Usability Heuristics for Designing Web Dashboard

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Final Approval

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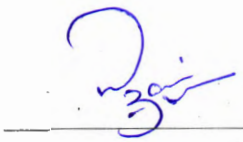

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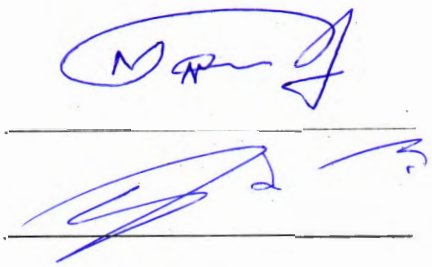

Dedication

I dedicate this work to my beloved parents and my technical advisor Muhammad Irfan who had always been so kind, encouraging and helpful. They always provided me with their utmost support in every field of my life. Their encouragement had been a great source of determination for me to achieve my goals in life.

Hira Ghaffar

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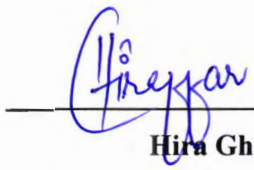
Degree of *MS Software Engineering*.

Declaration

I hereby declare that this Thesis ***"Usability Heuristics for Designing Web Dashboard"*** neither as a whole nor as a part has been copied out from any source. It is further declared that I have done this research with the accompanied report entirely on the basis of my personal efforts, under the proficient guidance of my teachers especially my supervisor *Muhammad Nasir, Salma Imtiaz*. If any part of the system is proved to be copied out from any source or found to be reproduction of any project from any of the training institute or educational institutions, I will stand by the consequences.



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Acknowledgement

"To him belongs the dominion of the Heavens and the earth, it is He who gives life and death and He has power over all things" (Al-Quran)

I would like to express my humble gratitude to ALMIGHTY ALLAH, the most merciful and compassionate who has been so kind in conferring his blessings upon me and providing me the energy, courage, quest and sanity to accomplish my responsibilities and to successfully complete this thesis.

I am really thankful to my supervisors Muhammad Nasir and Ms. Salma Imtiaz for their guidance and support. They truly encouraged me to continue this research work and overwhelmed the difficulties that I faced while completion of my research degree.

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Project In Brief

Project Title:	Usability Heuristics for Designing Web Dashboard
Undertaken By:	Hira Ghaffar
Supervised By:	Muhammad Nasir Salma Imtiaz
Start Date:	April, 2014
Completion Date:	March, 2016
Tools & Technologies	PHP, CSS, MYSQL, MS Excel, SPSS
Documentation Tools	MS Word, Adobe Reader
Operating System:	Microsoft Windows 2008
System Used:	Intel CORE i3

ABSTRACT

Context: Websites are used to communicate the information about the business on number of web pages. The most important of all the web pages is dashboard that has a single screen display. Moreover, dashboard provides critical information to the user for a particular objective. Through the study of literature, it was observed that no appropriate set of heuristics exist for designing web dashboard. **Objective:** The objective of this research study is to compose an optimal set of usability heuristics that are effective for designing web dashboard. Moreover, we need to validate this optimal set of heuristics. **Method:** In this regard, we conducted systematic mapping study to find out what heuristics for designing web dashboard already exist in literature. Later on, we categorize these heuristics into two sets i.e. Heuristic Set 1 (Common Heuristics) and Heuristic Set 2 (Common + Other Heuristics). After that, we designed an experiment in which we developed web dashboards based on both set of heuristics. For dashboard development, we made 2 teams having 1 BSSE student each. 1 team was given Heuristic Set 1 while other was given Heuristic Set 2. Later, when the dashboard is developed we evaluate the usability of that implemented dashboard with user testing. **Results:** We considered 6 usability scales i.e. Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation and Novelty. Statistical findings reveal that significant difference is observed between dashboards in case of 4 usability scales while, no significant difference is observed in case of 2 usability scales. **Conclusion:** From analysis of results, we conclude that dashboard designed with Heuristic Set 2 is better in terms of usability.

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Chapter 1: Introduction

1 INTRODUCTION

1.1 Background

Dashboard is defined as visual display for Information Visualization (Info Vis) built on Business Intelligence (BI) platform [16] to change raw data into valuable information to make decisions. The purpose of dashboard is to provide their user right information at right time. The goal is to provide useful information for gaining vision and understanding in a dataset [1].

Business Intelligence applications are consulted to gain information that contributes in making business assessments. Besides that, it gains a deeper understanding of the business and its developing forces. The benefits that can be derived from the use of business intelligence applications include quicker and easier access to information, saving time in information technology, more customer satisfaction and enhanced competitiveness of enterprises [2]. Similarly, the importance of dashboard is that it provides the most meaningful and specific information to the users with accuracy. Moreover, the benefits of dashboard includes right information at right time, better flexibility, less time, less cost, quick decision making and it reduces the workload [1,2].

User interfaces are evaluated in order to notice interaction and layout design issues [25]. In information visualization, usability problems of interface and quality of visual representation are very important [25]. Hence, we performed usability evaluation to check the quality of user interfaces [25]. We divide the usability evaluation into two major categories [26] [27]. 1) Usability Inspection 2) User Testing [26] [27].

Usability inspection is a generic name for a set of methods that are Heuristic Evaluation, Cognitive Walkthroughs, Formal Usability Inspections, Pluralistic Walkthroughs, Feature Inspection, Consistency Inspections and Standard Inspection [13][26][27]. In this method, experts analyses the user interfaces [13, 26, 27]. In cognitive walkthroughs, feature inspection and standard inspection, only single evaluator, inspect the interface at a time. Besides that, pluralistic walkthroughs, consistency inspection are group inspection methods [13, 26, 27]. However, heuristic evaluation involves group of individual evaluators to form a set of usability problems. Out of these set of assessment methods heuristic evaluation can find some usability problems more cost effectively [14]. A heuristic evaluation includes evaluators in order to inspect a system with respect to guidelines or heuristics that are appropriate for the designing

of the system. Similarly, expert heuristic evaluators found more problems than any method and predicted about half of the problems found in a usability test [14]. It can be used both in design and evaluation phases of development and can even be applied to paper based designs before the first working prototype is created [3].

Evaluation involving user testing include laboratory studies, think Aloud, cooperative evaluation, protocol analysis, post task walkthrough, interviews and questionnaires and physiological measurement [26]. While in user testing, usability problems are reported with the help of observation and user interaction [26]. In this method user perform some tasks and give their feedback about the design of the interface and its usability [26].

While heuristic evaluation has been part of the HCI set of evaluation tools for long time, it has not been utilized for evaluating dashboard to some extent. It is hard to determine which set of heuristics are best for designing web dashboard. This leads to the challenge of composing the best set of heuristics that report the most important or common dashboard issues.

Hence, the main focus of this research was to first compose a set of usability heuristics that were appropriate for designing web dashboard. Therefore, we implemented the dashboard based on the set of composed usability heuristics. Similarly, to evaluate the implemented dashboard we performed user testing. At the end, user testing of our dashboard concluded the results.

1.2 Research Motivation & Challenges

Usability heuristics are most commonly used to design the interface and to improve the user interaction with an application [4] [3] [17]. From the analysis of literature, it can be seen that there are many authors that used the heuristic evaluation technique to assess the usability of their applications. Besides that, they compare their user interface with Nielson's 10 usability heuristics [32] [6] [4]. But no exact set of heuristics or guidelines exist for designing web dashboard. Users faced a lot of problems like contrast issues, lack of information in tooltips, difficulty to perceive relationships, failure to express information, navigation issues and difficulty for users to locate relevant information [3][1][5][2]. So, in this research study we are filling this gap by composing an optimal set of heuristics that are helping the user in designing the web dashboard.

1.3 Research Questions

Q 1) What usability heuristics exist for designing web dashboard in theory?

Q 2) What is the optimal set of heuristics for designing web dashboard?

1.4 Research Contribution

Primary contribution of this research is to compose an optimal set of usability heuristics. By providing these set of heuristics, we are helping the users in designing the web dashboard. We collected the heuristics from the literature by performing systematic mapping study. These heuristics were based on information visualization and business intelligence applications. Hence, the heuristics that were commonly used for information visualization and business intelligence application are mapped in heuristic set 1 i.e. common heuristics. While, the heuristics that were not commonly used are mapped in heuristic set 2 i.e. common + other heuristics. In this research, we need to identify whether the dashboard designed with heuristic set 2 is better than the dashboard designed with heuristic set 1? Therefore, we conducted an experiment and designed two polio information web dashboards. One dashboard is designed using heuristic set 1 while other is designed using heuristic set 2. At the end, we evaluated both the dashboards from the users. The users gave their feedback which dashboard is better.

1.5 Research Methodology

1.5.1 Research Process

The research process and its diagrammatical representation are as follows:

- Research Question
- Systematic Mapping Study
- Collect Heuristics
- Develop Optimal Set of Heuristics
- Develop Dashboard
- Test Dashboard
- Perform User Testing
- Results
- Future Work

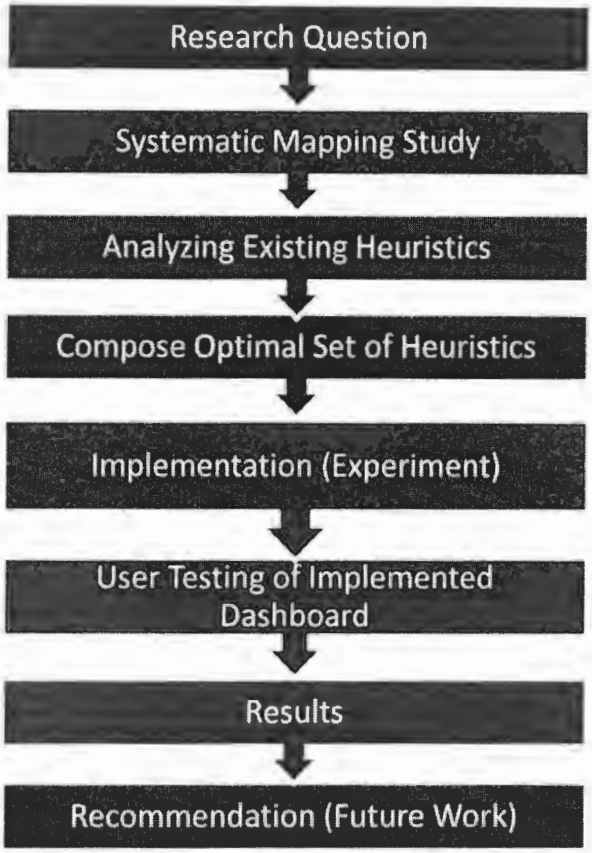


Fig 1: Research Process

1.6 Research Objective

To assess usability heuristics for designing web dashboard

a) To determine the existence of usability heuristics for designing web dashboard in theory

b) To find out usability heuristics that are better for designing web dashboard in comparison with already existing heuristics

1.6.1 Study Context

A web dashboard based on our suggested heuristics is designed. Moreover, we evaluate the usability of our test web dashboard in our experiment. It is the **formal experiment** in which we study the outcome by changing input variables to the process. We have two type of variables **dependent** and **independent variables**.

- **Dependent Variable:** The variables that help us to see the consequence of changes in the independent variable are called dependent variable [18]. Usability is the dependent variable in our experiment.
- **Independent Variable:** Manipulated and controlled variables in the process are independent variables [18]. Usability heuristics for designing dashboard and experience of the subjects are independent variables in our case.
- **Object:** Objects are the programs to be developed [19]. In our experiment objects are web dashboards design with heuristic set 1 and set 2.
- **Subjects:** Subjects are the personnel [19] and they are the undergraduate students.
- **Treatment:** The variables that would help us to see the consequences of changes in the independent variable are called factors [19]. One specific value of the factor is called treatment [19]. Set of usability heuristics is the treatment in our experiment.

1.6.2 Data Collection

The data was collected by conducting **Systematic Mapping Study** through different digital libraries. The digital libraries include IEEE, ACM, Science Direct, Google Scholar, Wiley and Springer that use usability set of heuristics for designing web dashboard.

1.6.3 Data Analysis Method

Trend analysis technique was used to analyze the data collected through systematic mapping study in different digital libraries.

1.6.4 Evaluation Method

After composing a set of heuristics after data analysis, user testing determined whether the suggested heuristics are useful in the context of dashboards or not. The user feedback will confirm the claims.

1.7 Thesis Outline

This study is organized as follows. Chapter 2 explained the systematic mapping study. Chapter 3 highlight literature and gap analysis. Chapter 4 focus on proposed solution. Chapter 5 presents research method i.e. experiment design. Chapter 6 discuss the results and analysis. Chapter 7 describes the conclusion and future work.

Chapter 2: Systematic Mapping Study

2 SYSTEMATIC MAPPING STUDY

Systematic mapping study was conducted to build a classification in the field of interest i.e. usability of web dashboard. It is very important to summarize the results if a research area in particular field matures. Therefore, Systematic Mapping Study is the method in which we go through the existing results and get an overview of the research area [21]. Systematic mapping basically arrange the results and contents of a research area into a structured category and a visual summary. Therefore, it requires less effort to overview the results [21].

2.1 Systematic Mapping Process

We have adopted the systematic mapping in our research and we detailed its process

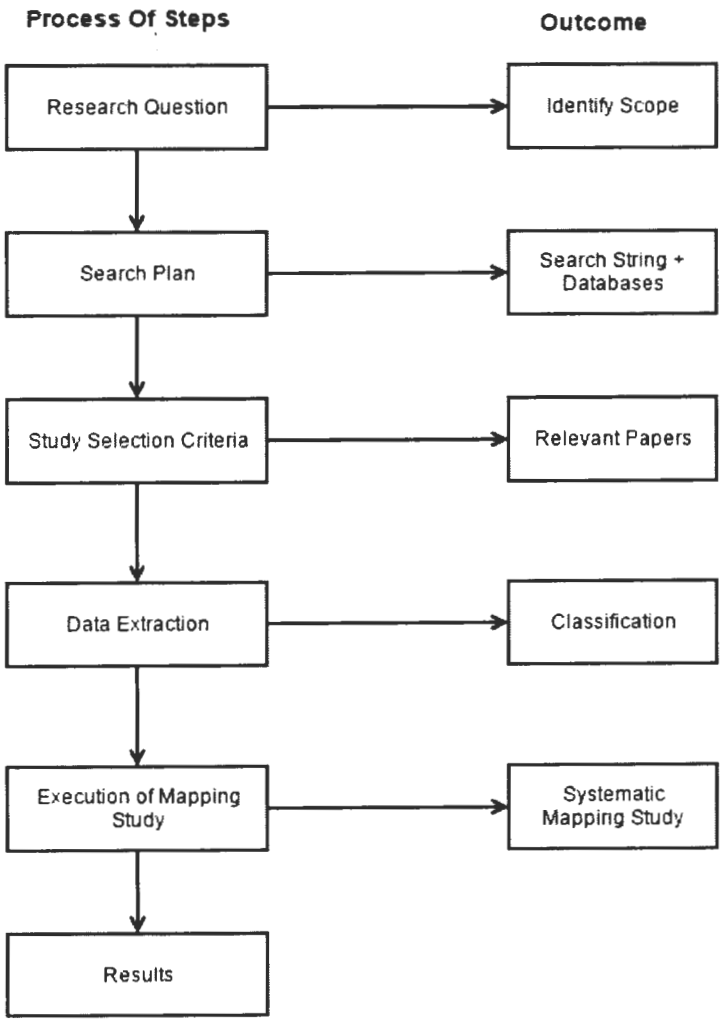


Fig 2: Systematic Mapping Process

2.1.1 Research Question (Identify Scope)

The purpose of systematic mapping study is to identify how many results are available in a particular research area and to provide overview of that results. In this mapping study, we studied the trend of publications of our research question with the frequency of time. The definition of research question focused the aim and objective of the research. The aim of this research was to determine usability heuristics for designing web dashboard. Here, is the research question due to which we have conducted this systematic mapping study.

Q: What usability heuristics exist for designing web dashboard in theory?

2.1.2 Search Plan (Search String + Databases)

First of all, we made a search string because it's very important to design the string before conducting the search. We used that search string in different online libraries i.e. IEEE, ACM, Science Direct, Google Scholar, Wiley and Springer. Through these search strings we identified our primary studies. The structure of search strings depicted the research question. A good way to create the search string is to structure them in terms of population, intervention, comparison and outcome [21]. First, we performed the pilot testing by using different search strings in different online libraries and then we got the optimal string. These search strings were applied on full papers. The following were the search strings used in different online libraries for pilot testing:

Search String Used for Dashboard

1. Usability AND (Heuristic OR Guideline) AND (Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND Dashboard
   Results: 17

2. Usability AND Heuristic AND (Guideline OR Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND Dashboard
   Results: 7

3. Usability AND (Heuristic OR Guideline OR Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND Dashboard
   Results: 11

Search String Used for Information Visualization

1. Usability AND (Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Information Visualization

   Results: 77

2. Usability AND (Heuristic OR Guideline) AND (Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND ((Data OR Information) AND Visualization)
   Results: 641

3. Usability AND Heuristic AND (Guideline OR Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND ((Data OR Information) AND Visualization)
   Results: 264

Search String Used for Business Intelligence

1. Usability AND (Heuristic OR Guideline) AND (Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND Business AND Intelligence
   Results: 39

2. Usability AND Heuristic AND (Guideline OR Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND Business AND Intelligence
   Results: 412

3. Usability AND (Heuristic OR Guideline OR Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND Business AND Intelligence
   Results: 44

Optimal String

Usability AND (Heuristic OR Guideline) AND (Review OR Analysis OR Assessment OR Evaluation OR Inspection) AND Web AND Information AND Visualization AND Business AND Intelligence

Results: 525

2.1.3 Study Selection Criteria (Relevant Papers)

We used inclusion and exclusion criteria to get only those studies that were relevant to our research question.

Inclusion Criteria	Exclusion Criteria
Studies that were relevant to web Dashboard, Information Visualization and Business Intelligence	Papers that didn't report usability heuristics w.r.t dashboard, information

	visualization and business intelligence were excluded
Only journals and conferences papers were considered	Literature that was available in presentation and idea papers were excluded. Grey literature, PhD thesis, master thesis and technical reports were not included
we considered studies from 2000 to 2014	Research articles that were not written in English language.
Studies that discussed usability heuristics for dashboard, information visualization and business intelligence were included	

Table 1: Selection of Papers

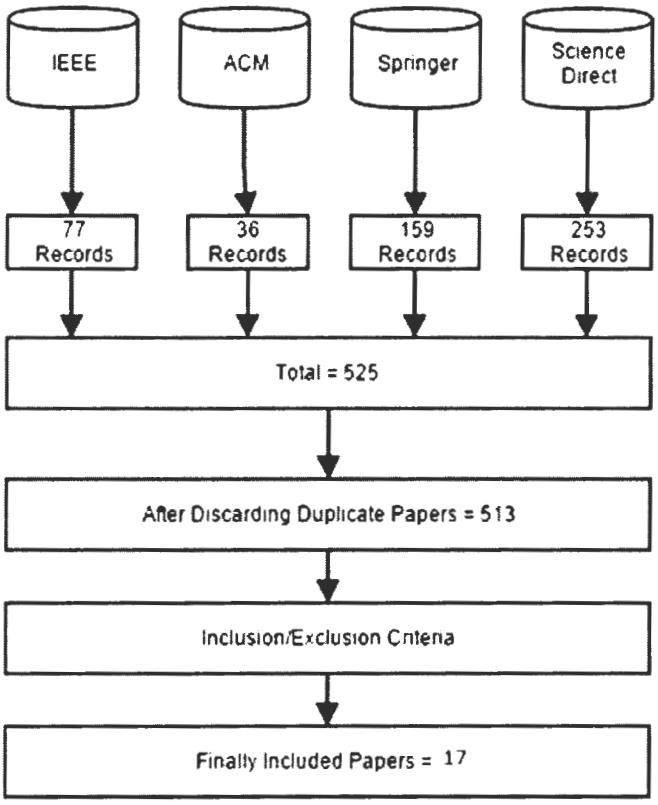


Fig 3: Selection of Papers

2.1.4 Data Extraction (Classification)

Keywording is the way to reduce the time needed in developing the classification scheme and ensuring that the scheme takes the existing studies into account [21]. In this mapping study, we reviewed the abstracts of the paper as well as the keywords. There were papers whose abstracts were short and meaningless, therefore we gone through their introduction and conclusion section.

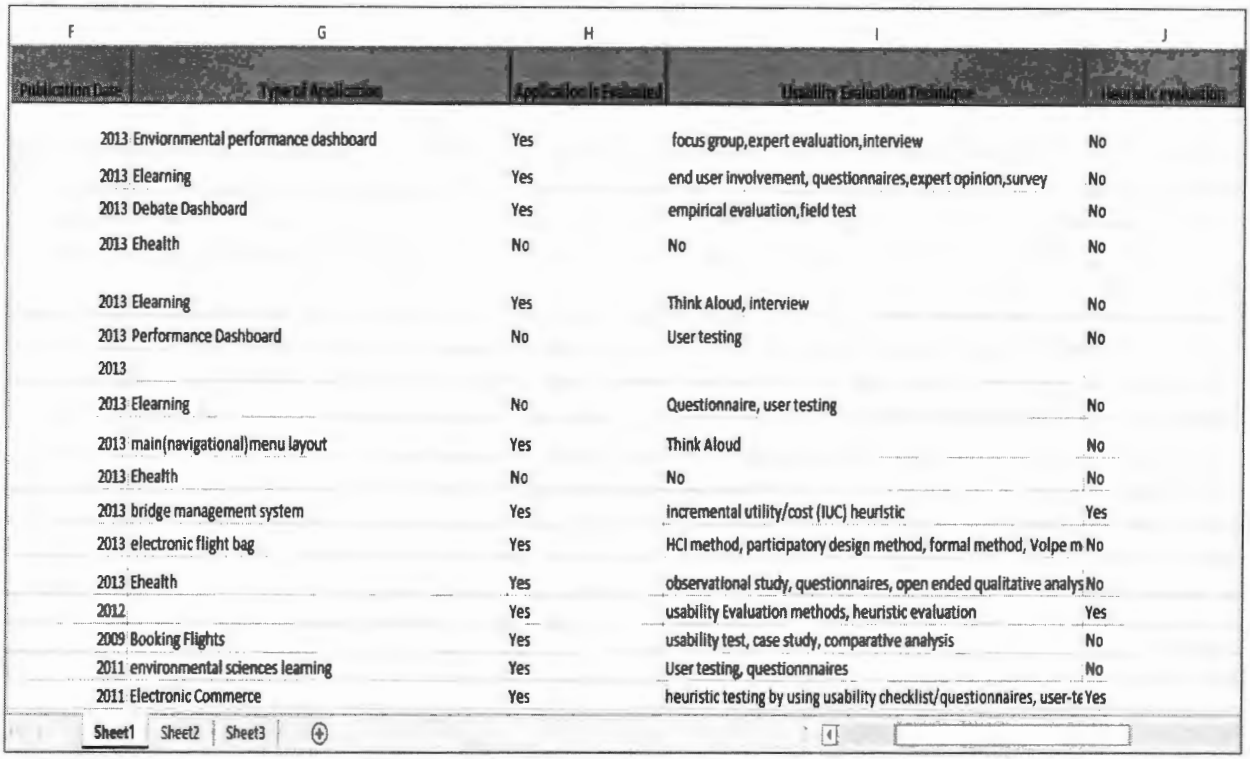
First, we need to mention the name of the article and its citation. Date of publication would show the frequency of publication with time and its trend in this area. Besides that, we had to identify which type of application was used in the article and the application was evaluated or not? If the application was evaluated than the author used which usability evaluation technique. As, the concern of our research was with heuristics, so we needed to identify which author used heuristic evaluation. After heuristic evaluation, we have to mention the list of heuristics used in that article. Moreover, we need to give the general details of the articles i.e. the paper was published in Journal or Conference, in which publisher, by which author as well as the limitations of the paper.

2.1.5 Execution of Mapping Study (Systematic Mapping Study)

We sorted only the relevant papers into the classification scheme. In order to document the data extraction process, we used MS Excel. In excel sheet, each column contained the category of the classification scheme. All the data extraction questions were used as columns in excel sheet. The screenshots of systematic mapping study are shown below:

1	Jambalaya: The Closest Visualisation Fit for the Protégé Ontology Conceptual-Relationship Tracer	2 Web-ontologies	Yes
2	Query Graph Visualizer: A Visual Collaborative Querying System	1 Web	Yes
3	USABILITY EVALUATION GUIDELINES FOR BUSINESS INTELLIGENCE APPLICATIONS	4 Web	Yes
4	Visualisation of web based e-Learning activity	2 Web	Yes
5	A task by data type taxonomy for information visualization	2923 web	yes
6	Theoratical Analysis of uncertainty visualization	75 web	yes
7	A knowledge task based framework for design and evaluation of information visualizations	150 web	Yes
8	Ergonomic criteria for evaluating the ergonimic quality of interactive system	290 web	yes
9	Guidelines for using multiple views in information visualization	539 web	yes
10	Animated transitions in statistical data graphics	184 web	yes
11	heuristic evaluation of ambient displays	426 web	yes

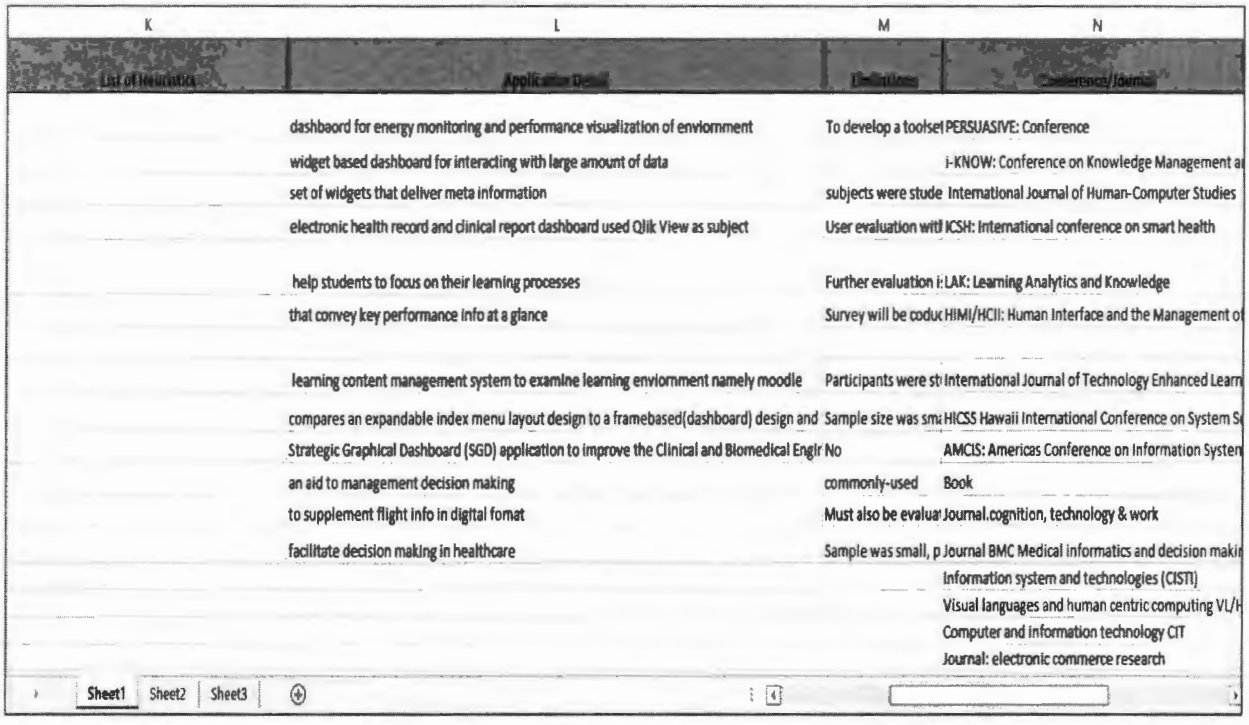
Fig 4: Screenshot 1 of Mapping Sheet



F	G	H	I	J
Publication Date	Type of Application	Application is Evaluated	Usability Evaluation Technique	Heuristic evaluation
2013	Enviornmental performance dashboard	Yes	focus group,expert evaluation,interview	No
2013	Elearning	Yes	end user involvement, questionnaires,expert opinion,survey	No
2013	Debate Dashboard	Yes	empirical evaluation,field test	No
2013	Ehealth	No	No	No
2013	Elearning	Yes	Think Aloud, interview	No
2013	Performance Dashboard	No	User testing	No
2013				
2013	Elearning	No	Questionnaire, user testing	No
2013	main(navigational)menu layout	Yes	Think Aloud	No
2013	Ehealth	No	No	No
2013	bridge management system	Yes	incremental utility/cost (IUC) heuristic	Yes
2013	electronic flight bag	Yes	HCI method, participatory design method, formal method, Volpe m	No
2013	Ehealth	Yes	observational study, questionnaires, open ended qualitative analys	No
2012		Yes	usability Evaluation methods, heuristic evaluation	Yes
2009	Booking Flights	Yes	usability test, case study, comparative analysis	No
2011	environmental sciences learning	Yes	User testing, questionnnaires	No
2011	Electronic Commerce	Yes	heuristic testing by using usability checklist/questionnaires, user-te	Yes

Sheet1 Sheet2 Sheet3

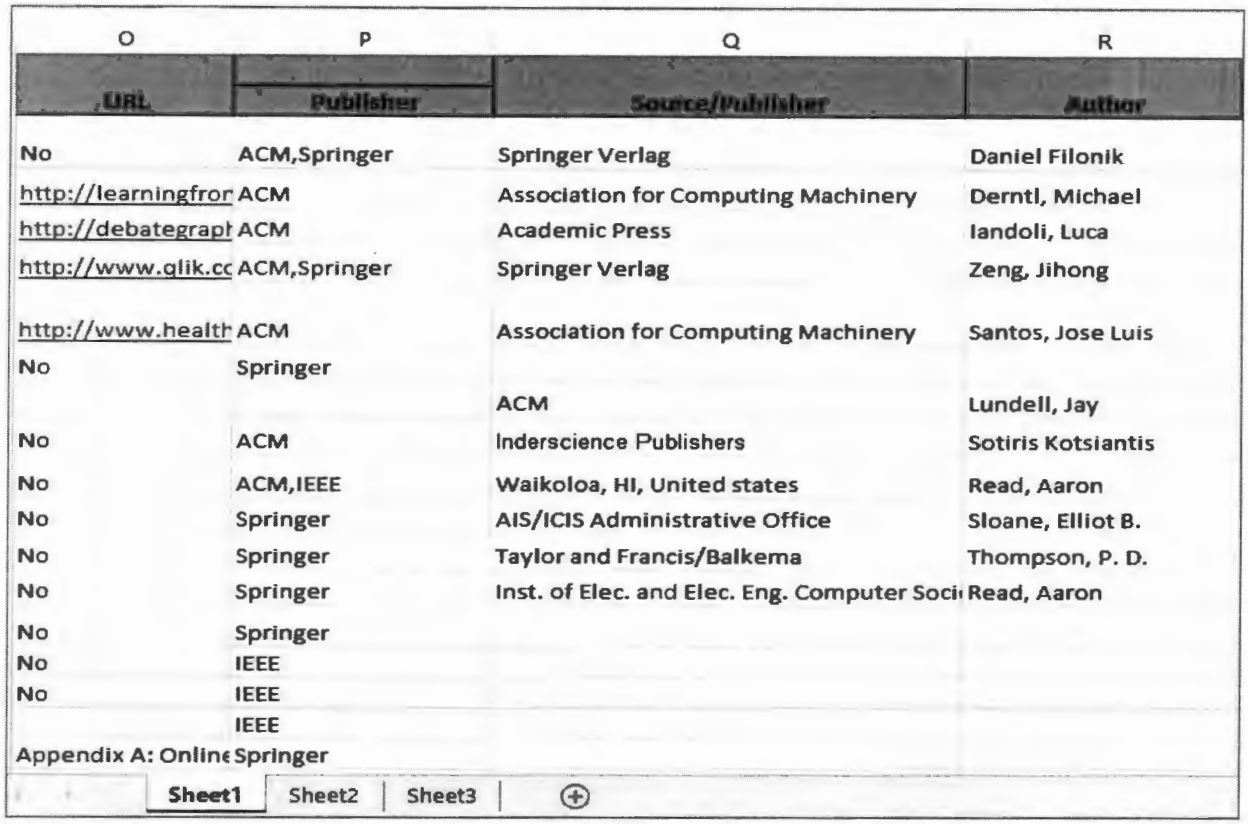
Fig 5: Screenshot 2 of Mapping Sheet



K	L	M	N
List of Heuristics	Application Detail	Limitations	Conference/Journal
	dashboard for energy monitoring and performance visualization of enviornment	To develop a toolset	PERSUASIVE: Conference
	widget based dashboard for interacting with large amount of data		i-KNOW: Conference on Knowledge Management a
	set of widgets that deliver meta information	subjects were stude	International Journal of Human-Computer Studies
	electronic health record and clinical report dashboard used Qlik View as subject	User evaluation with	ICSH: International conference on smart health
	help students to focus on their learning processes	Further evaluation i	LAK: Learning Analytics and Knowledge
	that convey key performance info at a glance	Survey will be coduc	HIMI/HCII: Human Interface and the Management o
	learning content management system to examine learning enviornment namely moodle	Participants were st	International Journal of Technology Enhanced Learn
	compares an expandable index menu layout design to a framebased(dashboard) design and	Sample size was sm	HICSS Hawaii International Conference on System S
	Strategic Graphical Dashboard (SGD) application to improve the Clinical and Biomedical Engir	No	AMCIS: Americas Conference on Information Systen
	an aid to management decision making	commonly-used	Book
	to supplement flight info in digital fomat	Must also be evalua	Journal.cognition, technology & work
	facilitate decision making in healthcare	Sample was small, p	Journal BMC Medical informatics and decision maki
			Information system and technologies (CISTI)
			Visual languages and human centric computing VL/H
			Computer and information technology CIT
			Journal: electronic commerce research

Sheet1 Sheet2 Sheet3

Fig 6: Screenshot 3 of Mapping Sheet



O	P	Q	R
URL	Publisher	Source/Publisher	Author
No	ACM,Springer	Springer Verlag	Daniel Filonik
http://learningfror	ACM	Association for Computing Machinery	Derntl, Michael
http://debategrapl	ACM	Academic Press	Iandoli, Luca
http://www.qlik.cc	ACM,Springer	Springer Verlag	Zeng, Jihong
http://www.health	ACM	Association for Computing Machinery	Santos, Jose Luis
No	Springer		
		ACM	Lundell, Jay
No	ACM	Inderscience Publishers	Sotiris Kotsiantis
No	ACM,IEEE	Waikoloa, HI, United states	Read, Aaron
No	Springer	AIS/ICIS Administrative Office	Sloane, Elliot B.
No	Springer	Taylor and Francis/Balkema	Thompson, P. D.
No	Springer	Inst. of Elec. and Elec. Eng. Computer Soci	Read, Aaron
No	Springer		
No	IEEE		
No	IEEE		
	IEEE		
Appendix A: Online	Springer		

Sheet1 Sheet2 Sheet3

Fig 7: Screenshot 4 of Mapping Sheet

2.1.6 Results

Time period selected: 2000-2014

Type of Papers: Journal, Conference and Conference Proceedings

1. **IEEE : 10**
2. **ACM Digital Library : 4**
3. **Springer : 2**
4. **Science Direct : 1**

Total Papers : 17 Results

Data Extraction Questions	Parameters	Results	%
Total Studies	All	17	100%
Relevant Studies having List of heuristics	Dashboard	1	1%
	Information visualization	14	29%
	Business Intelligence	2	4%
Type of Studies	Journal	3	18%
	Conference	14	82%
Application Evaluated		16	94%
Heuristic Evaluation		10	58%

Table 2: Systematic Mapping Results

2.2 Data Analysis

There are lot of studies available in literature that argued the guidelines for designing information visualization and business intelligence applications. Following section provides the overview of these studies and presents the existing state of art related to usability heuristics for designing information visualization and business intelligence applications. Besides that, we tried to find the limitations in these studies to contribute in the area of the study by developing the optimal set of heuristics for designing web dashboard.

2.2.1 Animated Transitions in Statistical Data Graphics by [Jaffrey Heer et al, 2007]

Due to the intuitive and engaging nature in user interface, animations has proven popular [28]. Similarly, in order to increase understanding and interactions animations may be used. In this study, Jeffrey Heer et al [28], examine the efficacy of animated transitions among common statistical data graphics such as scatter plots, bar charts, pie charts etc. To create effective transitions, author proposed the design guidelines. Ideally, the transitions would be that the viewer can understand the relation between current and previous views. Authors applied these guidelines on Dynamic Visualization. In order to determine the effectiveness of animated transitions they performed two controlled experiments. They took 24 participants for this experiment balanced across profession, age and gender [28]. The study provided strong evidence that by using our proposed design principle animated transitions can improve graphical perception of changes between statistical data graphics [28]. The subjects of this study felt that animated graphics enhanced interaction and understanding [28].

2.2.2 Usability Evaluation Guidelines for Business Intelligence Applications [Chrisna Jooste et al, 2013]

Chrisna et al. [1] develop a set of business intelligence usability evaluation guidelines for business intelligence applications. In order to extract an initial set of criteria for business intelligence applications general usability criteria were compared and contrasted with issue based usability evaluation criteria. To validate the initial set of criteria a self-reported metrics were compared from the survey and heuristic evaluations done on the same business intelligence applications. To counter the effects of self- reporting and researcher involvement a standardized questionnaire with independent data analysis was used. The questionnaire did not cover all the criteria identified in the initial set of criteria for business intelligence applications were the major disadvantage. Overall the study [1] confirmed the importance of

efficiency, effect, learnability, helpfulness and control but highlighted the focus on information architecture, reporting format and data quality. The major contribution of the study is to develop a set of business intelligence usability heuristic evaluation guidelines. Identification of issues for business intelligence usability, evaluation of applications and development of business intelligence heuristic evaluation questionnaire is the secondary contribution. Proposed set of guidelines need further verification using other evaluation methods and other business intelligence applications.

2.2.3 Heuristics for Information Visualization Evaluation [Torre Zuk et al, 2006]

In HCI, heuristic evaluation is a very well-known technique but in information visualization it has not been used to the same extent [3]. For information visualization, there are lot of heuristics that exist in literature but which heuristic is suitable for which problem is still not known. Therefore, Torre Zuk et al. [3] propose the issues of heuristic evaluation for information visualization and perform a meta- analysis on it. The issues are related to the selection, organization and process of heuristics. Three sets of already published heuristics were used to assess the visual decision support system. In this study, author applied three different set of heuristics to a single visualization and then analysed and evaluate the results. The approach provided very useful results and revealed some characteristics i.e. redundancy and conflicts. The meta-analysis shows that the evaluation process and results have a high dependency on the heuristics and the types of evaluators chosen [3]. Author argued that it may be more efficient in finding problems and suggesting solutions if we gone through different organization of heuristics and different processes.

2.2.4 An Heuristic Set for Evaluation in Information Visualization [Camilla Forsell, 2010]

Camilla Forsell et al [4] argues that there were lot of authors who have been proposed the set of heuristics for information visualization techniques. But still there is no consensus as to which heuristic address which specific visual display issues. Therefore, Camilla Forsell et al. [4] empirically proposes a new set of heuristics first time for usual and significant usability problems in information visualization techniques. Author took 6 participants who rated 63 heuristics against 73 usability problems in information visualization technique. The aim of this study was to find a set of heuristics that provided the coverage to all of the 73 problems [4]. These heuristics provides a larger coverage than heuristics that has already been proposed.

Authors suggest that for future improvement and validation these set of heuristics should be used but they don't claim that this is the final and optimal set of heuristics.

2.2.5 Jambalaya: The Closest Visualization Fit for the Protégé Ontology Conceptual-Relationship Tracer [Muthukkaruppan Annamalai, 2010]

Besides that, Muthukkaruppan et al. [5] argues that the Conceptual-Relationship Tracer (CRT) has been developed as a front end application for the Protégé ontology editor [5]. They considered three plugins: TGViz, OntoViz and Jambalaya to provide the visualization support for the CRT [5]. The objective was to conclude which plugin is best at providing the support of visualization to the CRT. This paper compares the utility and usability of candidates by using the set of visualization factors and concludes that Jambalaya is the nearest visualization fit. But, still jambalaya lacks effective support in many cases for query expressiveness [5].

2.2.6 Query Graph Visualizer: A Visual Collaborative Querying System [Dion Hoe-Lian Goh, 2008]

Popular means of obtaining information on the web are through search engines. But, the search engine and information retrieval system users faced several challenges. First, it is difficult for user to locate relevant information because of the explosive growth of web. Unable to express the information require is another major challenge. The performance of IR systems can be accomplished by the automatic query expansion or query recommending in which related queries are presented to users as alternatives to the original query by Dion et al. [2]. The study [2] describes the design and implementation of the QVG, a collaborative querying system designed to help users to formulate queries to an IR system. Evaluators who used QVG performed their tasks quicker than the evaluators who used search engine only [2]. Evaluation described the agreement that the system obeys Nielson's ten usability heuristics and recommends the visibility of using it. Author suggest that to validate our results larger scale evaluation is needed and documentation is needed to ensure that the users are aware with the features and terms of the systems.

2.2.7 Visualization of Web Based e-Learning Activity [Ana Patricia Oliveira, 2010]

Another study, Ana Patricia et al. [6] report visual methods and techniques in order to monitor the community that participates on Thinkster e-learning platform. It is a monitoring application that supports teachers to take into account the student's activity. The following research has two independent components: one for the development of prototype to allow teachers and system administrator the visualization and analysis of the user interaction, other for the

evaluation of prototype to reveal the user expectation, opinion and satisfaction related to the application interface [6]. The evaluation is based on heuristic evaluation and proposes six heuristics but these heuristics were extracted from the Nielson's 10 usability heuristics.

2.2.8 Ergonomic Criteria for Evaluating the Ergonomic Quality of Interactive Systems [Dominique L. Scapin et al, 1997]

In this study, Dominique et al [29] introduced the issues related to ergonomic dimensions in order to evaluate interactive systems [29]. Similarly, the research work conducted on the design was summarized as well as set of usability dimensions called 'Ergonomic Criteria' was assessed in this study [29]. Each individual 'Ergonomic Criteria' was discussed in detail. This paper also discussed the limitations of the method, potential users of the method, notion of ergonomic quality and differences in perspective compared to empirical testing [29]. In order to further improve the method this study also identified the issues in it.

2.2.9 Beyond Guidelines: What Can We Learn from Visual Information Seeking Mantra? [Brock Craft et al, 2005]

"Visual Information Seeking Mantra" is a remarkable development in the field of information visualization. Mantra basically guide the user to design information visualization software. 'Overview first, zoom and filter, than details on demand' of mantra explains how data should be presented on the screen to make it most effective for users [30]. The purpose of this study was to view the existing literature who refer the Mantra. The study noticed what different authors have found useful about mantra and why they site it [30]. The results indicate that there is a need for empirical validations of mantra and for method such as design patterns, to inform the holistic approach to visualization design [30]. It is analysed from the study that mantra is important for designing the tool but many authors don't specify how they use it and don't cite particular to their application [30]. The implementer who develop their new information visualization tools identify that mantra is very significant for their work while those who discuss the method and taxonomy recognize that it is only a single component in a much larger puzzle [30].

2.2.10 Guidelines for Using Multiple Views in Information Visualization [Michelle Q et al, 2000]

In this study, Michelle Q et al [31] focused on multiple views in information visualization. Multiple view systems uses two or more distinct views to support the investigation of a single conceptual entity [31]. In this study author present eight guidelines in order to design the

multiple view systems. To address the issues specific to multiple view system, author present general guidelines as well as guidelines that are more unique to multiple view system [31]. Author explain the guidelines through examples. But they cannot review all the multiple view systems due to the lack of space. The first four guidelines are for the selection of multiple views while the last four guidelines are for the presentation of multiple views. Author derived these guidelines from the analysis of existing systems and participation in CHI 98 workshop on information exploration environments.

2.2.11 An Extended Set of Ergonomic Criteria for Information Visualization Techniques [Paulo R.G. Luzzardi et al, 2004]

User interfaces are evaluated to identify the design issues while interaction with the users. Interface usability problems in information visualization is related to the expressiveness of the visual representation [32]. So, they need to be evaluated to verify how much a visualization support user's task [32]. In this study, Paulo et al [32] provided specific criteria to evaluate information visualization technique. This criteria is categorized by visual representation characteristics and usability factors [32] and it reports different aspect of issues from other published literature [32]. In this study, author conducted a case study to demonstrate the benefits of the criteria. The criteria was tailored for hierarchical information visualization and was based on two set [32]. One set for usability testing of visual representation and other for evaluating interaction mechanism [32]. Author compared the criteria with the traditional Nielson's and Bastein's sets. Results from the evaluation performed by students show that more problems are detected while using our proposed set as compared to the Nielson and Bastein's sets. Hence, the study proved that our set provided much coverage to usability problems.

			already published literature of web design					
5	Information Visualization	2006	Propose the issues of heuristic evaluation for information visualization and perform a meta-analysis on it	Case study was conducted and author applied 3 different set of heuristics to a single visualization and then analyse and evaluate the results.	Author argued that it may be more efficient in finding problems and suggesting solutions if we gone through different organization of heuristics and different processes.	Yes	Yes	[3]
6	Information Visualization	2000	Present 8 guidelines in order to design the multiple view system	Analyse the existing system	Should use other aspect of information visualization guidelines and use formal models	No	Yes	[31]
7	Animated Transitions for Visualization	2007	Investigate the effectiveness of animated transitions b/w common statistical data graphics such as scatter plots, pie charts and bar charts etc. To create effective transitions author proposed the design guidelines	Conducted 2 controlled experiment. Took 24 participants for the experiment		No	Yes	[28]
8	Visual Collaborative	2008	Implemented QVG, a collaborative query	Heuristic evaluation technique was used	The results should be validated by using	Yes	Yes	[2]

	Querying System		system to help users to formulate queries to an IR system and is evaluated with Nielsen's usability heuristics	to evaluate the usability of QVG	large scale evaluation and user should provide the document to understand the QVG features			
9	Information Visualization	2010	Reports visual methods and techniques in order to monitor the community that participates on Thinkster e-learning platform	To evaluate the application, author used analytic methods based on heuristics	Author proposed 6 heuristics but these heuristics were extracted from Nielson's usability heuristics	Yes	Yes	[6]
10	Ergonomic Criteria	1997	Introduced the issues related to ergonomics in order to evaluate the interactive systems	Experiments were conducted	In order to further improve the method this study also identified issues in it	No	Yes	[29]
11	Visual Information	2005	The purpose of this study was to view the existing literature who refer the Mantra		There is a need for empirical validations of Mantra	No	Yes	[30]
12	Ergonomic Criteria for Information Visualization	2004	Provided specific criteria to evaluate information visualization technique	Conducted case study to demonstrate the benefits of the criteria	Colour is an important attribute but it is missing in current implementation as well as results should be further evaluated	Yes	Yes	[32]
13	Heuristic Evaluation of Ambient Displays	2003	Modified the set of heuristics for ambient displays and compare	Heuristic evaluation and survey was conducted	This final set of heuristics should also be applied to other ambient displays	Yes	Yes	[34]

			this set with Nielsen's heuristics					

Table 3: Data Analysis

2.3 Gap Analysis

User interfaces are evaluated to identify design problems in the layout as well as while interaction with the user [32]. Heuristic evaluation is the most commonly used technique to assess the usability of the applications [4] [3] [17]. From the analysis of literature, it can be seen that there are many studies in which authors proposed their heuristic sets to design information visualization and business intelligence applications. Similarly, some authors compare their heuristic sets as well as user interfaces with traditional Nielson's, Bastein's and Scapin's heuristic sets. But no exact set of heuristics or guidelines exist for designing web dashboard in theory. So, the study is filling this gap by composing the set of heuristics that are helping the user in designing of web dashboard.

Concept / Reference	Visibility	Color use	Flexibility & efficiency of use	Orientation & help	Consistency & standards	Aesthetic & minimalist design	Error control & help	Learnability	Recognition rather than recall
Chrisna Jooste et al. (2013)	✓		✓	✓	✓	✓	✓	✓	
Dion Hoe-lian Goh et al. (2008)	✓		✓	✓	✓	✓	✓		✓
Torre Zuk et al. (2006)	✓	✓			✓				✓
Camilla Forsell et al. (2010)	✓		✓	✓	✓	✓	✓		✓
Muthukkaruppan et al. (2010)	✓		✓	✓	✓	✓	✓		✓

Ana Patricia et al. (2010)	✓	✓	✓			✓			
Mazlan et al. (2012)	✓		✓	✓	✓		✓	✓	
Roberto Garcia et al. (2010)	✓			✓	✓	✓	✓		✓

Table 4: Commonly referred heuristics for Information Visualization and Business Intelligence

Chapter 3: Mapping of Usability Heuristics for Web Dashboard Designing

3 Mapping of Usability Heuristics for Web Dashboard Designing

3.1 Data Collection

The data was collected by conducting Systematic Mapping Study through different digital libraries. From the study of literature, it was concluded that the heuristics for designing web dashboard doesn't exist in theory. But, there are many authors who discussed heuristics for designing business intelligence applications. Similarly, many authors proposed guidelines for information visualization. We collected all the heuristics either they were for business intelligence applications or information visualization.

3.2 Heuristic Set 1 (Common Heuristics)

As Nielson and Schneider were the founder of usability, so we took their heuristics as major category and mapped all the other collected heuristics under these categories. There were many heuristics whose meaning was same but used by different authors in different way. Hence, we mapped these kind of heuristics once under the category. The purpose of doing this was to compose an optimal set of heuristics for designing web dashboard. This optimal set of heuristics was named as Heuristic Set 1 i.e. Common Heuristics. These heuristics were used commonly while designing business intelligent applications and information visualization.

3.2.1 Matrix of Common Heuristics

Categories / Heuristics	**Nielson: Visibility of system status [35]** **Schneider: Informative feedback [36]**	**Nielson: Match btw system & real world [35]**	**Nielson: User control & freedom [35]** **Schneider: Permit easy reversal of actions [36]**	**Nielson: Flexibility & efficiency of use [35]** **Schneider: Enable frequent users to use shortcuts [36]**	**Nielson: Consistency & Standards [35]** **Schneider: Strive for consistency [36]**	**Nielson: Error Prevention [35]**	**Nielson: Help users recognize, diagnose & recover from errors [35]** **Schneider: Error Handling [36]**	**Nielson: Recognition rather than recall [35]** **Schneider: Minimize memory load [36]**	**Nielson: Help & documentation [35]**	**Nielson: Aesthetic & minimalist design [35]**
1	Immediate feedback [29]	Match user characteristics with task characteristics [29]	Undo & redo of actions [33]	Interface customization [29]	Interface for multiple views consistent [31]	Exceptions & Alerts [38]	Quality of error messages [29]	Intuitive Mappings [34]	Orientation & help [32]	Legibility [29]
2	Prompting [29]	Significance of codes [29]	Explicit user actions to initiate process [29]	User experience [29]	Consistent response rate [1]	Error protection [29]			Details on demand [33]	Useful & relevant information [34]
3		Information coding [32]	Allow extraction of items [33]	Use of acceleration keys & shortcuts	Maintain consistent interface design choices [29]	Conciseness [29]			Include annotations to help understanding [37]	
4			Design for easy							

			navigation [32]							
5			Overview, Zoom, filter [33]							
6			Control of system processing [29]							

Table 5: Matrix of common heuristics

3.2.2 Details of Common Heuristics

3.2.2.1 Category: Visibility of System Status & Informative Feedback

3.2.2.1.1 Covering Heuristics:

- Prompting
- Immediate Feedback

3.2.2.1.2 Explanation: Prompting is a way to guide the users while performing some particular tasks. When there is a possibility to make several actions, prompting will guide the user to know the alternatives depending on the context. Prompting concerns the status information of the system such as loading, updating, saving etc. Moreover, it concerns the information regarding help facility and its accessibility.

Besides that, **Immediate Feedback** is how long the system response to the actions of the user. These actions may be simple keyed entries or more complex transactions such as stacked commands [29]. Dashboard must have to provide the response along with the details on the requested transactions. These responses should be fast, appropriate and with consistent timings.

3.2.2.2 Category: Match between System and Real World

3.2.2.2.1 Covering Heuristics:

- Match user characteristics with task characteristics
- Significance of codes
- Information coding

3.2.2.2.2 Explanation: Match user characteristics with task characteristics basically concerns with compatibility of the application with its environment. User characteristics include memory, perception, age, skills, customs, expectations [29] etc. Hence, this criterion refers to the match b/w user characteristics and task characteristics as well as organization of the output, input and dialogues for a given application [29].

Moreover, **Information Coding** is the major aspect in information visualization. Perception of information would be easier if we map the data elements to visual objects. This can be improved by using realistic characteristics and additional symbols [32]. Another important aspect is the use of alternative visual attributes or object to represent information [32].

Significance of Codes: In information visualization we can present the information by using codes. These codes and names should be significant to users because the more the codes are significant the more they are easier to identify and remember. Similarly, non-significant codes may lead to errors e.g. we should use F for female and M for male rather than 1 for female and 2 for male.

3.2.2.3 Category: User control and freedom & Permit easy reversal of actions

3.2.2.3.1 Covering Heuristics:

- Undo & redo of actions
- Explicit user actions to initiate process
- Allow extraction of items
- Design for easy navigation
- Overview, zoom and filter
- Control of system processing

3.2.2.3.2 Explanation:

Undo & Redo of Actions: In order to support undo, replay and progressive refinements we should keep the history of actions. It is rare that a single user action produces the desired outcome [33]. Information exploration is a process which have many steps, therefore we should maintain the history of actions so that user can retrace their steps. Designers should design the system in such a way that users can retrieve their information and system preserve the sequence of searches rather than reflecting the current state of GUI only [33].

Allow extraction of items: System should be that it allow the users to extract their desired set of items. Moreover, when they extract their desired set they should be able to save that set into a file that would facilitate their other uses such as sending by email, printing, graphing or insertion into a statistical or presentation package [33].

The criteria **explicit user action** refers to the relationship b/w the computer processing and the user actions. This means that when user request the system to do the particular action, computer must have to process only that action. Only user should have right to initiate the process by pressing Enter rather than initiating the process as side effect (e.g. updating a file) of some other action (e.g. printing a file).

Overview, Zoom & Filter: System should be that user can gain the view of the entire collection. Dashboard interface should support this overview strategy. The overview contains a moveable field of view box to control the contents of detail view [33]. Similarly, users may show interest in some portion of the system therefore, they should be facilitate with zoom in. Moreover, system should facilitate the user to filter out uninterested items [33]. System should allow the user to filter the items that are unwanted. By filter users can control the contents of the display and quickly focus on their interest [33].

Control of System Processing: This refers to the fact that the processing of the system should always be in control of the user e.g. user can interrupt, pause, cancel and continue the system processing [29]. Every possible action by a user should be anticipated and appropriate options should be provided [29].

3.2.2.4 Category: Flexibility and efficiency of use & Enable frequent users to use shortcuts

3.2.2.4.1 Covering Heuristics:

- Interface customization
- User experience
- Use of acceleration keys & shortcuts

3.2.2.4.2 Explanation: In **interface customization** we provide the user flexible displays. When some displays are unnecessary, users should be able to remove them temporarily [29]. In other words, it is the capacity of the interface to adapt to the users particular needs [29]. While designing dashboard, we should consider the level of **user experience**. There are two type of users experienced users and inexperienced users. They both have different information needs [29]. For experienced users there should be proper dialogues and simple step by step actions. But these things may be boring for the experienced users, hence there should be shortcuts for these users so that they can do their work more rapidly. The interface should be designed to accommodate the varying levels of user's experience.

3.2.2.5 Category: Consistency and standards & strive for consistency

3.2.2.5.1 Covering Heuristics:

- Interface for multiple views consistent
- Consistent response rate
- Maintain consistent interface design choices

3.2.2.5.2 Explanation:

Interface for multiple views consistent: system should be that the interfaces as well as their states must be consistent. We must have to balance the complexity introduced by multiple view by ease of learning, which is facilitated by consistency [31]. When states are consistent their comparisons would be easier. While, inconsistent views can lead to false cognitive inferences by user [31].

Application should increase the efficiency of user through a **consistently rapid response rate** [1]. The application behaviour should be consistent [1].

Maintain consistent interface design choices: If the format, location and syntax of procedures, labels and commands are stable from one screen to other or from one session to other they would be easily identified, used and recalled [29]. Through consistent interface we can reduce the errors and facilitate the learning [29]. If we lack the consistency that means we are increasing the search time [29].

3.2.2.6 Category: Error protection & Error handling

3.2.2.6.1 Covering Heuristics:

- Error protection
- Conciseness
- Exceptions & Alerts

3.2.2.6.2 Explanation:

Error Protection: System should be that it detect and prevent error that can cause destructive consequences. It would be better to detect the errors before the validation [29].

Conciseness: This criterion concerns that more concise the items, the shorter the reading times [29]. If the items on dashboard would be concise, then the probability of making errors would be better.

Exceptions & Alerts: System should be that it provide the alert notifications to users. These alert notifications should be given to users when they make mistakes while performing some specific actions.

3.2.2.7 Category: Help users recognize, diagnose and recover from errors

3.2.2.7.1 Covering Heuristics:

- Quality of error messages

3.2.2.7.2 Explanation: The content given in error messages should be relevant, readable and specific about the nature of error [29]. If the error messages would be of good quality they will promote the learning and teach the users how they could solve their errors. Messages given in the error should not be lengthy, they should be brief and informative [29]. In error messages, don't blame the users for errors, therefore adopt the neutral wordings.

3.2.2.8 Category: Recognition rather than recall & Minimize memory load

3.2.2.8.1 Covering Heuristics:

- Intuitive mappings

3.2.2.8.2 Explanation: Display of the system should be that the users have not to remember anything. Display should add minimum cognitive load as well as display should be intuitive [34].

3.2.2.9 Category: Help & documentation

3.2.2.9.1 Covering Heuristics:

- Orientation & help
- Details on demand
- Include annotations to help understanding

3.2.2.9.2 Explanation:

Details on demand: Display should be that users can get the details of items or groups when desired or on demand. The typical approach is to simply click on an item to get a pop up window along with detail [33].

Include annotations to help understanding: There is a need to include important annotations in a dashboard i.e. title, lead in paragraph or sentence, data source call out etc. [37].

3.2.2.10 Category: Aesthetic and minimalist design

3.2.2.10.1 Covering Heuristics:

- Legibility

- Useful and relevant information

3.2.2.10.2 Explanation:

Useful and relevant information: Dashboard should include only that information that is useful and relevant to the users. Information should be specific to the nature of the application.

Legibility: We should present the information in such a way that it increase the readability of that information. It include character brightness, contrast between the letter and background, font size, interword spacing, line spacing, paragraph spacing, line length etc. [29].

3.3 Heuristic Set 2 (Common + Other Heuristics)

There were few heuristics that didn't lie under the Nielson and Schneider categories therefore, we separated these heuristics from Set 1. We arranged these heuristics under the categories made by ourselves. We gone through the details of heuristics given by their authors and mapped the same heuristics under the suitable categories. These heuristics were not commonly used. As, we needed to implement two dashboards, one with common heuristics and other with common + other heuristics. So, the participants that were given the heuristic set 2 were given both common + other heuristic matrix and their details. This optimal set of heuristics was named as Heuristic Set 2 i.e. Common + Other Heuristics.

3.3.1 Matrix of Other Heuristics

Heuristics / Coverings	Effective Transitions	Dashboard should ensure understandability	Grouping and spatial organization of layouts	Information reduction for easy observation
1	Maintain Valid data graphics during transitions [28]	Decision support [1]	Grouping/distinction of items by location [29]	Provide multiple levels of detail [3]

2	Use consistent semantic-syntactic mappings [28]	Space/time resource optimization [31]	Grouping/distinction of items by format [29]	Cognitive complexity [32]
3	Respect semantic correspondence [28]	Self-evidence [31]	Spatial Organization [32]	
4	Avoid ambiguity [28]	Information density [29]	Spatial orientation [32]	
5	Group similar transitions [28]	Sufficient information design [34]		
6	Minimize occlusion [28]			
7	Maximize predictability [28]			
8	Use simple transitions [28]			
9	Use staging for complex transitions [28]			
10	Make transitions as long as needed [28]			

Table 6: Matrix of other heuristics

3.3.2 Details of Other Heuristics

3.3.2.1 Category: Effective Transitions

3.3.2.1.1 Covering Heuristics:

- Maintain valid data graphics during transitions

- Use consistent semantic-syntactic mappings
- Respect semantic correspondence
- Avoid ambiguity
- Group similar transitions
- Minimize occlusion
- Maximize predictability
- Use simple transitions
- Use staging for complex transitions
- Make transitions as long as needed

3.3.2.1.2 Source: Heer, J.; Robertson, G.G., "Animated Transitions in Statistical Data Graphics," Visualization and Computer Graphics, IEEE Transactions on, vol.13, no.6, pp.1240, 1247, Nov.-Dec. 2007

3.3.2.1.3 Explanation: Transition means change of state e.g. a business analyst is viewing the product sales in a bar chart may want to review relative percentages by switching to pie chart or compare sales with profits in a scatter plot [28]. Therefore, dashboard should be designed in such a way that data in graphics (pie chart, scatter plot, bar chart etc.) remain valid and maintained during transitions to understand the relationship between current and previous view. Use consistent mappings to avoid ambiguity in dashboard transitions. To respect semantic correspondence syntax should not violate semantics. Similar transitions should more likely to be grouped to maximize the predictability; complex transitions should break into simple sub transitions in order to observe the multiple changes more easily. Make transitions as long as needed i.e. not too long and not too short so that they perform faster.

3.3..2.1.4 Example: This is the online CensusInfo India 2011 web portal dashboard to view aggregated demographic data from the 2011 census such as population, education etc. In first transition i.e. Fig 8 the total population size is presented in bar chart, while in other transition i.e. Fig 9 it is presented in scatter plots. In fig 8 and fig 9, relation between axis and data marks is valid and remain same in both transitions. In fig 8 and fig 9, marks that represent specific data points are not reused to depict different data points to respect semantic correspondence. In both figures, same colour and semantics are used to keep both transitions consistent. In Fig 9, the covering minimize occlusion is voilated because scatter dots occlude with eachother so they are more difficult to track and result in harming perception. In fig 8 and fig 9, transition time i.e. the change of population from bar chart to scatter plot is not too long and not too short.

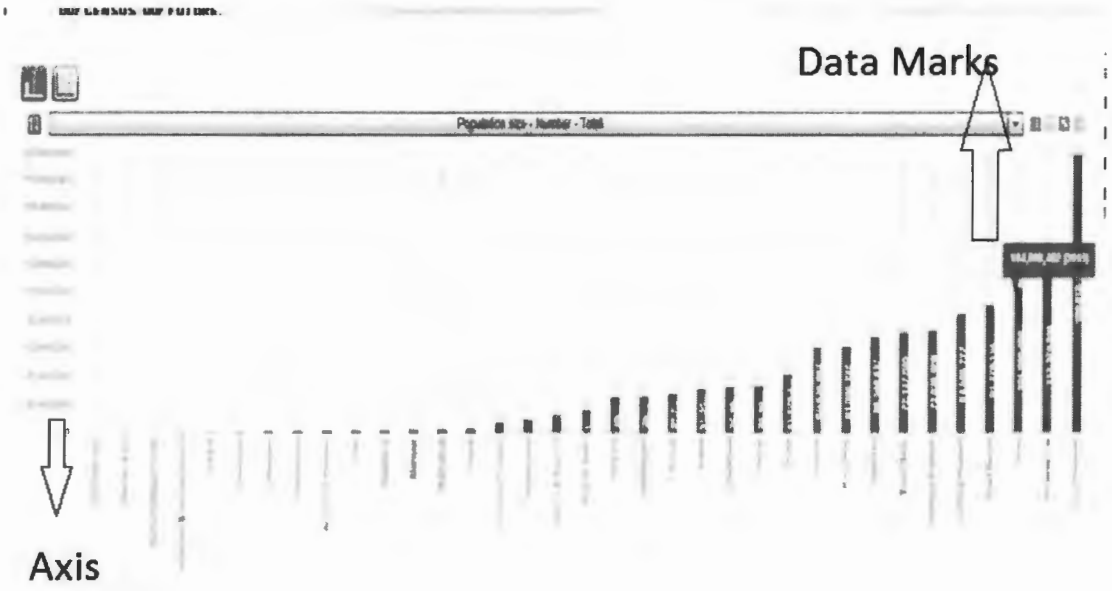


Fig 8: Bar chart of population size

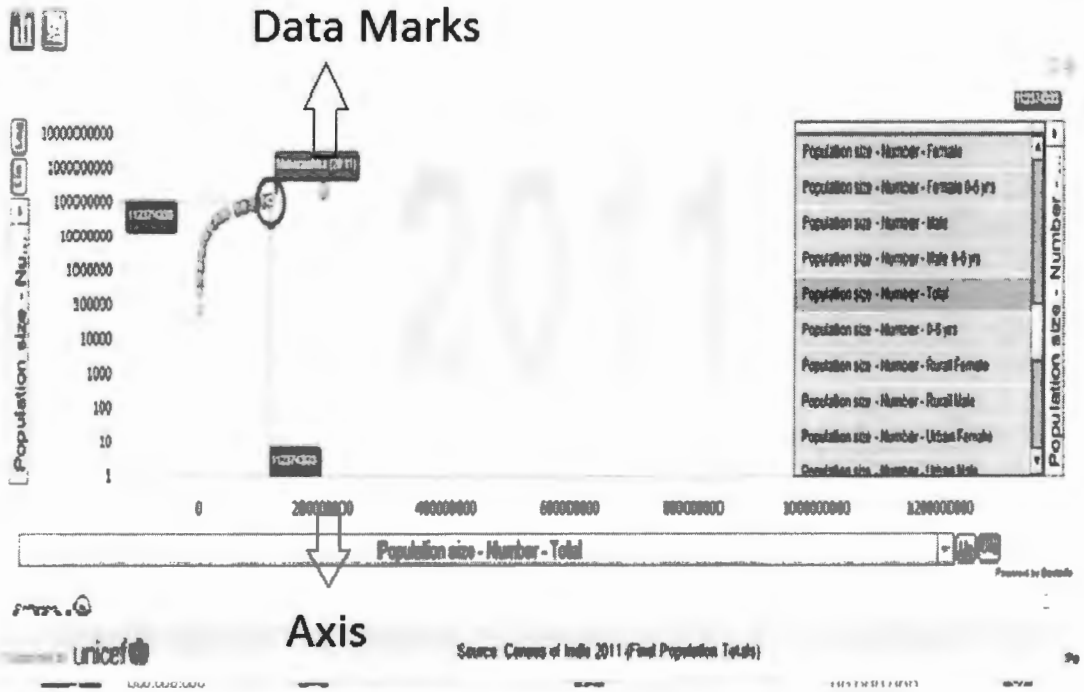


Fig 9: Scatter plot of population size

3.3.2.2 Category: Dashboard should ensure understandability:

3.3.2.2.1 Covering Heuristics:

- Decision support
- Space/time resource optimization
- Self-evidence
- Information density
- Sufficient information design

3.3.2.2.2 Source: Dominique L. Scapin & J. M. Christian Bastien, "Ergonomic criteria for evaluating the ergonomic quality of interactive system", behaviour and information technology, volume 16, pages 220-231, 8 Nov 2010.

3.3.2.2.3 Explanation: Dashboard should promote understandability of information to help the user in making decisions. Therefore, use multiple views of data to assist user in making business decisions. Multiple views should be that it takes less time and space. There are two types of views i.e. simultaneous view and sequential view. Simultaneous view could result in information overload and it can increase the density of information because the user would not be able to view all the data at once. Another disadvantage of simultaneous view is that it increase the loading time of data and takes much space. Besides that, sequential views are shown one at a time i.e. 1-day, 1-week, 1-month, 1-year etc. Moreover, sequential views takes less loading time and space because they are showing one at a time. So, use sequential views because they are likely to win over simultaneous views and result in sufficient information design. Furthermore, use self-evident relationship among multiple views to ensure understandability of information. For that, designer should use perceptual cues. Perceptual cues can be highlight, aligned and spatially arrange the information in dashboard.

3.3.2.2.4 Example 1: This is the live stock market dashboard that share market statistics, prices, global markets and others. In fig 10, the data is presented in multiple views, one view is tabular view and other view is graphical view. In this example, graphical view is helping the user in making business decision because graphs are used for decision purpose. Graphical view is sequential view and tabular view is simultaneous. 1D, 5Day, 3Month, 6Month, 1Year is used for sequential views in graph as it takes less loading time and space. If designer present the graphs simultaneously it can overload the dashboard and increase the density of information. It is designer's responsibility to decide which view should be sequential and which view should

be simultaneous. In fig 10, the perceptual cues are used in tabular view i.e. red colour for loss and green colour for profit to make the dashboard self-evident for user to increase their understanding about information.

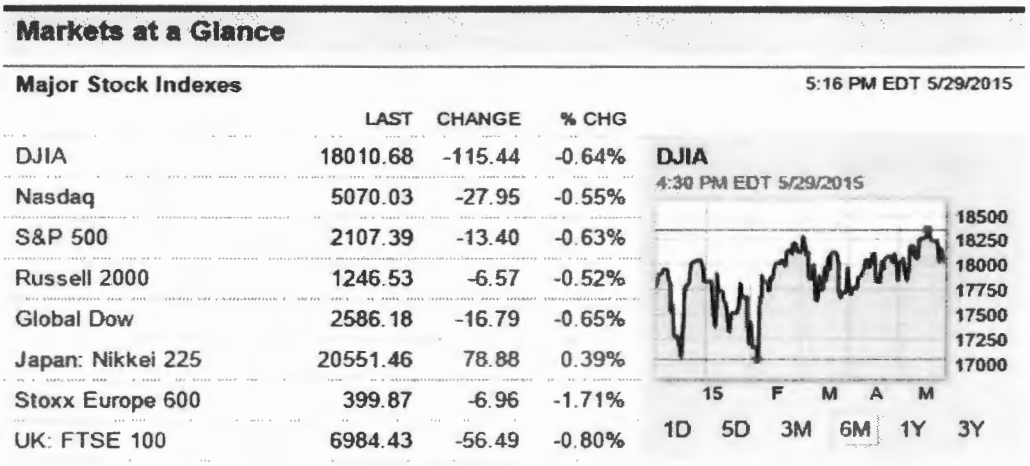


Fig 10: Multiple view dashboard

URL: http://profit.ndtv.com/market/domestic-index-nse_nifty; http://markets.wsj.com/

3.3.2.2.5 Example 2: In order to support user in making decisions, display the data in comparison charts and graphs that reveal trends. In fig 11, multiple views in dashboard are used to present the data to assist user in making business decisions. One view is numeric view and other view is graphical view. 1D, 1M, 3M, 6M, 1Y is used for sequential view and it takes less loading time and less space. In this dashboard if designer present the graphs simultaneously than, dashboard became overload and increase the density of information. Therefore, sequential view results in sufficient information design. In this dashboard, the perceptual cues are used in numeric view i.e. red colour for loss and green colour for profit to make them self-evident. Red colour means negative points and green colour means positive points to increase user understanding about the information in dashboard.

Fig 11: Multiple view dashboard

3.3.2.3 Category: Grouping and spatial organization of layouts

3.3.2.3.1 Covering Heuristics:

- Grouping/distinction of items by location
- Grouping/distinction of items by format
- Spatial Organization
- Spatial Orientation

3.3.2.3.2 Source: Dominique L. Scapin & J. M. Christian Bastien, "Ergonomic criteria for evaluating the ergonomic quality of interactive system", behaviour and information technology, volume 16, pages 220-231, 8 Nov 2010.

P.R.G. Luzzardi, C.M. Dal Sasso Freitas, R.A. Cava, G.D. Duarte, and M.H.S. Vasconcelos, "An extended set of ergonomic criteria for information visualization techniques", from proceeding(426) computer graphics and imaging, 2004.

3.3.2.3.3 Explanation: In dashboard, the overall layout and distribution of information elements should be in such a way that it follows the logical organization. Grouping and organization of information in dashboard will improve the readability of layouts that eventually leads to better guidance. If items are presented in spatial organization or group by location, it will be easier to locate the information element in a display mode and indicate whether or not

they belong to same or different class. Grouping/distinction of items by location and spatial organization concerns the presentation of items in alphabetic order, logical order and frequency of use [29]. Similarly, grouping/distinction of items by format concerns more specifically to the graphical features i.e. colour and format [29]. Besides that, spatial orientation concerns organization of items according to the reference context or its environment.

3.3.2.3.4 Example 1: This is the trading economy dashboard and is showing the monthly and annual increment/decrement in Pakistani Currency. In fig 12, similar items of Market, GDP, Labour, and Prices etc. are grouped according to the location and in spatially organized manner i.e. logical order. Logical order means all the items that are related to labour are grouped under one main heading of Labour. While, the sub items of heading labour are arranged alphabetically. This organization of items is helping the user to locate the information elements more easily and quickly.

URL: http://www.tradingeconomics.com/pakistan/currency

Fig 12: Grouping/distinction by location & spatial Organization

3.3.2.3.5 Example 2: In fig 13, items i.e. Company Info, Market Reports, Technical Analysis and Company Financials are presented in spatial organization and group according to the location (logical order). All the financials i.e. cash flow, balance sheet etc. are grouped in logical order under the Company Financial heading. This grouping and organization is guiding

the user to locate the relevant information more effortlessly and rapidly as well as increasing the readability of layout.

http://www.investmentguruindia.com/Derivatives_Dashboard.aspx

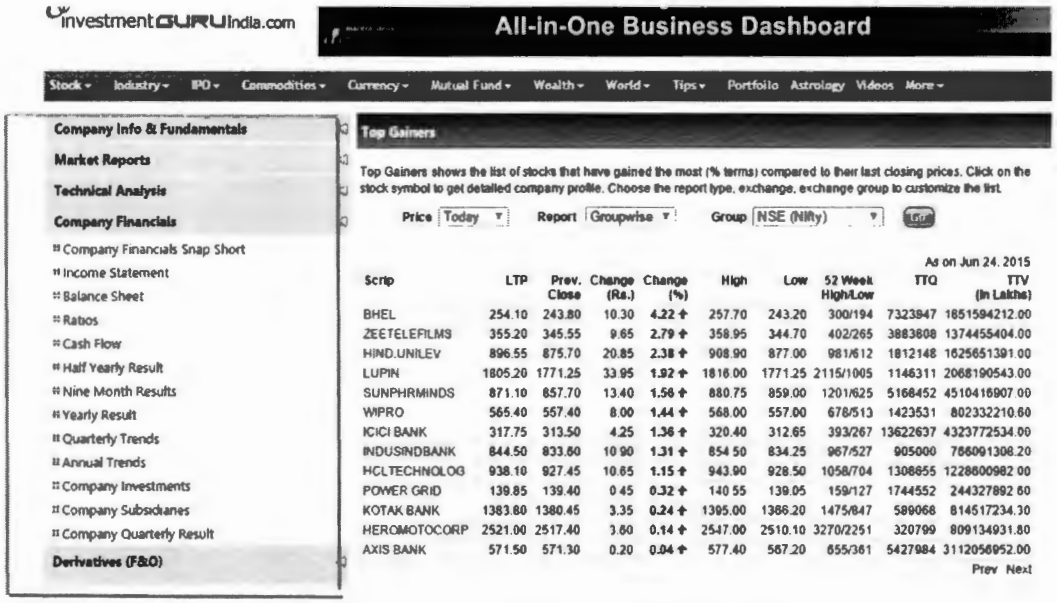


Fig 13: Grouping of items by spatial organization

3.3.2.3.6 Example 3: Fig 14 presents grouping/distinction of items by format i.e. colour. Each item is presented by specific colour in different areas to provide clear visual distinctions to user. In pie chart, bar chart and line chart Donald duck, Mickey, Minnie and others are presented by same colour everywhere. This type of grouping/distinction will help the user to learn and remember the items more easily that eventually leads to better guidance.

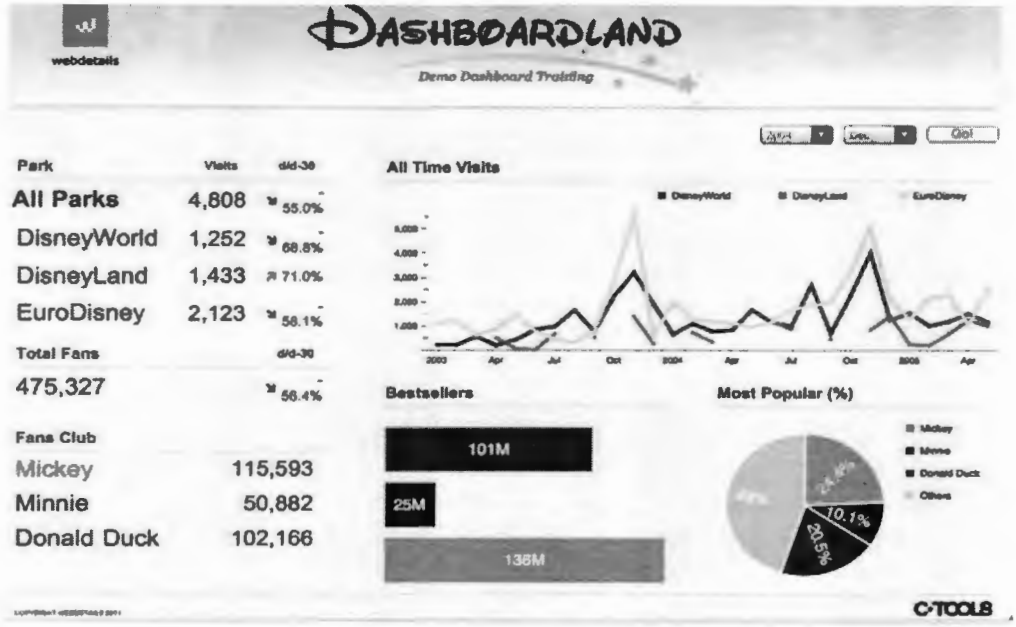


Fig 14: Grouping/distinction by format

3.3.2.3.7 Example 4: In fig 15, executive dashboard of sales presents both grouping/distinction of items by location (logical order, alphabetic order) as well as grouping/distinction of items by format (colour). Items in drop down i.e. year, customer region and product category are organized spatially and according to the location i.e. (logical order). Moreover, sub items in drop down i.e. furniture, supplies and technology are grouped under product category heading and in alphabetic order. Besides that, there is clear visual distinction between products that sale on profit and products that sale on loss. Product furniture is presented by red colour in 'sales by product category' graph that means loss. Moreover, products that sale on profit are presented by blue colour. This layout is increasing the readability of dashboard by grouping the products in some order and distinguishing the products by specific colours.

http://www.tableau.com/solutions/business-dashboards

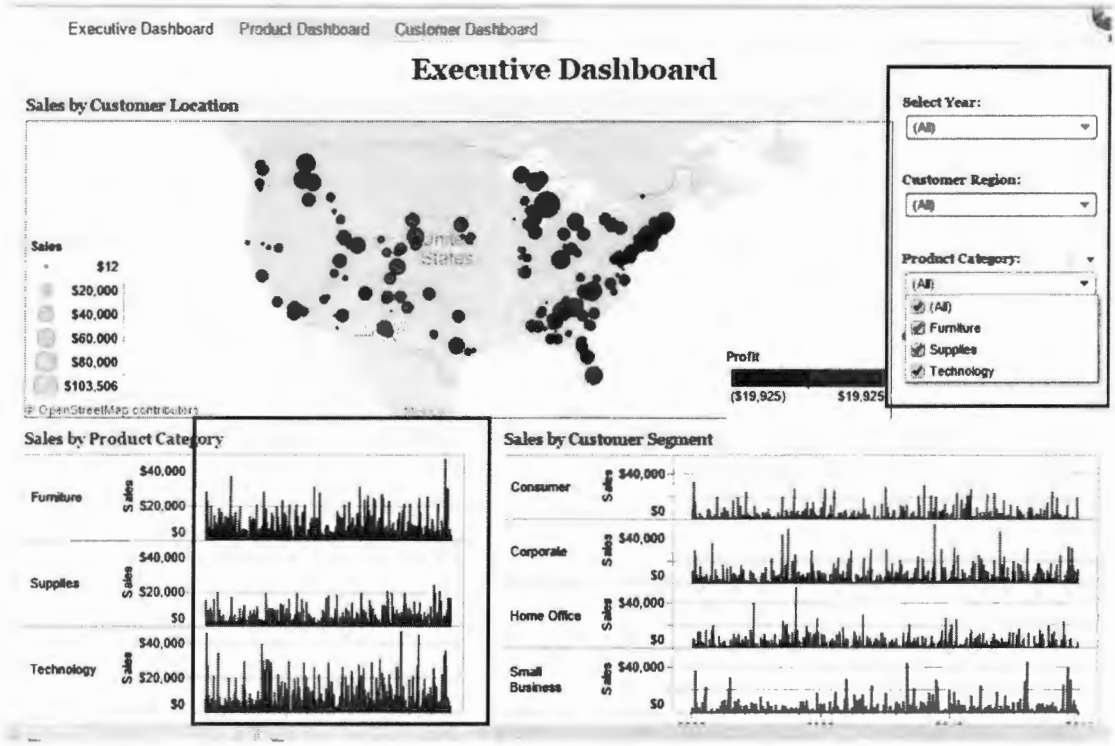


Fig 15: Grouping/distinction of products by colour & format

3.3.2.4 Category: Information reduction for easy observation

3.3.2.4.1 Covering Heuristics:

- Provide multiple levels of detail
- Cognitive Complexity

3.3.2.4.2 Source: Torre Zuk, Sheelagh Carpendale, "Theoretical Analysis of Uncertainty Visualization", proceeding of visualization and data analysis, 16 Jan 2006.

P.R.G. Luzzardi, C.M. Dal Sasso Freitas, R.A. Cava, G.D. Duarte, and M.H.S. Vasconcelos, "An extended set of ergonomic criteria for information visualization techniques", from proceeding(426) computer graphics and imaging, 2004.

3.3.2.4.3 Explanation: As all of the data may not be important equally, so the information reduction is required in dashboard to present only relevant and selected information. Therefore, we need to present the information in hierarchy or multi levels to reduce the cognitive complexity of the user. Cognitive complexity concerns how easy and complex the presentation

of information is. Hence, information visualization hierarchy corresponds to multiple level of data elements. In dashboard, multiple levels or hierarchy of detail should be provided to the user rather than presenting all the detail at once. Hierarchy or multi levels should be that it promote quick and easy observation.

3.3.2.4.4 Example 1: This is the online CensusInfo India 2011 web portal dashboard to view aggregated demographic data from the 2011 census such as population, education etc. In fig 16, hierarchy or multi-level detail is used to present all the information on dashboard and to reduce the cognitive complexity of user because it is not possible present this all at once. Hence, total population is divided into demography and education, demography has further sub levels i.e. area, population density, population size etc. Third level present population size of male, female, total, urban and rural population. However, total, urban and rural population is presented in individual bar charts. This hierarchy is helping the user in quick observation of dashboard.

URL: http://censusindia.gov.in/2011census/censusinfodashboard/index.html

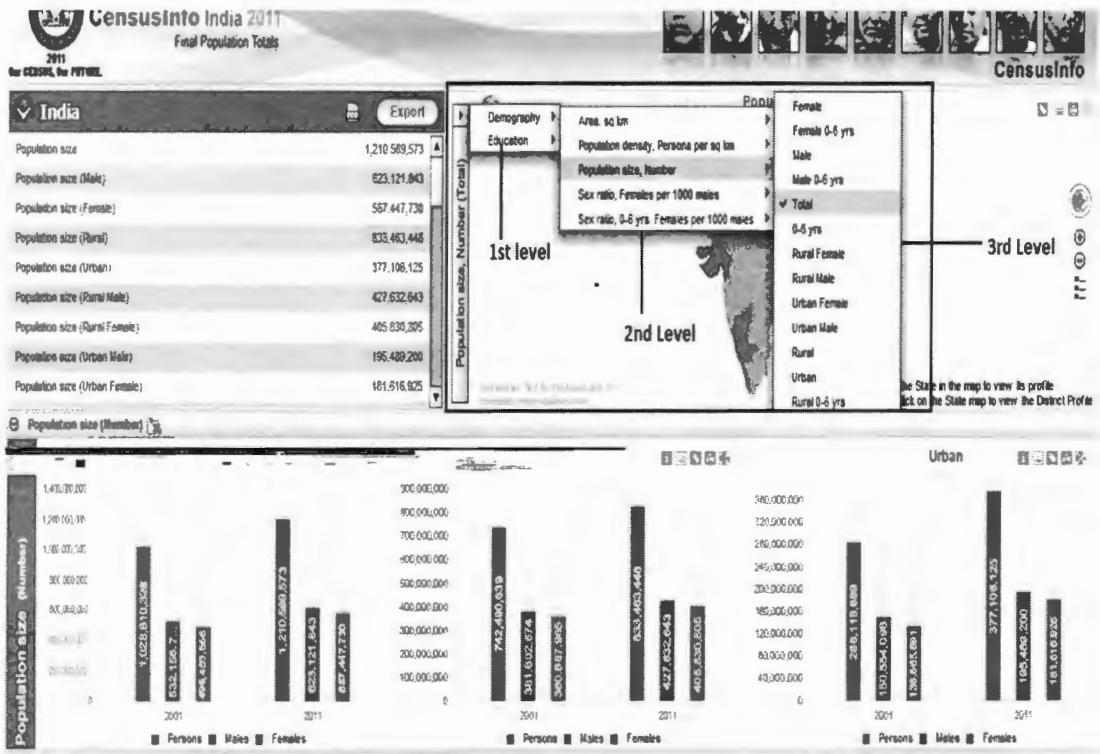


Fig 16: Information Reduction in dashboard

3.3.2.4.5 Example 2: In fig 17, dashboard is presenting the items in a hierarchy or multi-levels to reduce the information and cognitive complexity of the user. The purpose of information reduction is that it is impossible to present all the data at once so, we need to present them in a hierarchy. Item Commodities is the first level in below screen shot and it has second level i.e. Live Stats and Live Analysis. Live stats and Live Analysis has further 3rd level of information. This hierarchy is promoting quick and easy observation.

http://economictimes.indiatimes.com/marketstats/pid-112,pageno-1,sortorder-desc,sortby-spread.cms

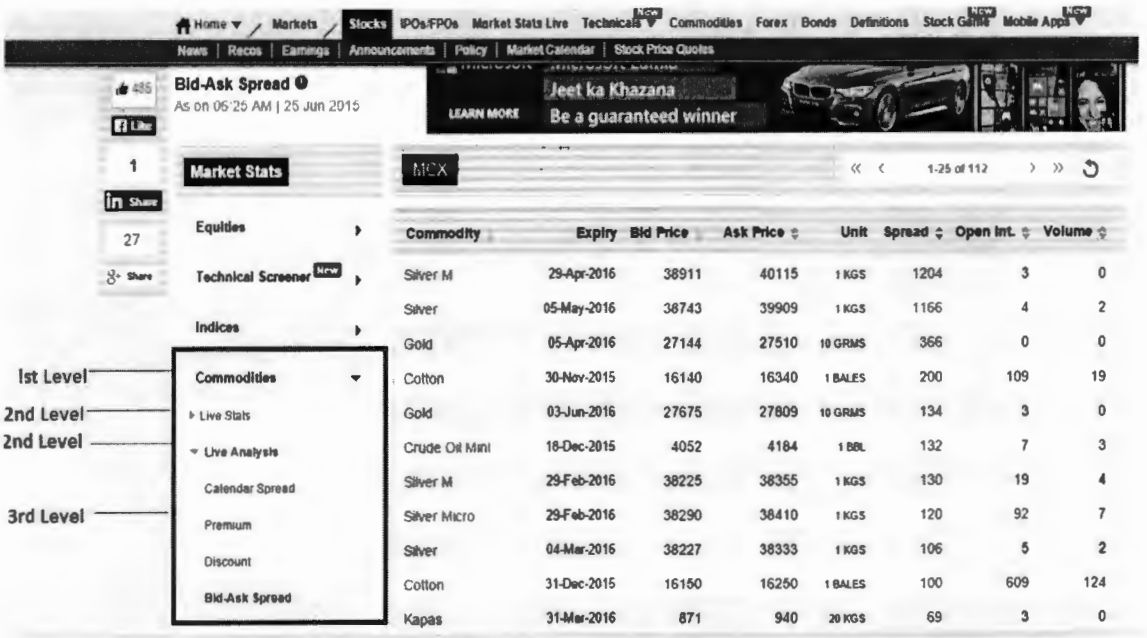


Fig 17: Information Reduction

Chapter 4: Experiment Design & Implementation

4 EXPERIMENT DESIGN & IMPLEMENTATION

4.1 Experiment Definition

The purpose of definition phase is to define the goals of experiment in terms of the defined framework

4.1.1 Goal

Goal is needed to define the important aspects of the experiment before the planning and execution phase of the experiment. The goal is defined according to the framework

"Analyse the dashboards implemented with heuristic set 1 and heuristic set 2 with respect to usability from the point of view of the participants of user testing"

The objective of this empirical study is to determine the differences between two dashboards implemented with two different set of heuristics. Similarly, the experiment is motivated by a need to understand the variances in each set of heuristics in terms of usability within the dashboard.

4.1.2 Definition framework

Object of Study	Purpose	Quality Focus	Perspective	Context
Polio Information web dashboards designed with heuristic set 1 and heuristic set 2	Evaluation	Usability on following scales i.e. Attractiveness, Perspicuity, Dependability, Efficiency, Stimulation and Novelty	Participants	1. Size and complexity of dashboard 2. Experience, Team Size and workload of participants

Table 7: Definition Framework

4.1.2.1 Object of study:

Entity is the object which we are going to study in our experiment. Polio information web dashboard designed with heuristic set I and set 2 is the object that is studied in the experiment.

4.1.2.2 Purpose:

Purpose concerns with the intention of the experiment. Our intention is to evaluate the impact of two different set of heuristics on the polio information web dashboard.

4.1.2.3 Quality Focus

When we evaluate the dashboard with two different set of heuristics, it effect the usability and its scales. This effect is basically the quality focus.

4.1.2.4 Perspective

The experiment results are interpreted from the participant's point of view. This viewpoint is the perspective from which the results of experiment are interpreted.

4.1.2.5 Context

Context is the environment in which the experiment is run along with the subjects and objects characteristics. We need to select two BS Students randomly from the same session, having good understanding in PHP and CSS and will give them task to implement the dashboard of polio information domain. Both students will be given the dashboard of same size and same complexity. After the implementation, we need to evaluate both the dashboards. Traditional testing is the environment in which we evaluate them.

4.2 Experiment Planning

After the definition, planning phase of the experiment takes place. The definition phase defines why this experiment is conducted while the planning phase describes how this experiment is conducted? In order to control the experiment, there must be the plan of the experiment. If the experiment is not properly planned, than the results can be disturbed or destroyed. The problem due to which the experiment is conducted is as follows:

"We want to determine the effect on usability and its scales when using two different set of heuristics on the polio information web dashboard"

4.2.1 Hypothesis Formulation

In the planning phase of the experiment, goals are translated into hypothesis. Hypothesis is stated formally and we can draw conclusions from it, if they are rejected. Two hypothesis have to be formulated i.e. null hypothesis and alternative hypothesis. Null hypothesis H_0 assumes that there is no significant difference between two treatments with respect to the dependent variables [24]. While, alternative hypothesis H_1 assumes that there is a significant difference between two treatments with respect to dependent variables [24].

Hence, the goal and hypothesis related to this experiment is as:

"Analyse the dashboards implemented with heuristic set 1 and heuristic set 2 with respect to usability for the purpose of evaluation from the point of view of the participants of user testing"

H_0: 'There is no significant difference between dashboards implemented with heuristic set 1 and heuristic set 2 in terms of usability'
H_1: 'There is significant difference between dashboards implemented with heuristic set 1 and heuristic set 2 in terms of usability'

Table 8: Hypothesis Formulation

4.2.2 Variables Selection

In variable selection, we have to select dependent and independent variables before the design of experiment starts. Those variables that we can change and control in our experiment are independent variables while in dependent variables we can measure the effect of changes [24]. It is not the easy task to choose the right variables because it requires lot of domain knowledge. Independent variables will be usability heuristics set 1 (based on common heuristics) and set 2 (based on common + other heuristics) for evaluating web dashboard as well as experience, team size and workload of subjects. Similarly, usability along with its scales i.e. attractiveness, dependability, perspicuity, stimulation, efficiency and novelty will be the dependent variable.

4.2.3 Pilot Study

Before executing the real experiment, a pilot study is conducted to assess whether the details given in the heuristics document are understandable and necessary enough for the layman. 6 BS level students of SE are requested to participate in pilot study. The outcome of pilot study suggested some changes in details of heuristics. After discussion, we considered some of the changes while few of them are not necessary and irrelevant. In some guidelines, participants are not satisfied with the given examples. They wanted more examples for better understanding. Therefore, we added more examples in the details of heuristics.

4.2.4 Selection of subjects

While conducting an experiment it is important to select the subject. Selection of subject is also called selection of sample from population [24]. In order to generalize the results to the desired

population, the selection must be representative for that population [24]. Choice of sample size from population may affect the analysis of results in experiment.

For implementation, we planned to select 2 students from BSSE degree of same session having good understanding in PHP and CSS. While, for user testing we will select 30 students of BSSE degree of same session. We planned to select the students randomly. In order to remove the biasness, we will not implement the dashboards by ourselves.

3.2.5 Object Selection

Objects are the programs to be developed. In this experiment, object will be polio information web dashboard and will be implemented by the subjects. We will implement 2 web dashboards. 1 will be implemented using heuristic set 1 while, another will be implemented using heuristic set 2. The experiment plan diagram is shown below:

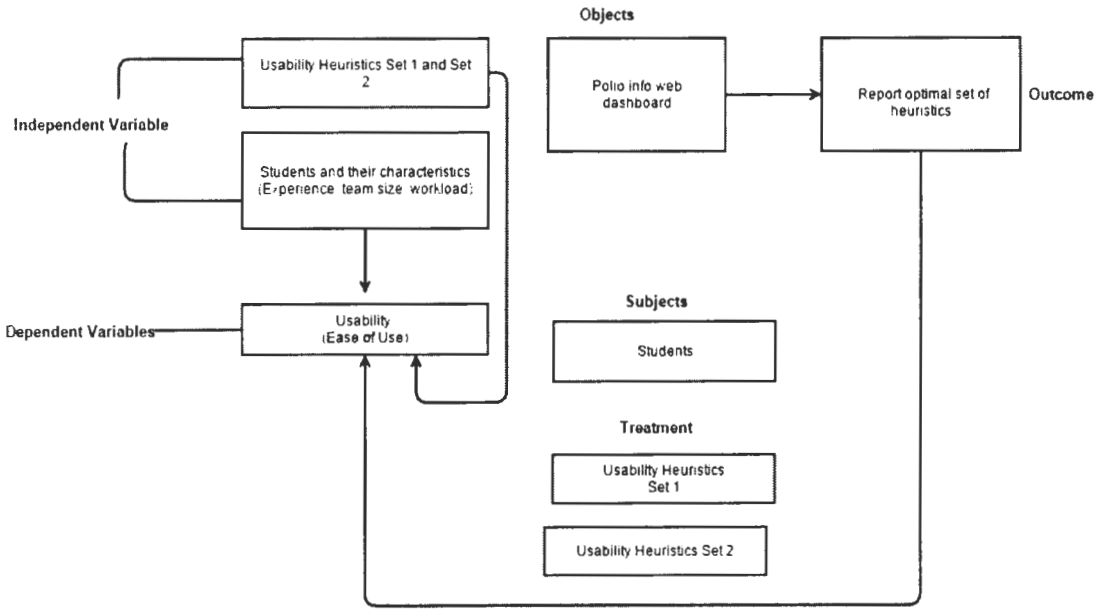


Fig 18: Experiment Plan

4.3 Experiment Design

4.3.1 General Design

In this experiment, subjects will be selected randomly as well as assignment to each treatment i.e. heuristic set 1 and heuristic set 2. We will arrange the subjects into groups i.e. Group A and Group B and each group will have 1 participant. Group A will be given the heuristic set 1 while

Group B will be given the heuristic set 2. Both groups applied their given set of heuristic to the object i.e. polio information dashboard while implementation.

Besides that, in evaluation of both the dashboards we will again make 2 groups. Group A will have 15 random participants and will be given the dashboard implemented with heuristic set 1 while, Group B will also have 15 random participants but will be given the dashboard implemented with heuristic set 2. Both groups will evaluate them according to their observations in terms of usability and its scales i.e. Attractiveness, Perspicuity, Dependability, Efficiency, Stimulation and Novelty.

4.3.2 Design Type

In this experiment, we have one factor (Usability Heuristics) and two treatments (Usability Heuristic Set 1 and Set 2) therefore, we used **"One Factor Two Treatment"** design type. We want to compare the two treatments against each other [24]. The aim of this experiment is to investigate the dashboard implemented with heuristic set 2 is much better than the dashboard implemented with heuristic set 1. In this design, both the participants will apply the set of heuristics given to them to the dashboard while implementation and it is a completely randomized design. Similarly, in evaluation both groups will be given the different dashboards implemented with two different set of heuristics.

Participants	Usability Heuristic Set 1	Usability Heuristic Set 2
Group A	✓	
Group B		✓

Table 9: Completely Randomized Design

4.4 Implementation

After the experiment is planned, we need to implement the dashboards based on the composed set of heuristics.

4.4.1 Subject Selection

For implementation of polio information web dashboards, we made 2 groups having 1 participant each. For that, we selected 2 random BSSE degree students of same session i.e. 8th semester. Group A was given the heuristic set 1 while group B was given the heuristic set 2. As, the students were selected randomly so, we were totally unaware about their intuitive thinking and intellectual abilities. After selection, a presentation regarding the domain of the object was given to them by our supervisor. It was about 1 hour presentation, in which they

were given the necessary details and requirements of the domain system i.e. polio information web dashboard. In order to remove the biasness, we didn't implement the dashboard by ourselves. The requirements to implement the dashboard is given in Appendix.

4.4.2 Object of Study

Polio information web dashboard was an object of this experiment. Polio is a very critical and merging issue in Pakistan and there is no dashboard on web which shows the polio situation of Pakistan. We tried to present the dashboards as same as the polio campaigns are working in the real environment.

2 random participants were selected to implement the object. Both the participants implemented the dashboard using PHP, CSS as a programming language and PHP MyAdmin as database. We gave the participants 2 different set of heuristics along with their details. They were also given the requirements of polio information dashboard in a presentation. Every participant must had to fulfil the requirements of the dashboard. They were insisted not to miss any single heuristic. The time duration of this implementation was about 1 month. Every participant must had to complete the implementation within the time duration. The requirements to implement the dashboard are given in Appendix.

When the implementation was completed, we tested both the dashboards thoroughly and reported the bugs and issues to participants so that they could fix them. After the fixing of bugs, we deployed the dashboard to the URL i.e. www.itestbuddy.com/poliodashboard . The advantage of deploying to URL was that we have not to configure the dashboards in every computer of user while the user testing of that dashboards. The screenshots of both the implemented dashboards are shown below:

Fig 19: Dashboard Implemented by Group A using Heuristic Set 1

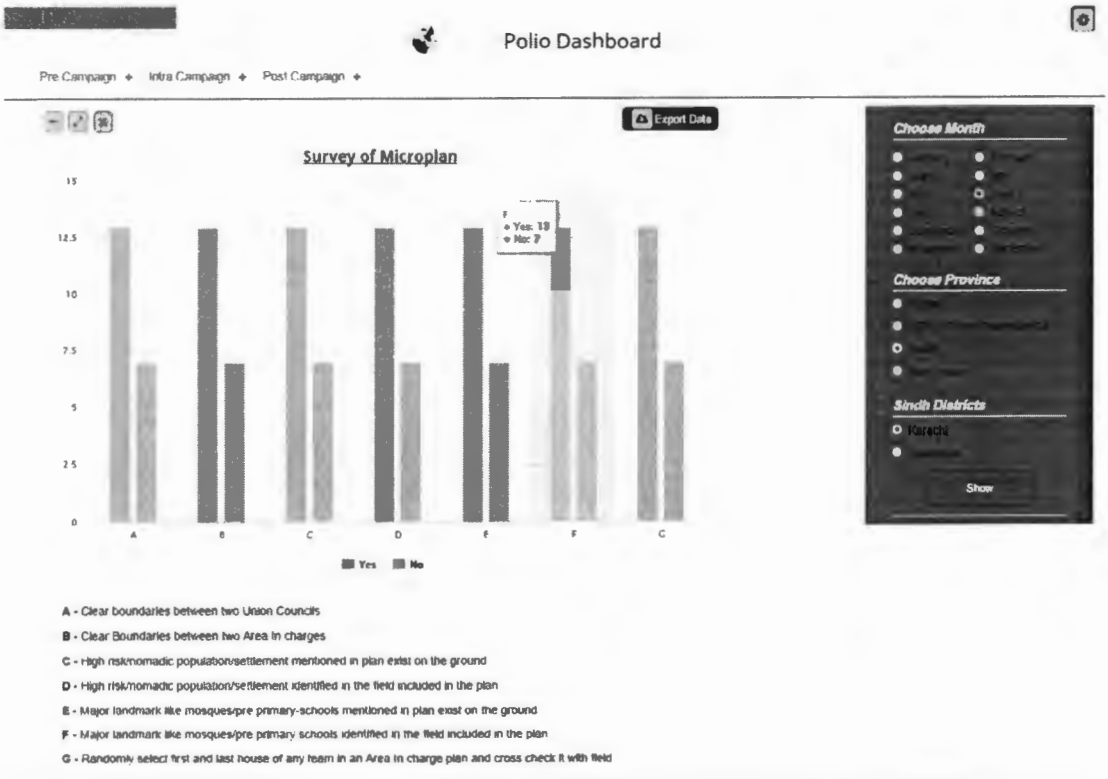


Fig 20: Dashboard Implemented by Group A using Heuristic Set 1

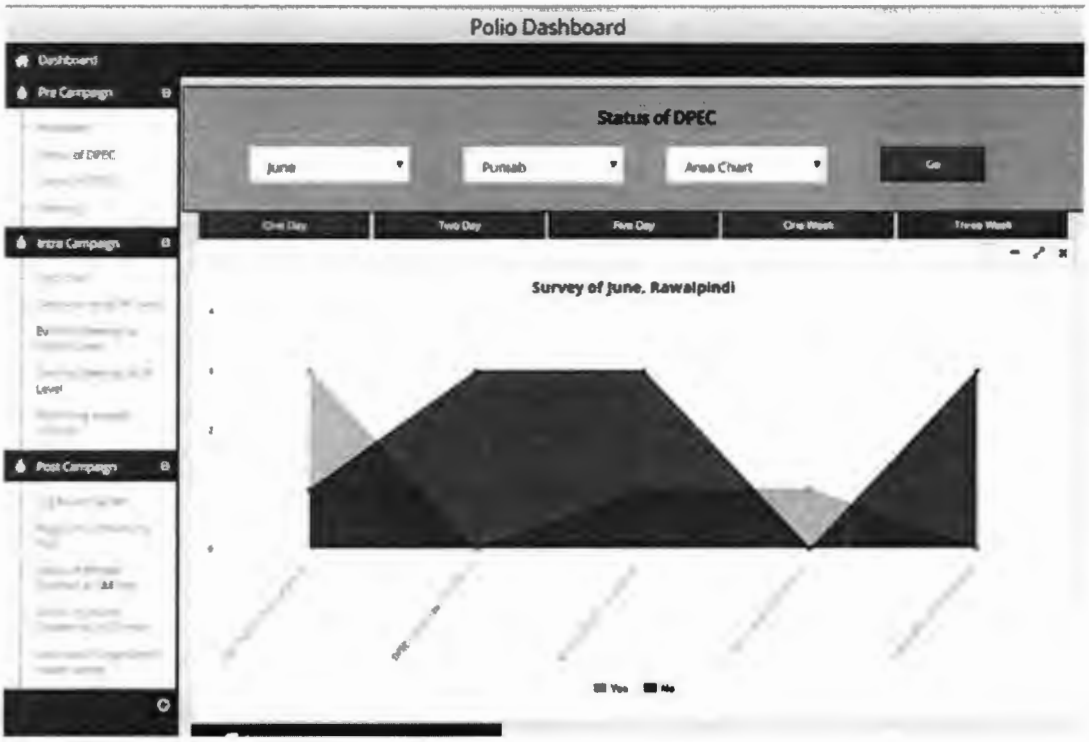


Fig 21: Dashboard Implemented by Group B using Heuristic Set 2

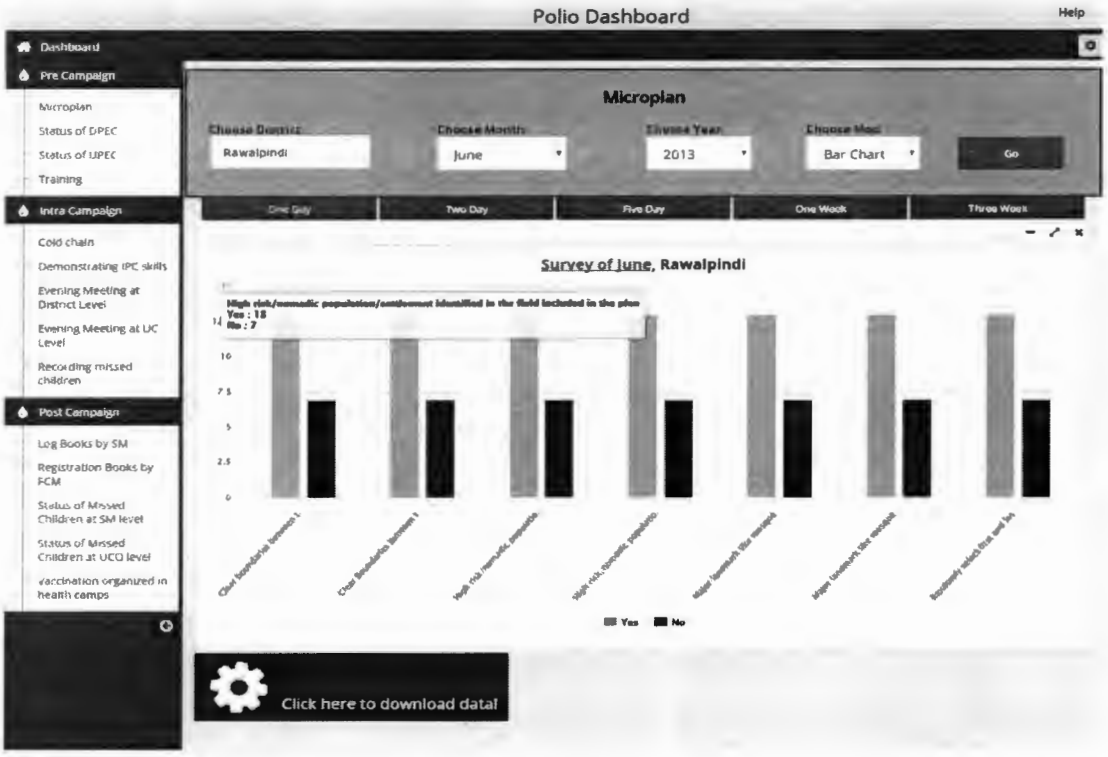


Fig 22: Dashboard Implemented by Group B using Heuristic Set 2

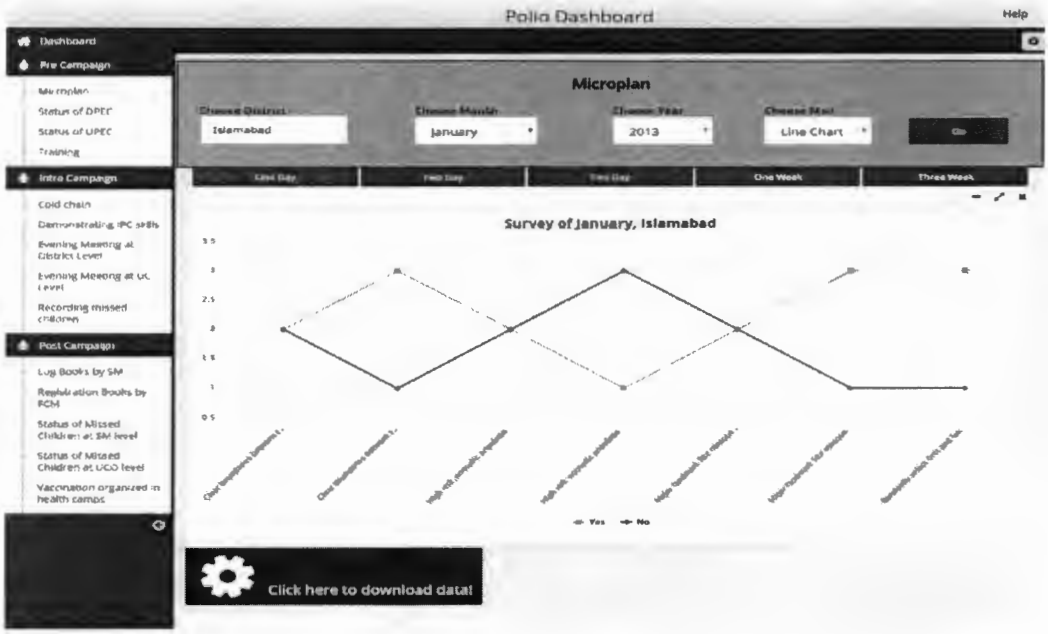


Fig 23: Dashboard Implemented by Group B using Heuristic Set 2

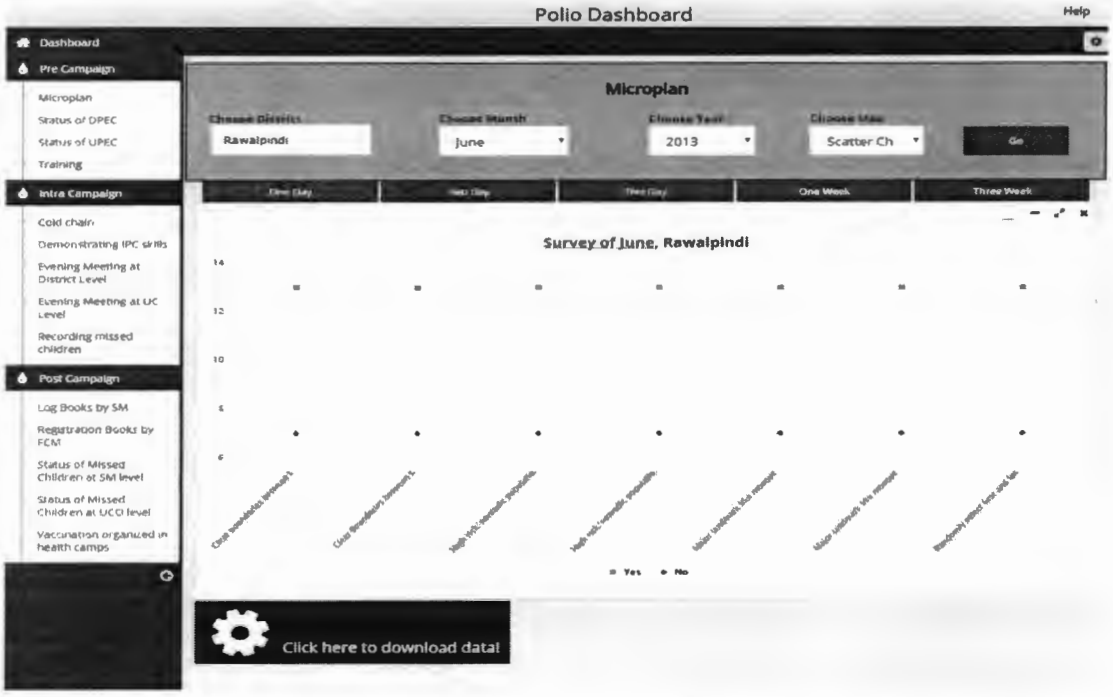


Fig 24: Dashboard Implemented by Group B using Heuristic Set 2

Fig 25: Dashboard Implemented by Group B using Heuristic Set 2

Chapter 5: User Testing

5 USER TESTING

After the implementation of dashboards based on our composed optimal set of heuristics, we need to evaluate the usability of that dashboards. In this chapter, we discuss the details of user testing of dashboards and get the feedback from the participants.

5.1 Subject Selection

For user testing of both implemented dashboards, we selected 30 participants randomly. They all were the BSSE students of the same session. 15 participants were given the dashboard implemented with heuristic set 1 and other 15 were given the dashboard implemented with heuristic set 2. All the 30 participants were given the same tasks and same questionnaires for evaluation.

5.2 Test Design

In evaluation of both the dashboards we made 2 groups. Participants of each group were selected randomly. Group A had 15 random participants and were given the dashboard implemented with heuristic set 1 while, Group B also had 15 random participants but were given the dashboard implemented with heuristic set 2. Testing was completed in two sessions in two different days, 1st session was with Group A and 2nd session was with Group B. Testing was conducted in lab in traditional environment. Both groups evaluate them according to their observations in terms of usability and its scales i.e. Attractiveness, Perspicuity, Dependability, Efficiency, Stimulation and Novelty.

5.3 Tasks

In order to understand what works and what doesn't in an implemented dashboard is to watch people use it [23]. In order to notice participants of user testing, we have to give them some assignments to do [23]. These assignments are referred to as tasks [23]. Tasks were used to guide the participants properly and to train them. This is how we did user testing. We selected 30 BS students randomly, gave them some realistic activities i.e. tasks and we gain qualitative visions into what is causing students to have trouble. We gave the tasks to user testing participants because we must had to engage them with the interface so that they gone through almost all the necessary links of the dashboards.

The tasks are constructed for the usability evaluation of polio information dashboard. It is essential for the user to complete all these tasks in getting familiar and experience with the polio information dashboard. These tasks will further pointed as an input for the usability evaluation questionnaire. User testing participants have to give the written answers that they

observed while using the polio information dashboard. Participants have to perform the steps in a sequence and their experience will help them in filling the usability evaluation questionnaire accurately. The time duration given to participants for the completion of tasks was only 30-45 mins.

Task 1: In the polio vaccination **Pre-Campaign**, the vaccination teams are given the **"Training"**. You need to write down which training indicators has highest Yes% for month September in district Rawalpindi? Also mention the year (if any) _____?

Task 2:

a) **Post-Campaign** activities include the **"Log Books"** of the polio vaccination campaign. You need to find the trend of **"status of missed children at SM level"** is increasing or decreasing for month June in district Rawalpindi?
b) Mention the chart and year (if you have option to select it by yourself) for above task a)

Task 3:

a) Extract (download) the 1 week (if any) information of **"Cold Chain"** given in **Intra-Campaign** for district Multan and month December. After downloading, you need to calculate from excel sheet total Yes and total No and write down your answer?
b) Mention your selected year (if any) _____?

Task 4: Browse the **"Microplan"** in the polio vaccination **Pre-Campaign** menu. You need to write down the individual Yes and No% of indicator **"Clear Boundaries between two Union Councils"** in district Rawalpindi, June by using Bar Chart? Select the year 2013 (if any)

Task 5: Search the **"Recording Missed Children"** in polio vaccination **Intra-Campaign** menu. Figure out **'is the team recording the expected date of return of the missed children or not?'** for month June in district Abbottabad? Select the year 2015 (if any)

Task 6: In polio vaccination **Post-Campaign** menu browse the **"Status of Missed Children at UCO Level"** in district Khairpur? Mention the selected month and year (if any)

5.4 Pilot testing

Before executing the real user testing, a pilot study was conducted to assess either the details in tasks are understandable and necessary enough for the layman. 5 students of BS degree were requested to perform the pilot testing. The purpose of tasks were to engage the users and to train them. Hence, we need to know the tasks are enough for the users to get familiar with the dashboard. Similarly, we need to know using these tasks we will get correct feedback from users or not. The outcome of pilot study suggested some changes in tasks. After discussion, we considered some of the changes while few of them were not necessary and irrelevant. Some tasks were not understandable for the user how is using the system first time. Besides that, user get bored while performing tasks. Therefore, we tried to make the tasks in such a way that they are understandable for the users. Moreover, we tried to make only few important tasks that are enough to train them and take their less time so that they won't get bore.

5.5 Measurement

In an experiment, measurements are collected through data collection [22]. This experiment uses questionnaire to get the feedback from the participants. Measurement of both dashboards for usability was performed by semantic differential questionnaire. In semantic differential scale we asked the participant to rate the dashboard in terms of usability and its scales. This questionnaire was based upon a seven point rating scale that has two bi-polar adjectives at each end [22]. When the students successfully performed the tasks, we gave them the questionnaire so that they evaluate the dashboard according to their observation. The questionnaire has 26 items and 6 scales [39]. The scales include Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation and Novelty [39]. The screenshot of the questionnaire is given below as well as the questionnaire is given in Appendix

	1	2	3	4	5	6	7		
annoying	O	O	O	O	O	O	O	enjoyable	1
not understandable	O	O	O	O	O	O	O	understandable	2
creative	O	O	O	O	O	O	O	dull	3
easy to learn	O	O	O	O	O	O	O	difficult to learn	4
valuable	O	O	O	O	O	O	O	inferior	5
boring	O	O	O	O	O	O	O	exciting	6
not interesting	O	O	O	O	O	O	O	interesting	7
unpredictable	O	O	O	O	O	O	O	predictable	8
fast	O	O	O	O	O	O	O	slow	9
inventive	O	O	O	O	O	O	O	conventional	10
obstructive	O	O	O	O	O	O	O	supportive	11
good	O	O	O	O	O	O	O	bad	12
complicated	O	O	O	O	O	O	O	easy	13
unlikable	O	O	O	O	O	O	O	pleasing	14
usual	O	O	O	O	O	O	O	leading edge	15
unpleasant	O	O	O	O	O	O	O	pleasant	16
secure	O	O	O	O	O	O	O	not secure	17
motivating	O	O	O	O	O	O	O	demotivating	18
meets expectations	O	O	O	O	O	O	O	does not meet expectations	19
inefficient	O	O	O	O	O	O	O	efficient	20
clear	O	O	O	O	O	O	O	confusing	21
impractical	O	O	O	O	O	O	O	practical	22
organized	O	O	O	O	O	O	O	cluttered	23
attractive	O	O	O	O	O	O	O	unattractive	24
friendly	O	O	O	O	O	O	O	unfriendly	25
conservative	O	O	O	O	O	O	O	innovative	26

Fig 26: User Questionnaire

5.5.1 Attractiveness

In attractiveness, we gone through the dashboard overall impressions i.e. participants like or unlike the dashboard. It include the following items of the questionnaire

- Annoying/enjoyable
- Good/bad
- Unlikable/pleasing
- Unpleasant/pleasant
- Attractive/unattractive
- Friendly/unfriendly

5.5.2 Perspicuity

In perspicuity, we would check the ease of getting familiar with the dashboard. Following are the items of perspicuity given in questionnaire

- Not understandable/understandable
- Easy to learn/difficult to learn
- Complicated/easy
- Clear/confusing

5.5.3 Efficiency

In efficiency, we gone through that the dashboard is efficient or not? Can users effortlessly answer their tasks with the dashboard? Efficiency include the following items of questionnaire

- Fast/slow
- Efficient/inefficient
- Impractical/practical
- Organized/cluttered

5.5.4 Dependability

In dependability, we check whether the dashboard is in control of the user or not. It include the following items of questionnaire

- Unpredictable/predictable
- Obstructive/supportive
- Secure/not secure
- Meet expectation/ does not meet expectations

5.5.5 Stimulation

In stimulation, we need to check user feel excited and motivated to use the dashboard as well as the dashboard is interesting. Following are the items of stimulation given in questionnaire

- Valuable/inferior
- Boring/exciting
- Not interesting/interesting
- Motivating/demotivating

5.5.6 Novelty

In novelty, we gone thorough that the dashboard is attracting the user through its creative and innovative design. The items of questionnaire that are considered for novelty includes

- Creative/dull
- Inventive/conventional
- Conservative/innovative

5.6 Validity

5.6.1 Internal Validity

Internal validity is used to determine either the outcomes observed were due to the treatment or other factors. We tried to control the threats to validity as much as we can because it is impossible to control all the 100% threats. Therefore, we strictly followed the random selection of subjects and random assignment of treatments for both evaluation and implementation in order to remove the threats of biasness and learning effects of participants that may cause

internal validity. While user testing, we organised the sitting arrangement of users so that they were not communicate with each other and we monitored the testing session by ourselves. We provide the same questionnaire and same tasks to the participants of user testing. There was no time pressure on participants to complete the tasks. Hence, we can claim that the results of experiment are not effected by content bias and time pressure.

5.6.2 External Validity

External validity is the way in which the conclusions of study would hold for other persons in other places and at other time. The sample was divided into 2 groups and each group had different people. For each situation i.e. dashboard designed with set 1 and dashboard designed with set 2 followed the same procedure but the session was different. The group A of situation dashboard designed with heuristic set 1 was performed in one day but the Group B of situation dashboard designed with heuristic set 2 was performed in next day. Both groups were given the different treatment to remove the learning effect. In order to remove the threats of individual's personal abilities, we randomly selected the sample and assignment of participants to the groups. We maintained the motivation of participants by giving them refreshment after the completion of the session as well as we considered their availability on the basis of their convenience.

Chapter 6: Results & Analysis

6 ANALYSIS AND RESULTS

After the evaluation of dashboards in terms of usability, we needed to analyse which hypothesis is correct. In this chapter, we discuss the details of analysis and results of both implemented dashboards.

6.1 Data Preparation

MS Excel analysis tool [39] was used to convert the 26 items of questionnaire into 6 scales i.e. attractiveness, perspicuity, efficiency, dependability, stimulation and novelty. Only the raw data of 30 questionnaires were entered in MS Excel tool. This tool used the number of items as same as were in questionnaire and categories 1(if a participant marked extreme left value) and 7 (if a participant marked extreme right value). In case, if a person has not answered to any question we left that cell empty. In order to avoid any error in the calculations, we didn't enter any special character. The data entered is shown below in fig 26:

Items																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
5	7	3	2	5	3	3	3	3	2	3	3	6	6	3	6	5	3	3	5	3	6	3	2	1	5
7	2	4	2	3	6	6	5	1	3	6	2	3	6	5	5	4	2	7	5	5	5	2	3	3	5
6	4	2	1	3	6	5	3	2	5	2	2	4	5	3	6	2	2	3	5	4	5	3	2	2	5
7	6	3	2	1	3	7	7	1	1	6	2	6	7	6	6	4	2	2	7	4	6	1	2	2	7
6	6	4	2	1	6	6	2	1	2	7	1	4	5	7	5	5	2	1	6	2	6	1	3	1	7
5	7	2	3	1	6	3	7	1	2	7	1	4	7	4	7	4	5	4	7	1	7	1	1	2	6
5	5	6	2	1	5	5	3	3	6	6	3	2	6	6	7	1	2	1	5	2	2	3	3	3	6
5	5	6	5	5	6	6	3	3	2	6	2	6	5	6	1	5	5	1	3	2	2	2	3	5	6
6	6	3	3	2	5	5	6	2	5	2	3	6	6	2	3	2	3	5	5	3	5	2	5	5	3
3	6	1	5	2	7	6	3	2	3	6	2	5	5	2	6	5	2	5	7	2	3	2	3	3	5
6	7	3	2	3	6	6	6	3	2	3	3	6	5	1	5	3	3	6	6	2	5	1	5	5	3
6	3	2	3	5	5	5	2	2	6	6	5	1	3	3	6	5	5	5	3	3	7	2	3	2	3
5	6	1	1	1	6	3	3	2	3	5	5	7	3	6	3	5	3	7	7	1	6	3	1	1	5
7	2	3	1	3	3	6	2	3	6	5	3	6	6	6	6	3	1	3	6	6	6	5	5	1	6
6	6	5	2	2	6	6	2	3	1	3	2	5	6	2	6	5	3	2	6	3	6	2	2	2	3

Fig 27: Data Entry in MS Excel

In the questionnaire, there is a random order of positive and negative terms of an item. Half of the items start with positive terms and half start with negative terms. Hence in fig 27, MS Excel tool [39] transformed the values of each item. +3 means the most positive while, -3 means the most negative. The value +3 means extremely good while the value -3 means horribly bad. 0 represents the neutral value.

Items																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	3	1	2	-1	-1	-1	-1	1	2	-1	1	2	2	-1	2	-1	1	1	1	1	2	1	2	3	1
3	-2	0	2	1	2	2	1	3	1	2	2	-1	2	1	1	0	2	-3	1	-1	1	2	1	1	1
2	0	2	3	1	2	1	-1	2	-1	-2	2	0	1	-1	2	2	2	1	1	0	1	1	2	2	1
3	2	1	2	3	-1	3	3	3	3	2	2	2	3	2	2	0	2	2	3	0	2	3	2	2	3
2	2	0	2	3	2	2	-2	3	2	3	3	0	1	3	1	-1	2	3	2	2	2	3	1	3	3
1	3	2	1	3	2	-1	3	3	2	3	3	0	3	0	3	0	-1	0	3	3	3	3	3	2	2
1	1	-2	2	3	1	1	-1	1	-2	2	1	-2	2	2	3	3	2	3	1	2	-2	1	1	1	2
1	1	-2	-1	-1	2	2	-1	1	2	2	2	2	1	2	-3	-1	-1	3	-1	2	-2	2	1	-1	2
2	2	1	1	2	1	1	2	2	-1	-2	1	2	2	-2	-1	2	1	-1	1	1	1	2	-1	-1	-1
-1	2	3	-1	2	3	2	-1	2	1	2	2	1	1	-2	2	-1	2	-1	3	2	-1	2	1	1	1
2	3	1	2	1	2	2	2	1	2	-1	1	2	1	-3	1	1	1	-2	2	2	1	3	-1	-1	-1
2	-1	2	1	-1	1	1	-2	2	-2	2	-1	-3	-1	-1	2	-1	-1	-1	-1	1	3	2	1	2	-1
1	2	3	3	3	2	-1	-1	2	1	1	-1	3	-1	2	-1	-1	1	-3	3	3	2	1	3	3	1
3	-2	1	3	1	-1	2	-2	1	-2	1	1	2	2	2	2	1	3	1	2	-2	2	-1	-1	3	2
2	2	-1	2	2	2	2	-2	1	3	-1	2	1	2	-2	2	-1	1	2	2	1	2	2	2	2	-1

Skale means per person					
ATT	DUR	EFF	STEU	STI	ORI
1.83	2.00	1.25	-0.50	-0.50	0.75
1.67	-0.50	1.75	0.00	1.75	0.75
1.83	0.75	1.25	0.00	1.50	0.25
2.33	1.50	2.75	1.75	1.75	2.25
1.83	1.50	2.50	0.75	2.25	2.00
2.50	1.75	3.00	1.50	0.75	1.50
1.50	0.75	0.25	1.75	1.75	0.00
0.17	1.00	0.00	0.75	0.50	1.00
0.33	1.50	1.50	0.25	1.25	-0.75
1.00	1.00	1.50	-0.25	2.25	0.75
0.50	2.25	1.75	0.00	1.50	-0.25
0.83	-0.50	1.50	-0.50	0.00	-0.50
0.67	2.75	2.00	-1.00	1.25	1.75
1.67	0.25	1.00	0.25	1.25	0.75
2.00	1.50	1.75	-0.50	1.75	-0.25

Fig 28: Transformed Data

6.2 Results

MS Excel tool [39] individually calculated the results of both dashboards. It gave each item a scale i.e. Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation and Novelty. The questionnaire does not produce the overall score, so we needed to interpret the values properly by means of scales. If two different items having same scale shows a large deviation in evaluation, this means that the item is misinterpreted by most of the participants. The value between -0.8 to 0.8 means neutral evaluation, values >0.8 means positive evaluation and values <-0.8 means negative evaluation. This tool automatically calculates the mean, variance, standard deviation, scale values and graphs for the better interpretation of data.

Item	Mean	Variance	Std. Dev.	No.	Positive	Negative	Skale
1	⇨-0.1	1.9	1.4	15	annoying	enjoyable	Attractiveness
2	⇨ 0.1	2.2	1.5	15	not understandable	understandable	Perspicuity
3	⇨-0.1	2.4	1.5	15	creative	dull	Novelty
4	⇨ 0.0	3.1	1.8	15	easy to learn	difficult to learn	Perspicuity
5	⇨ 0.3	2.7	1.6	15	valuable	inferior	Stimulation
6	⇨ 0.3	3.1	1.8	15	boring	exciting	Stimulation
7	⇧ 0.9	4.8	2.2	15	not interesting	interesting	Stimulation
8	⇨ 0.1	2.2	1.5	15	unpredictable	predictable	Dependability
9	⇧ 1.8	1.2	1.1	15	fast	slow	Efficiency
10	⇨ 0.6	2.5	1.6	15	inventive	conventional	Novelty
11	⇨ 0.7	1.8	1.3	15	obstructive	supportive	Dependability
12	⇧ 1.0	3.6	1.9	15	good	bad	Attractiveness
13	⇨ 0.3	5.7	2.4	15	complicated	easy	Perspicuity
14	⇨-0.1	2.9	1.7	15	unlikable	pleasing	Attractiveness
15	⇧ 1.1	2.3	1.5	15	usual	leading edge	Novelty
16	⇧ 1.1	1.4	1.2	15	unpleasant	pleasant	Attractiveness
17	⇨ 0.2	3.3	1.8	15	secure	not secure	Dependability
18	⇧ 1.0	4.1	2.0	15	motivating	demotivating	Stimulation
19	⇨ 0.4	3.1	1.8	15	meets expectations	does not meet expectations	Dependability
20	⇨ 0.7	4.4	2.1	15	inefficient	efficient	Efficiency
21	⇨-0.3	3.9	2.0	15	clear	confusing	Perspicuity
22	⇧ 0.8	2.5	1.6	15	impractical	practical	Efficiency
23	⇨ 0.1	4.1	2.0	15	organized	cluttered	Efficiency
24	⇧ 1.2	5.2	2.3	15	attractive	unattractive	Attractiveness
25	⇧ 1.1	4.4	2.1	15	friendly	unfriendly	Attractiveness
26	⇨-0.1	3.2	1.8	15	conservative	innovative	Novelty

Fig 29: Results of dashboard designed with heuristic set 1

Item	Mean	Variance	Std. Dev.	No.	Positive	Negative	Skale
1	⇧ 1.7	1.1	1.0	15	annoying	enjoyable	Attractiveness
2	⇧ 1.2	2.9	1.7	15	not understandable	understandable	Perspicuity
3	⇧ 0.8	2.5	1.6	15	creative	dull	Novelty
4	⇧ 1.6	1.5	1.2	15	easy to learn	difficult to learn	Perspicuity
5	⇧ 1.5	2.3	1.5	15	valuable	inferior	Stimulation
6	⇧ 1.3	1.6	1.3	15	boring	exciting	Stimulation
7	⇧ 1.2	1.6	1.3	15	not interesting	interesting	Stimulation
8	⇨-0.2	3.5	1.9	15	unpredictable	predictable	Dependability
9	⇧ 1.9	0.7	0.8	15	fast	slow	Efficiency
10	⇨ 0.7	3.4	1.8	15	inventive	conventional	Novelty
11	⇧ 0.9	3.1	1.8	15	obstructive	supportive	Dependability
12	⇧ 1.4	1.4	1.2	15	good	bad	Attractiveness
13	⇨ 0.7	2.9	1.7	15	complicated	easy	Perspicuity
14	⇧ 1.4	1.4	1.2	15	unlikable	pleasing	Attractiveness
15	⇨ 0.1	3.8	2.0	15	usual	leading edge	Novelty
16	⇧ 1.2	2.7	1.7	15	unpleasant	pleasant	Attractiveness
17	⇨ 0.1	1.8	1.4	15	secure	not secure	Dependability
18	⇧ 1.1	1.6	1.2	15	motivating	demotivating	Stimulation
19	⇨ 0.3	4.4	2.1	15	meets expectations	does not meet expectations	Dependability
20	⇧ 1.5	1.7	1.3	15	inefficient	efficient	Efficiency
21	⇧ 1.1	2.0	1.4	15	clear	confusing	Perspicuity
22	⇧ 1.1	2.6	1.6	15	impractical	practical	Efficiency
23	⇧ 1.8	1.2	1.1	15	organized	cluttered	Efficiency
24	⇧ 1.1	1.7	1.3	15	attractive	unattractive	Attractiveness
25	⇧ 1.5	2.1	1.5	15	friendly	unfriendly	Attractiveness
26	⇧ 1.0	2.0	1.4	15	conservative	innovative	Novelty

Fig 30: Results of dashboard designed with heuristic set 2

The following table shows the individual results of both dashboards in terms of scales

Scales	Dashboard Designed with Set 1	Dashboard Designed with set 2
Attractiveness	0.722	1.378
Perspicuity	0.033	1.167
Efficiency	0.833	1.583
Dependability	0.333	0.283
Stimulation	0.617	1.267
Novelty	0.400	0.667

Table 10: Results in terms of scales

6.3 Comparative Analysis

In order to test hypothesis i.e. null hypothesis (mean for both groups are equal) versus alternative hypothesis (mean for both groups are not equal), we performed t-test for the difference in means. Hence, we used independent sample t-test to compare the mean between two dashboards. Significance value of 0.05 was selected to assure validity of results and SPSS tool was used to perform this test.

Scale means per person values calculated in excel sheet are entered in SPSS and applied Independent sample t-test on them. We have 2 groups in this evaluation, group 1 that evaluated the dashboard designed with heuristic set 2 and group 2 that evaluated the dashboard designed with heuristic set 1.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Attractiveness	Dashbaord designed with heuristic set 2	15	1.3773	.73792	.19053
	Dashboard designed with heuristic set 1	15	.7213	.88092	.22745
Perspicuity	Dashbaord designed with heuristic set 2	15	1.1667	.92421	.23863
	Dashboard designed with heuristic set 1	15	.0333	1.28823	.33262
Efficiency	Dashbaord designed with heuristic set 2	15	1.5833	.81650	.21082
	Dashboard designed with heuristic set 1	15	.8333	.92903	.23987
Dependability	Dashbaord designed with heuristic set 2	15	.2833	.85496	.22075
	Dashboard designed with heuristic set 1	15	.3333	.82195	.21223
Stimulation	Dashbaord designed with heuristic set 2	15	1.2667	.78186	.20188
	Dashboard designed with heuristic set 1	15	.6167	.91059	.23511
Novelty	Dashbaord designed with heuristic set 2	15	.6667	.92421	.23863
	Dashboard designed with heuristic set 1	15	.4000	.65329	.16868

Fig 31: Group statistics

Group statistics table in fig 32 give us some important and related information. N represents the no of participants in each group. In this evaluation, no of participants were 15 for each group. Mean of groups are very important because it tell us the extent of difference in scale between two groups. Hence, we can see which group has highest mean.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Attractiveness	Equal variances assumed	.150	.702	2.211	28	.035	.65600	.29671	.04822	1.26378
	Equal variances not assumed			2.211	27.165	.036	.65600	.29671	.04738	1.26462
Perspicuity	Equal variances assumed	2.567	.120	2.769	28	.010	1.13333	.40936	.29479	1.97188
	Equal variances not assumed			2.769	25.393	.010	1.13333	.40936	.29089	1.97577
Efficiency	Equal variances assumed	1.221	.279	2.349	28	.026	.75000	.31935	.09584	1.40416
	Equal variances not assumed			2.349	27.546	.026	.75000	.31935	.09536	1.40464
Dependability	Equal variances assumed	.000	1.000	-.163	28	.871	-.05000	.30622	-.67726	.57726
	Equal variances not assumed			-.163	27.957	.871	-.05000	.30622	-.67730	.57730
Stimulation	Equal variances assumed	2.522	.124	2.098	28	.045	.65000	.30989	.01522	1.28478
	Equal variances not assumed			2.098	27.374	.045	.65000	.30989	.01456	1.28544
Novelty	Equal variances assumed	1.429	.242	.913	28	.369	.26667	.29223	-.33193	.86527
	Equal variances not assumed			.913	25.195	.370	.26667	.29223	-.33495	.86828

Fig 32: Levene's test for equality of variances

Levene's test for equality of variances in fig 33 is a test that determines if the two groups have about the same or different amounts of variability between scores [20]. If the sig. value in Levene's test is greater than 0.05 this means that variability of scores in both the groups is almost the same. Hence, the scores of both groups do not vary much and variability is not significantly different in both groups [20]. In this evaluation, sig value is greater than 0.05 which shows the scores don't vary and is a good thing.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Attractiveness	Equal variances assumed	.150	.702	2.211	28	.035	.65600	.29671	.04822	1.26378
	Equal variances not assumed			2.211	27.165	.036	.65600	.29671	.04738	1.26462
Perspicuity	Equal variances assumed	2.567	.120	2.769	28	.010	1.13333	.40936	.29479	1.97188
	Equal variances not assumed			2.769	25.393	.010	1.13333	.40936	.29089	1.97577
Efficiency	Equal variances assumed	1.221	.279	2.349	28	.026	.75000	.31935	.09584	1.40416
	Equal variances not assumed			2.349	27.546	.026	.75000	.31935	.09536	1.40464
Dependability	Equal variances assumed	.000	1.000	-.163	28	.871	-.05000	.30622	-.67726	.57726
	Equal variances not assumed			-.163	27.957	.871	-.05000	.30622	-.67730	.57730
Stimulation	Equal variances assumed	2.522	.124	2.098	28	.045	.65000	.30989	.01522	1.28478
	Equal variances not assumed			2.098	27.374	.045	.65000	.30989	.01456	1.28544
Novelty	Equal variances assumed	1.429	.242	.913	28	.369	.26667	.29223	-.33193	.86527
	Equal variances not assumed			.913	25.195	.370	.26667	.29223	-.33495	.86828

Fig 32: T-test for equality of means

Now, look at t-test for equality of means in fig 34. These results will show if the means of two groups were statistically different or if they are relatively the same [20]. If the value of sig (2-tailed) is greater than 0.05, that means that there is no statistically significant between two groups.

Statistical findings in fig 34 reveal that significant difference between two dashboards is observed [t (28) =2.211, p=0.035] in situation of dashboard designed with heuristic set 2 in terms of **attractiveness**. It shows that difference is significantly proven and performance of dashboard designed with heuristic set 2 is better in terms of scale **attractiveness**. As, p is less than 0.05% so we reject (H0) null hypothesis and accept (H1) alternative hypothesis.

Similarly, statistical findings in fig 34 reveal that significant difference between two dashboards is observed [t (28) =2.769, p=0.010] in situation of dashboard designed with heuristic set 2 in terms of **perspicuity**. It shows that difference is significantly proven and performance of dashboard designed with heuristic set 2 is better in terms of scale **perspicuity**. As, p is less than 0.05% so we reject (H0) null hypothesis and accept (H1) alternative hypothesis

Moreover, statistical findings in fig 34 reveal that significant difference between two dashboards is observed [t (28) =2.349, p=0.026] in situation of dashboard designed with heuristic set 2 in terms of **efficiency**. It shows that difference is significantly proven and performance of dashboard designed with heuristic set 2 is better in terms of scale **efficiency**. As, p is less than 0.05% so we reject (H0) null hypothesis and accept (H1) alternative hypothesis.

But, statistical findings in fig 34 reveal that no significant difference between two dashboards is observed [t (28) =-.163, p=0.871] in terms of **dependability**. It shows that difference is not significantly proven and performance of dashboard designed with heuristic set 2 is equal to dashboard designed with heuristic set 1 in terms of scale **dependability**. As, p is greater than 0.05% so we accept (H0) null hypothesis and reject (H1) alternative hypothesis.

Besides that, statistical findings in fig 34 reveal that significant difference between two dashboards is observed [t (28) =2.089, p=0.045] in situation of dashboard designed with heuristic set 2 in terms of **stimulation.** It shows that difference is significantly proven and performance of dashboard designed with heuristic set 2 is better in terms of scale **stimulation.**

As, p is less than 0.05% so we reject (H0) null hypothesis and accept (H1) alternative hypothesis

On the other hand, statistical findings is fig 34 reveal that no significant difference between two dashboards is observed [t (28) =.913, p=0.369] in terms of **novelty**. It shows that difference is not significantly proven and performance of dashboard designed with heuristic set 2 is equal to dashboard designed with heuristic set 1 in terms of scale **novelty**. As, p is greater than 0.05% so we accept (H0) null hypothesis and reject (H1) alternative hypothesis

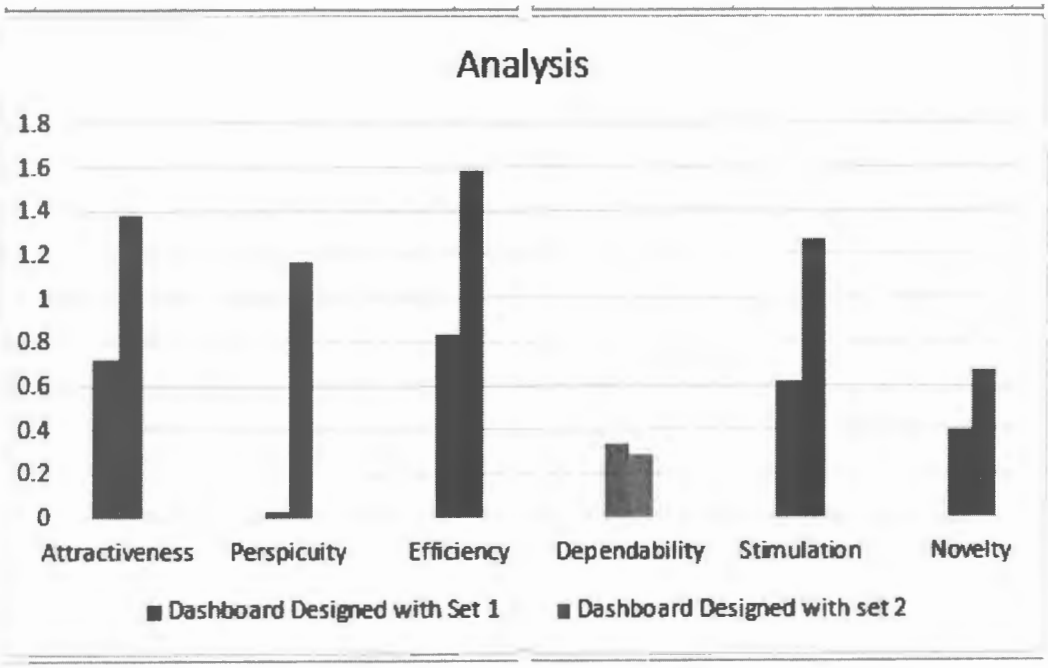


Fig 33: Analysis of dashboards

Chapter 7: Conclusion & Future Work

7 CONCLUSION

Dashboard is defined as a single screen display for information visualization. Dashboard provides only the important information to the users to make business decision quickly. Dashboard is like a control panel in which we organize and present the information in such a way that is easy to navigate and easy to read.

From the study of literature, we concluded that no optimal set of heuristics exist for designing web dashboard. But there were many authors that proposed their heuristic sets for designing information visualization and business intelligence applications. Hence, in this study we composed an optimal set of heuristics for web dashboard designing from already existing heuristics for information visualization and business intelligence. In this regard, an experiment was conducted to implement the dashboard based on the composed set of heuristics. Besides that, we evaluated the usability of that implemented dashboard with user testing. We got the feedback of testing participants through semantic differential questionnaire. We considered the usability with its scales i.e. attractiveness, perspicuity, efficiency, dependability, stimulation and novelty.

Statistical findings reveal that there is a difference between two dashboards in terms of usability on following scales i.e. attractiveness, perspicuity, efficiency and stimulation while no difference is observed on following usability scales i.e. dependability and novelty. From the analysis of results we conclude that dashboard designed with heuristic set 2 (common + other heuristics) is better in terms of usability than the dashboard designed with heuristic set 1 (common heuristics). As, the heuristics given in common heuristic set were commonly used by most of the studies to design the information visualization and business intelligence application which means that these are important heuristics. But, if we consider the heuristics mentioned in other heuristic set along with the common heuristic set the design of the dashboard would be better. So, it is proved that other heuristics are also important to some extent for web dashboard design.

7.1 Discussion

Dashboard designed with heuristic set 2 (common + other heuristics) provides more information to its users. Users can view the polio information w.r.t days, week, month and year. Similarly, users have option to view the polio information on different type of charts. Navigation is easier and information is well organized as compared to dashboard designed with heuristic set 1. Moreover, it shows proper error messages. Besides that, users of dashboard

designed with heuristic set 1 (common heuristics) felt annoyed with the labels A, B, C etc. Moreover, users can view the information w.r.t to month only and dashboard display only the bar chart.

7.2. Validity Threats & Limitations

In this research work, while conducting systematic mapping study we didn't consider the synonyms for usability. Moreover, we considered only usability testing method to measure the usability of our dashboard. Similarly, we didn't report the time when participants of user testing were completing the task and questionnaires.

8 FUTURE WORK

We selected the students randomly without knowing their intellectual abilities and intuitive thinking. Besides that, we gave only one trial to the experiment due to the time and cost constraint. So, in order to further improve the study one can consider the intellectual abilities and intuitive thinking of the participants while implementation of the dashboards. Moreover, more than 1 trial of an experiment is needed to get more refined results.

APPENDIX

TASKS FOR EVALUATION OF POLIO INFORMATION DASHBOARD

http://www.itestbuddy.com/poliodashboard

This document defines the tasks constructed for the usability evaluation of polio information dashboard in Pakistan. It is essential to complete all these tasks in getting familiar and experience with polio information dashboard that is given to you. It will further pointed as an input for the usability evaluation questionnaire.

- *Give the written answers that you have observed while using the polio information dashboard.*
- *All the steps should perform in a given sequence*
- *Your experience will help you in filling the usability evaluation questionnaire accurately*
- *This will take about 30-45 minutes of your time only.*

Participant's Name: _____

Participant's ID: _____

Task 1: In the polio vaccination **Pre-Campaign**, the vaccination teams are given the "**Training**". You need to write down which training indicators has highest Yes% for month September in district Rawalpindi? Also mention the year (if any) _____?

_____

_____

_____

Task 2:

c) **Post-Campaign** activities include the **"Log Books"** of the polio vaccination campaign. You need to find the trend of **"status of missed children at SM level"** is increasing or decreasing for month June in district Rawalpindi?

d) Mention the chart and year (if you have option to select it by yourself) for above task a)

_____

_____

_____

Task 3:

c) Extract (download) the 1 week (if any) information of **"Cold Chain"** given in **Intra-Campaign** for district Multan and month December. After downloading, you need to calculate from excel sheet total Yes and total No and write down your answer?

d) Mention your selected year (if any) _____?

_____

_____

_____

Task 4: Browse the **"Microplan"** in the polio vaccination **Pre-Campaign** menu. You need to write down the individual Yes and No% of indicator **"Clear Boundaries between two Union Councils"** in district Rawalpindi, June by using Bar Chart? Select the year 2013 (if any)

_____

_____

_____

Task 5: Search the **"Recording Missed Children"** in polio vaccination **Intra-Campaign** menu. Figure out **'is the team recording the expected date of return of the missed children or not?'** for month June in district Abbottabad? Select the year 2015 (if any)

_____

_____

_____

Task 6: In polio vaccination **Post-Campaign** menu browse the **"Status of Missed Children at UCO Level"** in district Khairpur? Mention the selected month and year (if any)

_____

_____

_____

Questionnaire

Please make your evaluation now.

For the assessment of the product, please fill out the following questionnaire. The questionnaire consists of pairs of contrasting attributes that may apply to the product. The circles between the attributes represent gradations between the opposites. You can express your agreement with the attributes by ticking the circle that most closely reflects your impression.

Example:

attractive ○ ⊗ ○ ○ ○ ○ ○ unattractive

This response would mean that you rate the application as more attractive than unattractive.

Please decide spontaneously. Don't think too long about your decision to make sure that you convey your original impression.

Sometimes you may not be completely sure about your agreement with a particular attribute or you may find that the attribute does not apply completely to the particular product. Nevertheless, please tick a circle in every line.

It is your personal opinion that counts. Please remember: there is no wrong or right answer!

Please assess the product now by ticking one circle per line.

	1	2	3	4	5	6	7		
annoying	O	O	O	O	O	O	O	enjoyable	1
not understandable	O	O	O	O	O	O	O	understandable	2
creative	O	O	O	O	O	O	O	dull	3
easy to learn	O	O	O	O	O	O	O	difficult to learn	4
valuable	O	O	O	O	O	O	O	inferior	5
boring	O	O	O	O	O	O	O	exciting	6
not interesting	O	O	O	O	O	O	O	interesting	7
unpredictable	O	O	O	O	O	O	O	predictable	8
fast	O	O	O	O	O	O	O	slow	9
inventive	O	O	O	O	O	O	O	conventional	10
obstructive	O	O	O	O	O	O	O	supportive	11
good	O	O	O	O	O	O	O	bad	12
complicated	O	O	O	O	O	O	O	easy	13
unlikable	O	O	O	O	O	O	O	pleasing	14
usual	O	O	O	O	O	O	O	leading edge	15
unpleasant	O	O	O	O	O	O	O	pleasant	16
secure	O	O	O	O	O	O	O	not secure	17
motivating	O	O	O	O	O	O	O	demotivating	18
meets expectations	O	O	O	O	O	O	O	does not meet expectations	19
inefficient	O	O	O	O	O	O	O	efficient	20
clear	O	O	O	O	O	O	O	confusing	21
impractical	O	O	O	O	O	O	O	practical	22
organized	O	O	O	O	O	O	O	cluttered	23
attractive	O	O	O	O	O	O	O	unattractive	24
friendly	O	O	O	O	O	O	O	unfriendly	25
conservative	O	O	O	O	O	O	O	innovative	26

Requirements for Dashboard Implementation

	A	B	C
1	Description	TYPE	
2	Microplan	Group	
3	Clear boundaries between two Union Councils	Component	
4	Clear Boundaries between two Area In charges	Component	
5	High risk/nomadic population/settlement mentioned in plan exist on the ground	Component	
6	High risk/nomadic population/settlement identified in the field included in the plan	Component	
7	Major landmark like mosques/pre primary-schools mentioned in plan exist on the ground	Component	
8	Major landmark like mosques/pre primary schools identified in the field included in the plan	Component	
9	Randomly select first and last house of any team in an Area in charge plan and cross check it with field	Component	
10	Training of Vaccination Teams conducted as per SIAs guidelines	Group	
11	Training Venue was comfortable and right spacing available for the participants	Component	
12	Is the number of participants attending training were as per plan/microplan?	Component	
13	Is the training facilitated by UCMO(must) and UNICEF/COMNet or WHO staff(if assigned) of that UC?	Component	
14	Availability of training material like agenda, training manual, board, charts, marker, tally sheet	Component	
15	Training agenda was followed	Component	
16	Any recommended methodologies(Role Play, demonstration on all the basic IPC questions etc.) were used to deliver the sessions / Topics used	Component	
17	Status of UPEC	Group	
18	Is UPEC held 15 days before campaign?	Component	
19	Is UPEC chaired by UCMO/senior health staff and co-chaired by UC secretary?	Component	
20	Are all the members in addition to Chair and co-chair of UPEC like SHO, AICs, LHS, Community Members & representatives, UCO, UCPW, School principles and Religious influentials are part of the UPEC	Component	
21	Are all the AICs presented or explained the updated and field validated microplans to the UPEC	Component	
22	Is UPEC discussed the security plan in the presence of SHO	Component	
23	Status of DPEC	Group	
24	DPEC held 10 days before campaign	Component	
25	DPEC chaired by DCO/DC/PA and co-chaired by EDO-H	Component	

	A	B	C
26	All the members in addition to Chair and co-chair of DPEC like DPO, EDO-Revenue, EDO-Edu, District Coordinator of LHWs Program, District Head of PPHI, District Heads of Govt. NGOs and Local representatives of partner organizations UNICEF (DHCSO), WHO (PEO), N-STOP, and Rotary International are part of the DPEC	Component	
27	Is there a meeting minutes of UPEC of HRUCs discussed in the DPEC?	Component	
28	Is the DPEC meeting discussed and formulated the district security plan with special focus on HR Ucs/areas of concern?	Component	
29	Vaccination Teams maintaining cold chain	Group	
30	Is vaccine carried in a proper and recommended vaccine carrier?	Component	
31	Are frozen ice packs used for maintaining cold chain?	Component	
32	Is VVM of the vaccine is valid (Stage 1 ad 2)?	Component	
33	Vaccination Teams recording missed children at the back of tally sheet	Group	
34	Is the team recording the name and father name of the missed child	Component	
35	Is the team recording the complete address of the missed child	Component	
36	Is the team recording the reason of missed children (Refusal & NA)	Component	
37	Is the team recording the expected date of return of the missed child	Component	
38	Vaccination Teams demonstrating IPC skills in households	Group	
39	Is the team going at the house for vaccination?	Component	
40	Is the team asking all the 7-9 (IPC specific) questions from mother?	Component	
41	Is the team asking about zero routine dose less than 1 year children in all houses?	Component	
42	Is the team vaccinating the child as per SOPs (not vaccinating in sunlight,45 &#8451 ?	Component	
43	Evening Meeting at UC Level	Group	
44	Is evening meeting held at UC level daily during campaign days under the chairmanship of UPEC?	Component	
45	Is evening meeting held at UC level daily during campaign days attended by all stakeholders (govt., UNICEF and WHO)?	Component	
46	Is data analysin done in the evening meeting held at UC level?	Component	
47	Evening Meeting at District Level	Group	
48	Is evening meeting held at district level during campaign days?	Component	
49	Is evening meeting held at district level daily during campaign days attended by all stakeholders (govt., UNICEF and WHO?	Component	

	A	B	C
49	Is evening meeting held at district level daily during campaign days attended by all stakeholders (govt., UNICEF and WHO?	Component	
50	Is data analysis done in the evening meeting held at district level?	Component	
51	Log Books by SM	Group	
52	Is the SM updated total refusal children in the logbook according to the refusals reported in last campaign	Component	
53	Is the SM updated total NA children in the logbook as per guidelines from the back of tally sheet	Component	
54	Registration Books by FCM	Group	
55	Is the FCM having registered children in the assigned area	Component	
56	Is the FCM having registered pregnant women in the assigned area	Component	
57	Is the FCM having registered routine vaccination status of all the registered children	Component	
58	Status of Missed Children (NA And Refusal) at SM level	Group	
59	Number of converted missed children (NA & Refusal) children checked by TPFM	Component	
60	Number of converted missed children (NA & Refusal) children found vaccinated by TPFM	Component	
61	Status of Missed Children (NA & Refusal) at UCO level	Group	
62	Number of converted missed children (NA & Refusal) children checked by TPFM	Component	
63	Number of converted missed children (NA & Refusal) children found vaccinated by TPFM	Component	
64	No. of training sessions attended	Component	
65	No. of inaccessible children mentioned in the microplan	Component	
66	No. of vaccination teams monitored	Component	
67	Is the team attended the training before campaign	Component	
68	No. of inaccessible children reported by team during the day of campaign	Component	
69	Vaccination organized in health camps according to set standard	Group	
70	Number of health camps monitored	Component	
71	Availability of OPV as per requirement at the vaccination center	Component	
72	Availability of functional cold chain equipment at the vaccination centre of health camp	Component	
73	Vaccination is done by vacinator	Component	
74	Availability of data collection tool at health camp to keep vaccination record	Component	

Name of Province:	Punjab	Name of District:	Rawalpindi.	
Name of Tehsil:	Rawalpindi.	Name of UC:		
Name of Village/ Area:	DCO office	Name of Monitors:	Yasir, Sanya Mahsud	
Date of Visit:	15-05-2015	Time of Visit:		
Name & Designation of UPEC Chairman		Name of UCO:		
Name of UCPW		Name of SM:		

A	Microplan	Yes	No	Remarks (if any, with complete information)
1	Clear boundaries between two Union Councils			
2	Clear Boundaries between two Area In charges			
3	High risk/nomadic population/settlement mentioned in plan exist on the ground			
4	High risk/nomadic population/settlement identified in the field included in the plan			
5	Major landmark like mosques/pre primary schools mentioned in plan exist on the ground			
6	Major landmark like mosques/pre primary schools identified in the field included in the plan			
7	Randomly select first and last house of any team in an Area in charge plan and cross check it with field			
B	Training of Vaccination Teams	Yes	No	If No (reason)
1	Training Venue was comfortable and right spacing available for the participants			
2	Is the number of participants attending training were as per plan/microplan?			
3	Is the training facilitated by UNICEF,WHO, Government etc jointly?			
4	Availability of training material like agenda, training manual, board, charts, marker, tally sheet			
5	Training agenda was followed			
6	Any recommended methodologies(Role Play, demonstration on all the basic IPC questions etc) were used to deliver the sessions / Topics used			
C	Status of UPEC	Yes	No	If No (reason)
1	Is UPEC held 15 days before campaign?			
2	Is UPEC chaired by UCMO/senior health staff and co-chaired by UC secretary?			
3	Are all the members in addition to Chair and co-chair of UPEC like SHO, AICs, LHS, Community Members & representatives, UCO, UCPW, School principles and Religious influentials are part of the UPEC			
4	Are all the AICs submitted the updated and held validated microplans to the UPEC			
5	Is UPEC discussed the security plan in the presence of SHO			
D	Status of DPEC	Yes	No	If No (reason)
1	DPEC held 10 days before campaign		✓	Sample size
2	DPEC chaired by DCO/DC/PA and co chaired by EDO-H	✓		
3	All the members in addition to Chair and co-chair of DPEC like DPO, EDO-Revenue, EDO-Edu, District Coordinator of LHWs Program, District Head of PPHI, District Heads of Govt. NGOs and Local representatives of partner organizations UNICEF (DHCSO), WHO (PEO), N-STOP, and Rotary International are part of the DPEC	✓	✓	
4	Is there a meeting minutes of UPEC of HRUCs discussed in the DPEC?		✓	
5	Is the DPEC meeting discussed and formulated the district security plan with special focus on HR UCs/areas of concern?	✓		

Name of Province:	Punjab	Name of District:	Rwp		
Name of Tehsil:	Rwp	Name of UC:	Ward 5		
		Name of Monitors:	Saqib Bashir		
Date of Visit:	20-4-15	Time of Visit:	9:30 Am		
Name & Designation of UPEC Chairman	Aslam	Name of UCO:	Sajid Hussain		
Name of UCPW	NA	Name of SM:	Nazia Sohail		
S	Routine Vaccination	Yes	No	If No (Reason)	
1	Number of under one year children checked in the field for routine vaccination from log book				
2	Number of under one year children checked in the field during refusal and NA verification for routine vaccination and cross check in the log book				
3	Has SM shared the Zero dose children list with UCMG/UCPW/UCO				
L	Log Books by SM	Yes	No	If No(Reason)	
1	Is the SM updated total refusal children in the logbook according to the refusals reported in last campaign	✓			
2	Is the SM updated total NA children in the logbook as per guidelines from the back of tally sheet	✓			
3	Is the SM having updated list of refusal with reasons (Refusal Log book) after last campaign held in the UC	✓			
4	Is the SM having updated list of NA with reasons (NA Log book/Missed Children form) after last campaign held in the UC	✓			
5	Is the UCO having updated list of refusal with reasons (Refusal Log book) after last campaign held in the UC	✓			
M	Registration Books by FCM	Yes	No	If No (Reason)	
1	Is the FCM having registered children in the assigned area				
2	Is the FCM having registered pregnant women in the assigned area				
3	Is the FCM having registered routine vaccination status of all the registered children				
N	Status of Refusals at SM level	Yes	No	(Total	(Reason)
1	Number of converted refusals children checked by TPFM	✓		7	
2	Number of converted refusal children found vaccinated by TPFM	✓		7	
O	Status of NA at SM level	Yes	No	(Total	(Reason)
1	Number of covered NA children checked by TPFM	✓		12	
2	Number of covered NA children found vaccinated by TPFM	✓		12	
P	Status of Refusals at UCO level	Yes	No	If Yes	If No
1	Is SM sharing list of covered refusals against still refusals with with UCO on daily basis	✓			
2	Total number of still refusals covered by UCOs	✓		2	
Q	Status of NA at UC level	Yes	No	If Yes	If No
1	Is SM sharing list of covered NA against still NA with UCO on daily basis	✓			
2	Total Number of still NAs covered by UCOs	✓		3	

Name of Province:	Punjab	Name of District:	Rwp	
Name of Tehsil:	Rwp	Name of UC:	Ward 9	
Name of Village/ Area	Dabira Colony	Name of Monitors:	Saqib Bashir	
Date of Visit:	21-5-15	Time of Visit:		
Name & Designation of UPEC Chairman	Waqas	Name of UCO:	Fiaz ur Rehman	
Name of UCPW	Asmatullah	Name of SM:	Anais	
E	Vaccination Teams Monitoring and Data	Yes	No	If No (Team No., AIC Name, Area Name, and any other Comment)
1	Is vaccine carried in a proper vaccine carrier?	✓		
2	Is [illegible] used for maintaining cold chain?	✓		
3	Is VVM of the vaccine is valid (Stage 1 and 2)?	✓		
F	Vaccination Teams recording missed children at the back of tally sheet	Yes	No	If No (Team No., AIC Name, Area Name, and any other Comment)
1	Is the team recording the name and father name of the missed child	✓		
2	Is the team recording the complete address of the missed child	✓		
3	Is the team recording the reason of missed children (Refusal & NA)	✓		
4	Is the team recording the expected date of return of the missed child	✓		
G	Vaccination Teams demonstrating IEC skills to households	Yes	No	If No (Team No., AIC Name, Area Name, and any other Comment)
1	Is the team going inside the house for vaccination?	✓		
2	Is the team asking all the 7 EPI specific questions from mother?	✓		
3	Is the team asking about zero routine dose < 1 year children in all houses?	✓		
4	Is the team vaccinating the child as per SOPs (not vaccinating in sunlight etc)?	✓		
H	Household Cluster (Checklist attached)			
I	Evening Meeting at UC Level	Yes	No	If No (Reason)
1	Is evening meeting held at UC level daily during campaign days under the chairmanship of UPEC	✓		
2	Is evening meeting held at UC level daily during campaign days attended by all stakeholders (govt., PHCEI and WHO)	✓		
3	What analysis done in the evening meeting held at UC level?		✓	
J	Evening Meeting at District Level	Yes	No	If No (Reason)
1	Is evening meeting held at district level during campaign days?			
2	Is evening meeting held at district level daily during campaign days attended by all stakeholders (govt., PHCEI and WHO)?			
3	What analysis done in the evening meeting held at district level?			

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