of various setups to better understand the interaction of the users with a practical performance on the tool.

User's completed tasks like to Create and save dashboards to favourites and share it with colleagues. Rearranging dashboards to their preference as well as Identify filters and capable of using it to ease work search. Moreover, the possibility to have different Q&A to verify users' aptitude on various hire counts per region, locate and open a new dashboard while working and navigate back to the existing baseboard. Figure 6 shows the scenario task page for Microsoft Power BI.

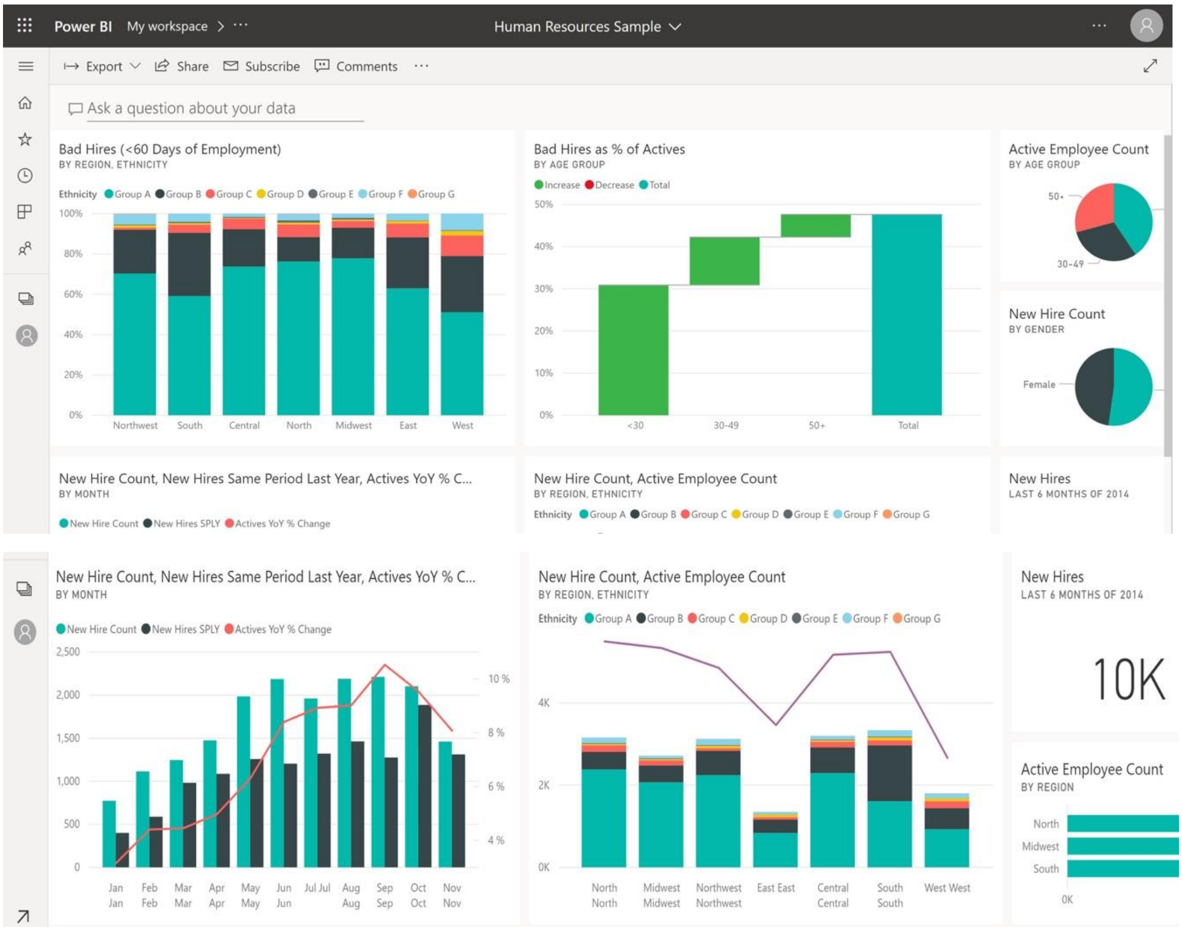


Figure 2 Author's Lab project template of Microsoft Power BI online tool, Source: Author originated Microsoft power BI online Field survey (2019)

Table 3 below outlines the average response time of users calculated based on the scenario task/response time (s) recorded for Microsoft Power BI.

Table 3 Indication of respondent time of scenario task of users on Microsoft Power BI, Source: Author originated (Field survey 2019)

Scenario task / Response time (s)	A	B	C	D	E	Average response time
Opening workspace	5	5	5	5	10	6
ChartCategories	25	30	30	58	60	41
Visual rating of colours, clarity, usefulness	30	27	35	45	57	39
Saving dashboard to favourites	5	5	5	10	8	7
Sharing documents	20	24	10	30	37	24
Reorganizing dashboard to preferred means of work	60	115	70	82	75	80
Aptitude Q&A to test users work around knowledge	110	60	130	157	138	119
Locating other dashboards	80	150	85	165	135	123
Creating a new dashboard	110	205	60	193	155	145

4.1.2 Scenarios for Tableau

The scenario based on this visualisation tool was set in the marketing analyst with a recent e-mail campaign. The dashboard was set to evaluate the campaign of the marketing analyst. The user's task was set up in part A and B. The task from Part A was based on how best users can Open and access the dashboard in the mail engagement page. How well they can classify the various sections in each chart using the Likert scale ranging from 1 = poor and 5 = Excellent. In addition, the ability to score on the display of the dashboard using a Likert chart from 1 = poor and 5 = Excellent, emphasising on UX characteristics such as the Colour, Clarity and Usefulness. Part B comprises various setups to better understand the interaction of the users with a practical performance on the tool.

User’s completed tasks like to Create and save dashboards as a new workbook or to favourites and to Share it with colleagues. Rearranging dashboards to their preference as well as identify filters and similarities of user’s capability in using such rearrangement to ease their work and search options. Moreover, the possibility to have different Q&A to verify users’ aptitude on the page they are working on to perform a task such as Changing the time zone. Correspondingly, locate and open a new dashboard while working and navigate back to the existing baseboard. Figure 3 below shows the scenario task for Tableau page.

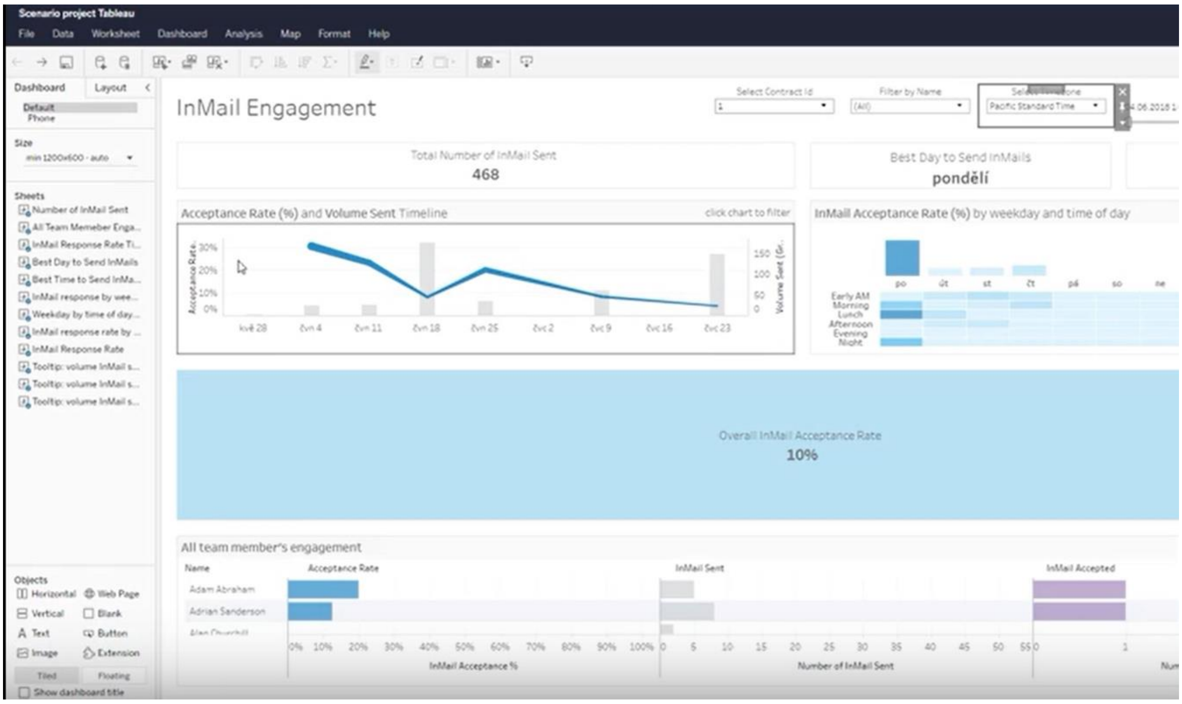


Figure 3 Author’s Lab project template of Tableau online tool, Source: Author originated Tableau online Field survey (2019)

Table 4 outlines the average response time users spent on a task which was calculated based on the scenario task/response time (s) recorded for Tableau.

Table 4 Indication of respondent time of scenario task of users on Tableau, Source: Author originated (Field survey 2019)

Scenario task / Response time (s)	A	B	C	D	E	Average response time
Opening workspace	5	5	5	5	15	7
Categories in chart rating	25	30	25	70	60	42
Visual rating of colours, clarity, usefulness	40	52	58	54	77	56
Save dashboard to view under name	135	145	175	171	190	163
Saving dashboard to favourites	10	15	10	30	37	20
Sharing document	45	55	70	77	80	65
Reorganizing dashboard to preferred means of work	100	140	120	135	167	132
Aptitude Q&A to test users work around knowledge	105	113	120	130	120	118
Locating other dashboards	113	120	90	180	137	128
Creating a new dashboard	54	45	60	70	83	62

4.2 Video Interaction with the online visualised tools

The usability and UX lab provided a suitable platform for the entire practical part of the research to be carried out. There was a video recording with a facial recognition tool included to record facial behaviours and expressions of respondents. The facial recognising tool took note of the respondents' facial expressions and behaviour reactions to each step of the scenario task carried out. The footage was taken during the entire process, excluding the questionnaire that respondents answered later. Important characteristics noted during such recordings included; the period participants spend on the scenarios, attitudinal measures, gauged by questionnaire ratings of satisfaction with the experience and various aspects related to the online visualised tools, descriptive interpretation using Likert scale as a measure, expressive explanation on the duration and action taken on each specific scenario task. Correspondingly, considering the facial expression and discomfort behaviour that each user exhibited on a positive, negative and neutral appearance when undertaking the specific scenario task. Consequently, the success rates, scenario task performed per second, facial responds, descriptive interpretation of the functions and error rates are all the challenges (i.e., strength and flaws) that they may have in using it which was observed and what could be working differently for them explained in the authors finding in the results and discussions part. Further interpretation and understanding of how the users use such tools, also the user's facial expression with respect to their interaction with the online visualised tools are explained in the same section under the author's findings.

Table 5 Scenario performance action, Source: Author originated (Field survey 2019)

Tasks	Microsoft Power BI	Tableau
Opening workspace	Done immediately	Done immediately
Categories in chart rating	Easily accessible	Hard to identify
Visual rating of colours, clarity, usefulness	Attractive, superior simplicity, Convenience	Less (Attractive, superior simplicity, Convenience)
Saving dashboard to favourites	Done immediately	Done immediately
Sharing document	Done with Ease	Done with assistance due to bad visuals
Reorganizing dashboard to preferred means of work	Easy to navigate and reorganize	Hard to navigate and reorganize
Aptitude Q&A to test users workaround knowledge	Better navigation and workaround	Inflexible means in navigation
Locating other dashboards	Done instantaneously	Inflexible means but gets it done

Table 6 Scale preference of performance action on the online visualized tools, Source: Author originated (Field survey 2019)

Tasks	Microsoft Power BI	Tableau
Opening workspace	Excellent	Excellent
Categories in chart rating	Excellent	Good
Visual rating of colours, clarity, usefulness	Excellent	Good
Saving dashboard to favourites	Excellent	Excellent
Sharing document	Good	Good
Reorganizing dashboard to preferred means of work	Excellent	Fair
Aptitude Q&A to test users workaround knowledge	Good	Fair
Locating other dashboards	Excellent	Fair
Creating a new dashboard	Good	Good

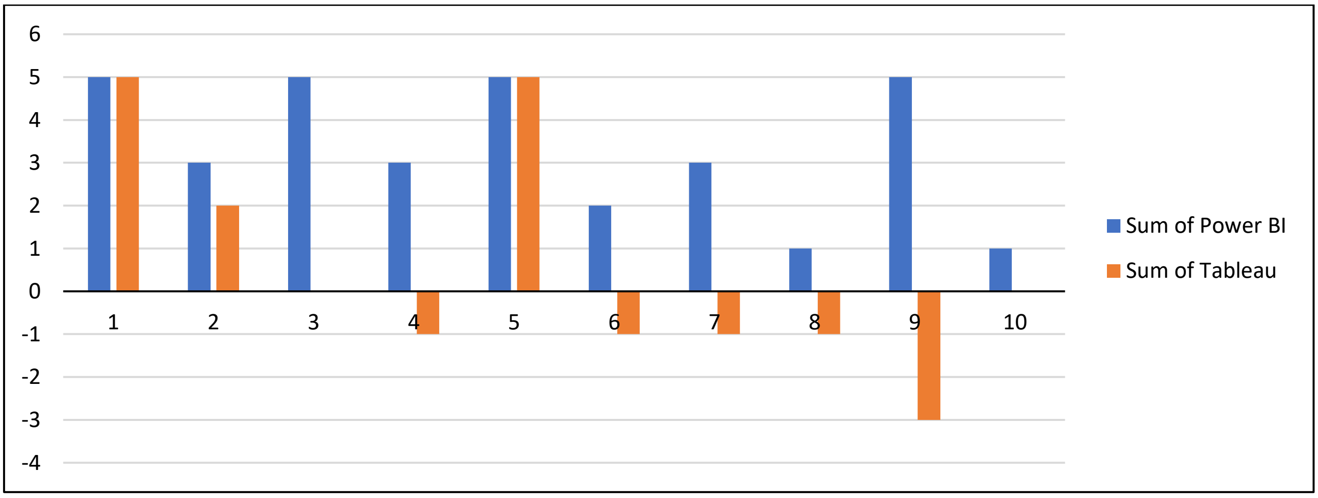
4.2.1 Facial reaction with the interface between Users and the online visualised tools

This stage elaborates on the facial behaviours of the users' facial expression and behaviours with respect to the types of scenario task that they are performing. Because each user is different and thus has a different understanding, different approach and a different idea on how to go by each scenario, the facial expression will be used to emphasize the difficulty and behaviour towards a task.

Such emphasis is identified and narrated in a descriptive analysis in the form of a positive, negative and neutral facial expression to the task that the participants are working on. However, as indicated in Graph 1 below, which displays the various facial expressions exhibited by the user during the scenario task process, these reactions are distinct into various categories. The positive facial expressions exhibited by the users designates that the user did not have any difficulty with such a scenario, they performed such task with imminent reaction with a quick response facing no difficulty. Likewise, scenarios that were hard and difficult, thus resulting in users going through a tough navigating process to pinpoint, classify and be familiar with the page to enable them to perform the task assigned. Nevertheless, the users who did not exhibit any facial reaction (i.e., positive or negative reaction) were categorised as neutral. Such users are also displayed a bit of struggle, stress and irritation with the scenarios. At the same time, they also exhibited a quick response with enough understanding of the scenarios and different means of going by the scenario tasks.

Graph 1 below shows the five participants' facial expressions and reactions when executing the scenario task. The x-axis are the executed tasks, and the y-axis are the frequency (how many times neutral, positive, negative facial expressions appeared). The tasks were:

1. Opening workspace
2. Categories in chart rating
3. Visual rating of colours, clarity, usefulness
4. Save dashboard to view under name
5. Saving dashboard to favourites
6. Sharing document
7. Reorganizing dashboard to preferred means of work
8. Aptitude Q&A to test users work around knowledge
9. Locating other dashboards
10. Creating a new dashboard



Graph 1 Facial expressions and reactions of users interacting with the tools, Source: Author originated (Field survey 2019

4.3 Analysis of the questionnaires

The analysis of the questionnaires is divided into three parts. The first part is made up of the personnel effect. The second part exhibits user experience and interaction with online visualised tools, lastly the knowledge base, interface and user's experience (UX) with the research tools.

4.3.1 Personnel effect

This part is about the gender, age and personal information of the respondents. The research was organised with 5 participants in the lab. No special preference was given to the dissimilarities in allocating questionnaires evenly, although three females made up 60% and two males made up 40% of the respondents. The ages of the respondents showed 60% between the ages of 18-24 and 40% between the ages of 25-34. 100% of the respondents are employed at a junior level in their respective occupations.

They all acknowledge the use of a different type of visualised tool in their workplace with very little knowledge of Tableau and Microsoft Power BI. They provided feedback on the reliability, quick response, work efficient use of their companies visualised tools and recognised little or no interaction with Tableau and Microsoft Power BI.

4.3.2 Respondents UX Knowledge and interaction with the tool

Although 60% of the users indicated no previous use with the online visualised tools in the research, 40% indicated having fair knowledge of the tools. The respondents' know-how of similar visualised tools in their workplaces, for instance, the use of monitoring tools such as Grafana, Sysdig, Excel spreadsheet, etc., helped them to give an overview of the study. There was one respondent who was quite familiar with Tableau and Microsoft Power BI and other monitoring tools.

Additionally, the respondent participated in the study were all junior employees in their various states of employment. However, it showed that 50% are familiar with such tools within a period of 1 – 3 months, and the other 50% also familiar within 3-6 months.

Moreover, in contrast to their workplace tools, 60% showed that the pages of the online visualised tools loaded excellent, 20% average and 20% good respectively. It demonstrates the higher satisfaction rate of users indicated in Figure 4 below.

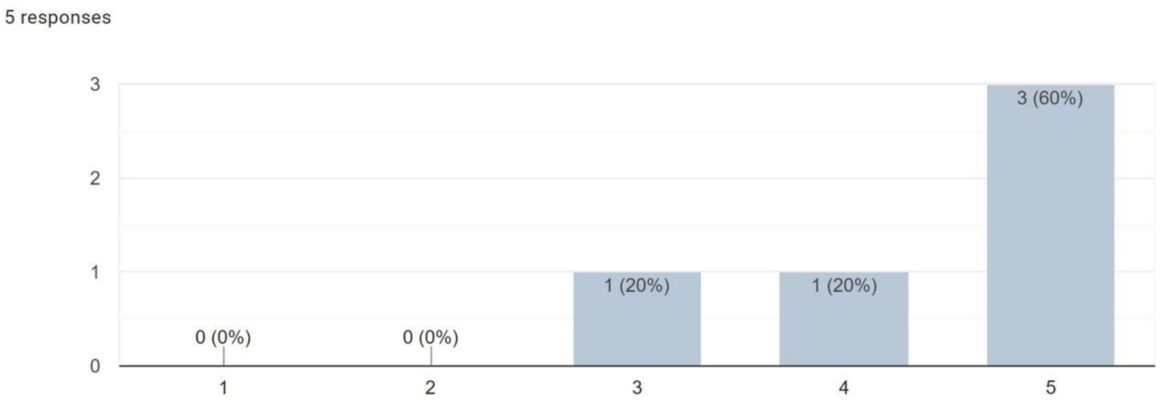


Figure 4 Responsive rate of the online visualised tools, Source: Author originated (Field survey 2019)

4.3.3 Knowledge base, interface and user's experience (UX) with the research tools.

This part elaborates on the interface between the users and the visualised tools, as well as their overall knowledge and understanding of the various features and key attention to details in their interaction with the tools. The features currently and previously used by users were listed as Data analysing, Metric Visualization and data aggregation in a short answer form. Respondents provided a 50% fair and 50% average on the Likert scale ranking (1 = Poor and 5 = excellent) comparing the usage of features on the online visualized tools in the research to the ones at their workplaces, which is illustrated in Figure 5 below.

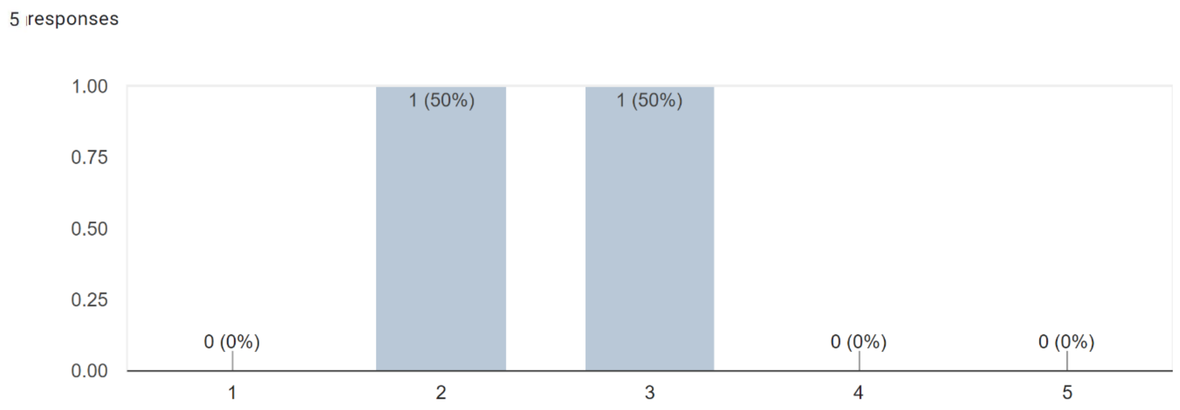


Figure 5 Knowledge and interaction of users with online visualized tools, Source: Author originated (Field survey 2019)

However, upon determining their preference for the online visualized features with Likert scale ranking (1 = Poor and 5 = excellent), 80% specified the features as Good and 20% specified it as Excellent (Figure 6).

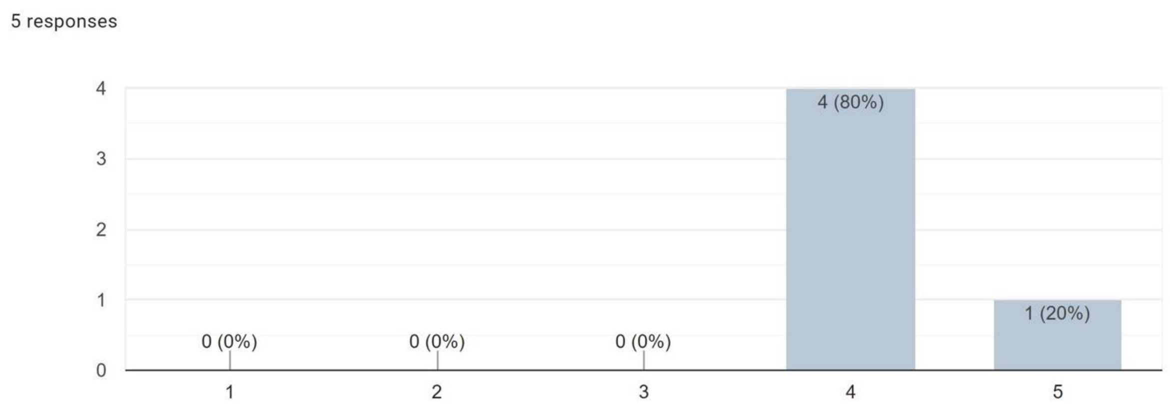


Figure 6 Preference of visualized features, Source: Author originated (Field survey 2019)

Additionally, in a short answer form, 50% of the respondents favoured the main design, 25% preferred the easy means to import date from various sources when working with the tools, and 25% also favoured simplicity, design status and display of colour in the design. This is highlighted below in Figure 7.

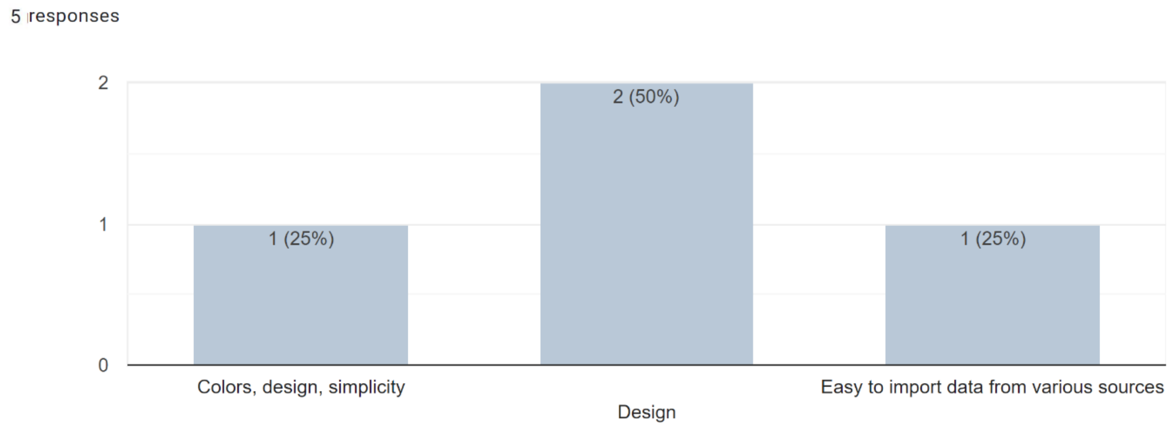


Figure 7 Users aesthetic preference of the online visualized tools, Source: Author originated (Field survey 2019)

Likewise, based on the above variations in the users interface with the online visualized tools, using the Likert scale ranking (1 = Poor and 5 = excellent), 60% good and 40% excellent of the respondents indicated that the tools offer the possibility to go into details when working with it.

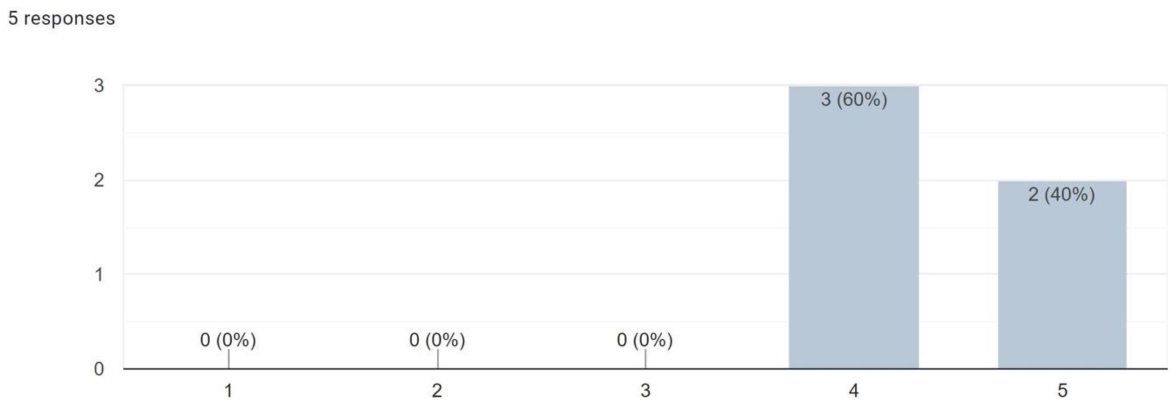


Figure 8 Comprehensive working response, Source: Author originated (Field survey 2019)

Additionally, 80% of the respondent specified that it is easy to navigate on the webpage when working with the tool, and 20% gave an excellent ranking when working on the webpage with the online visualized tools.

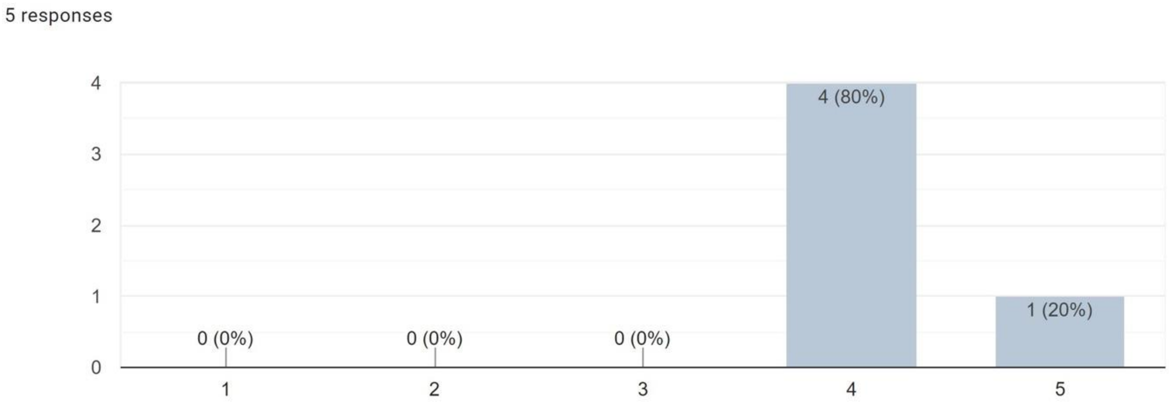


Figure 9 Responsiveness on navigation on the online visualized tools, Source: Author originated (Field survey 2019)

In addition, results showed that 66.7% of the respondents purchase commercial online visualized tools and 33.3% use inhouse tools in their workplace.

Also, 80% of the tools are online-based versions, while 20% are desktop versions (if there are any online visualized tools in their workplace).

Additionally, evaluating the level of novelty with the tool, for instance to the extent that the tools perform functions that are not in the Microsoft tools (word, excel, etc.) and other tools that user use on a daily basis at their work using the Likert scale ranking (1 = Poor and 5 = excellent). Correspondingly, evaluate the level of attractiveness and display of the online visualized tools, in view of the display of visuals, charts, graphs, etc. showed 60% good and 40% excellent on the Likert scale ranking (1 = Poor and 5 = excellent).

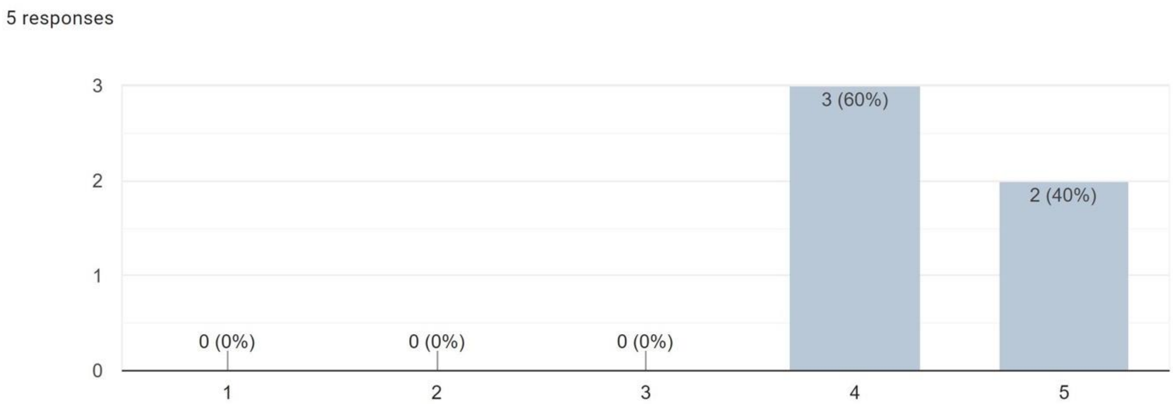


Figure 10 Evaluating level of novelty, Source: Author originated (Field survey 2019)

Nevertheless, evaluating the level of dependability with the tool, for instance, considering how often respondents will work with this tool on a regular basis showed, 40% on the average, 40% good and 20% excellent on the ranking rate as indicated below in Figure 11.

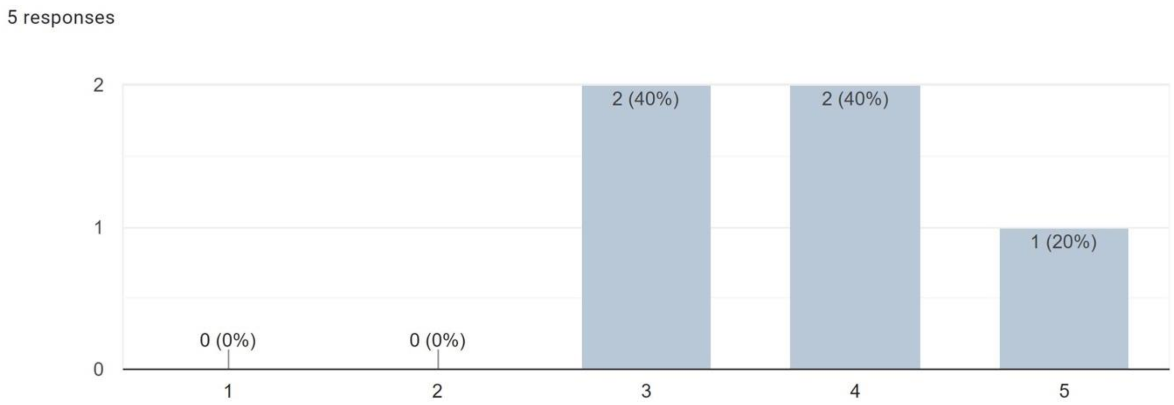


Figure 11 Evaluating the rate of dependability, Source: Author originated (Field survey 2019)

5 Result and discussion

In this section, we first discuss key findings from the study emphasizing those that are new, and the ones followed by findings that confirm current literature. A summary of key issues hindering the UX of human-machine interaction. However, the results deliver support for most of the theory proposed at the beginning of the research. Although some relations like the facial expressions exhibited by the users did not receive significant support from the data, the entire data received with analysis and results seem to hold well. However, with the need for some moderate revision and place, psychological influence as part of the variable will or will not impact the user's decision.

5.1 Perceived time during scenario task

Although in contrast, the sequential characteristics objectives of task completion time or the time on task are recurrently measured in UX testing's to deduce the efficiency of the system (Albert, Tullis et al. 2009), as well as measuring it spontaneously (Blackler, Popovic et al. 2010), or its anticipated conformity (ISO 2018). Considering the period users in this study take to respond to the individual task undertaking in the scenarios.

This dissertation emphasises on the user's knowledge base on the selected online visualised tools and investigating the response rate to a specific task on the devices. In Table 3 and Table 4, we can relate the lowest average on the table, which corresponds to Table 5, indicating a quick response to the task in the scenario. However, the users provided overall feedback on the scenarios on a Likert scale ranging from 1= poor and 5=excellent in Table 6. Although some of the users took a more second on their task, the scored average was completed and based on their feedback during the task, it was computed and tabulated in the tables above. Moreover, the subjectively experienced time (SXT) measured by Trukenbrod and colleagues in their work, which focused on waiting time during an interaction with a personal computer nonetheless attentive on ongoing interactions solving a specific task. (Trukenbrod, Backhaus et al. 2020) This is in relation to the ongoing task performed in the scenarios of this study, whereby attentive important was on the time interval per second on each of the scenarios. Moreover, Trukenbrod and colleagues defined SXT as the user's evaluation of the temporal attributes of interaction and further elaborated that users perceive the interactions with the computer duration (clock time), leading to an estimation of clock time and the circumstances with results. However, such results correlate with this study were mostly substantial, indicating that subjectively experienced time and the user's task performance rate per second is linked with both the user's perception of time and user experience. (Trukenbrod, Backhaus et al. 2020)

Furthermore, some interferences encountered by users in any interaction with a device or an online visualized tool can lead to delays that are not part of every interaction with a technical device. Trukenbrod and colleagues indicated that most authors referred to such delays as "temporal aspects", which is a very unspecific term. (Trukenbrod, Backhaus et al. 2020) However, such delays recognised as hindrances relating to the online visualised tools were also observed and encountered for in this study. Users with direct knowledge of the scenario task perform tasks immediately. With another task, the same users struggle around or work around, causing such "temporal aspects" delays, which are not part of the scenario process yet were observed and considered. Yet some authors refer to the temporal aspects of UX when they refer to the dynamics of UX over repetitive use. (Minge and Thüring 2018)

However, additional authors emphasize the importance hindrances such as delays, less understanding of the task, delays in the responsiveness of a single interaction in performing a scenario task (Liikkanen and Gómez 2013), taking brief delays on task performance into accounts (Szameitat, Rummel et al. 2009) and emphasis on waiting-intervals on task (Kurusathianpong and Tangmanee 2018).

5.2 Issues of UX with task measured on the subjective experience of time

Although, to the best of knowledge with the research, key findings on how users perceive and assess temporal attributes of interaction without delays are part of the human-machine interactions. Thus this study's findings are of the argument that the user's assessment that response rate and swiftness with a tool and delays, when working or interacting with a machine, can affect their interaction with the tool and even express a positive, negative and even neutral facial expression. (Trukenbrod, Backhaus et al. 2020) Therefore, the argument that users perceive time throughout most of their daily communications with computers independently, whether such communication comprises a delay or not. However, research on UX online tools and UX measures can benefit from understanding how users perceive and evaluate time in their work during any continuous, ongoing interaction with any tool or product. (Trukenbrod, Backhaus et al. 2020)

Besides, the subjectively experienced time as the user's subjective evaluation of temporal attributes of an interaction. In the process of accessing the user's response and delays on the task, users were measured on how the seconds spent on each task and the entire average estimated for them relates to temporal aspects of the interaction as well as to the user experience (UX). Consequently, during a typical interaction with an online tool on a computer, this, however, is associated with the definition work on such response time, which when taken into account, will propose a long term check for user-machine interaction. (Liikkanen and Gómez 2013)

Although, most issues which caused hindrances were explained as the subjective experience time and the user's evaluation of temporal attributes of interaction above based on, such temporal attributes which comprise of system responsiveness, overall duration (clock time), delays, and waiting intervals which go a long way to influence users interaction can be dealt with to ensure long term productivity in human-computer interaction. (Trukenbrod, Backhaus et al. 2020) Nevertheless, with a computer and all activities related to any online tool or program. In addition, the user perceives these attributes of the interaction and evaluates them in the process and influence the preference of such a particular tool or machine. (Liikkanen and Gómez 2013)

5.3 Facial expressions exhibited in the scenario task

Minge and colleagues suggest that UX evolves based on the user's perception of the objective characteristics of the interaction which includes three major components: first the usability and usefulness as the user's subjective perception of instrumental, second, the qualities such as aesthetics and other hedonic aspects of non-instrumental perception, third, the emotions during the interaction. These three components are argued as the core components of UX. They build the basis for creating a global UX and affect each other and including a general evaluation and a possible intention of the user to use or reuse the system. (Minge and Thüring 2018) The studies of authors supporting the argument of the framework, which shows an effect of the system's objective usability, UX and its visual appearance on all the above components involved in the user experience of a computer or its components. (Trukenbrod, Backhaus et al. 2020) The prime objective to understand the level of agreement between users interact with different online visualised tools and identify users desired preferences in association with the tools. The facial expressions identified the human capacity to detect task difficulty by observing the faces of users performing the tasks. This is in relation to human-computer interaction by UX_Mate by Trukenbrod and colleagues. (Trukenbrod, Backhaus et al. 2020)

Besides, evidence of connections between facial expressions as detected in the study and which further contributes to issues such as delays, responsiveness, etc. as indicated above, facial response with movements of the lips, facial frown which was not a powerful predictor of error occurrence, while mouth expressions, facial frown were weaker particularly in the moment of tension leading to video obstruction and impeding automatic detection of their emotional state. (Staiano, Menéndez et al. 2012)

5.3.1 Long term measures on UX related to facial and physiological effects

The usability interaction quality that users were able to use on the online visualised tools with ease, which contributes easy orientation, easy navigation, convenient use, easy understanding of processes, and the classical aesthetics, which included traditional notions of beauty emphasising symmetry, order and clear design of the tools. (Lavie and Tractinsky 2004) Upon analysis from the questionnaires based on all the indicated hindrances with comprehensive literature available, user's preference was more on Microsoft Power BI with its classy, fascinating and creative design, use of special effects, fascinating design of (graphs, visual displays, pie chart, etc.), easy use of symmetric design, pleasant, aesthetic design preferred to Tableau. (Carlisle 2018) The expressive aesthetics perception of creativity and originality of the design. (Lavie and Tractinsky 2004). Likewise, symbolism inference of connotative meanings associated with a human-machine instructiveness. (Tractinsky and Zmiri 2006) Furthermore, fits personality creates positive associations, represents likable things, communicates a desirable image, provides a positive pleasure enjoyment in the interaction. Joyful feelings, feelings of pleasure and gratified functionality, evaluation of system capability when performing the tasks required produces expected results when interacting with online visualised software. (Lavie and Tractinsky 2004) Based on the above functionalities and summary judgment behavioural intention on user interaction with computer specified tools specifies that users are more likely to enjoy using the tool and the higher interest to use the same tool or interface in the future with a further recommendation to a friend. (Trukenbrod, Backhaus et al. 2020)

The physiological strategies have the advantages of being able to detect changes in emotional states that cannot be measured using different methods. (Scheirer, Fernandez et al.

2002) While numerous psychophysiological measures, such as changes in, eye movement, or vocal tones, and muscular movement responsible for changes in facial expressions, can be measured through various a lot of devices, for instance, sensors, electrodes, diodes, such specifics were not considered in the study. Consequently, facial expressions are a rich source of knowledge for people to communicate their emotions. However, numerous research in psychology verified that facial expressions demonstrate a reliable association with self-reported emotions (Keltner 1995), and this attributed to physiological measures of emotion (Davidson, Ekman et al. 1990).

5.4 Proposal to address a long-term issue affecting the adaptation of online data visualization tools in multinational companies

The study has highlighted certain unmet human behaviour circumstances like facial expressions of which contributed to revealing the possible increase of stress and struggle of locating information on the dashboards of the two online visualised tools and other relevant clicks in their day to day activities. This should be considered to better address the stress, neutral and negative facial expressions in navigating on a dashboard, poor identification, unable to locate the save button on the dashboards, poor display of work tools, etc. All these need to be re-evaluated to help users a stress-free, relaxed interaction with the tools to help boost productivity.

An implication to Tableau is to concentrate on making their dashboard more colourful, with better visuals which was one of the main reasons' users preferred Microsoft Power BI, which had a much better visual and design. Moreover, a lot of the users preferred easy user identification of the available options with Microsoft Power BI and we identified that users expressed a more positive facial expression when working with Microsoft Power BI to a more neutral and negative form of expression to Tableau.

Although there was no emotional connection to the study when users were working on the various scenarios on the selected online visualized tools, there was an overall neutral reaction from users when they worked on Tableau to the more positive reaction when they were working on Microsoft power BI. Nonetheless, users gave an over visual difference for the two online tools to be revaluated to suit all forms of users better.

6 Conclusion

The main goal was to write a comprehensive literature review with an in-depth knowledge of information for the qualitative analysis of the procedure implemented in this study. However, the analysis from the finding outlined the issues hindering UX on human-machine interaction, which emphasise on the identification of the weak areas of the progress and evaluates key issues in the UX of the online visualised tools. The findings elaborated that with regards to the delay, design and aesthetics, responsiveness, ability to navigate and work, which can be attributed to the physio-psychological facial expressions of stress or positiveness to a task. However, as these factors all influence and contribute to the desire for the user to work with the tools, ensure excellent user experience, trust and recommend it to others.

All the above can be considered to propose effective measures to address such hindrances to ensure the long-term adaptation of such online data visualization tools into multinational companies.

However, the overall facial expressions exhibited a solid inter-individual unpredictability within the study as compared to works done by Staiano and Menéndez with their colleagues, which highlighted that some users had a very expressive and clear facial vocabulary. In contrast, other users had nearly no apparent variations. (Staiano, Menéndez et al. 2012)

We conclude that users perceive time and time plays an important factor in the completion of a task during an ongoing interaction with a technical device, thus integrating such evaluated measures into their UX evaluation when introducing a new device. Hence, the presented way of measuring subjectively experienced time (SXT) can be handy for UX practitioners to understand how objective the temporal characteristics of the interaction interpret into UX, particularly when designing any online tool to consider the “temporal aspects” of interactions to prompt a positive UX. (Trukenbrod, Backhaus et al. 2020)

6.1 Limitations and further research

The author of this thesis is not oblivious to the fact that this research work is limited in three ways. First, the sample size used is relatively small compared to the enormous amount of people who work with and use these online visualized tools daily. Secondly, the unwillingness of companies to cooperate to use their employees and database for the research and lastly the possibility to involve an eye-tracking device in the study.

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8 Appendix

Questionnaire on UX Experience testing of online visualization tools

By completing the questionnaire, you consent to follow.

The data will be used in a research project taken as part of an input for a Master's program in system engineering and informatics at the Czech University of Life science Prague.

1. Which category below includes your age?

- O 18-24
- O 25-34
- O 35-44
- O 45-55

2. What is your gender?

- O Male
- O Female

3. Which company do you work for?

____

4. Which of the following best describes your current occupational status?

- O Manager
- O Management position
- O Senior-level
- O Junior employee

5. What are the types of data visualized tools do you use daily at work?

- ○ Tableau
- ○ Microsoft Power BI
- ○ Other:

6. How fast do the pages load?

	○	○	○	○	○	
	1	2	3	4	5	
Very slow						Very fast

7. How long have you been using this online tool?

- ○ 1 – 3 months
- ○ 3 – 6 months
- ○ 6 months to 1 year
- ○ More than 1 year

8. Did you previously use a similar tool?

- ○ Yes
- ○ No
- ○ Maybe

9. How different is it from this current one?

	○	○	○	○	○	
	1	2	3	4	5	
Very different						Very similar

10. What features of the previous tools or current tools are you using?

____

11. Features: Do you like the features of Power BI and Tableau?

O	O	O	O	O
1	2	3	4	5

Very much Not at all

12. What is the feature that you like the most?

____

13. Scalability: Does the tool offer the possibility to go into details?

O	O	O	O	O
1	2	3	4	5

Very much Not at all

14. Is it easy to navigate through the website?

O	O	O	O	O
1	2	3	4	5

Poor Excellent

15. Do you only use the online tool or desktop version?

- O Online version
- O Desktop version (If there is one)

16. Do you use commercial tools, or do you use your own in the house?

- O Commercial tools
- O Inhouse tools

17. Evaluate the level of novelty with the tool. E.g.: To what extent do the tools perform functions that are not in excel, word, and other tools.

	O	O	O	O	O	
	1	2	3	4	5	
Poor						Excellent

18. Evaluate the level of attractiveness and display with the tool. E.g.: Display of visuals and charts.

	O	O	O	O	O	
	1	2	3	4	5	
Poor						Excellent

19. Evaluate the level of dependability with the tool. E.g.: How often will you work with this tool?

	O	O	O	O	O	
	1	2	3	4	5	
Poor						Excellent

20. How much online support with upgrades and updates influence your decision to use it?

- O More frequently
- O Less frequently
- O I do not know

21. What are the obstacles you encounter when using visualized tools? *Required to fill. E.g.: visualized

22. What is your overall satisfaction with the type of UX visualized tools you use in your works? Please describe your experience! *Required to fill