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Make it easy to make analyses look good

Support for information dashboard design

Master's thesis in Interaction Design

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Make it easy to make analyses look good

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Abstract

Data analysts are data driven while creating analyses in data analysis tools. Compiling an information dashboard with compelling analysis requires strong knowledge of dashboard design guidelines and visual design guidelines. Analysts who lack relevant design knowledge and experience, find it a difficult task to create good looking dashboards. Hence there is a need for support which helps to automatically apply dashboard design guidelines and visual design guidelines to create good looking dashboards. This thesis was conducted with a data analytics company who have developed a data analytics tool. Through literature study and expert interviews essential requirements for designing a good looking dashboard were identified. Following this, a design workshop was conducted to identify opportunities for support to create good looking dashboards. An ideation session after the workshop helped to identify that a combination of styling templates and layout permutations could help to provide the necessary support to create compelling analysis. A design regarding this concept was prototyped and evaluated through user testing. The concept and recommendations are presented to describe the support required to create good looking dashboards

Keywords: dashboard design, dashboard styling, dashboard design guidelines, templates, layouts, custom styling, information dashboard design, good looking analyses

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Table of Contents

1 Introduction.....	1
1.1 Research question.....	2
1.2 Goal.....	2
1.3 Delimitation.....	2
1.4 Ethical Concern.....	2
2 Background.....	3
2.1 Persona.....	4
2.2 User scenario.....	5
3 Theory.....	6
3.1 Human perception and cognition.....	6
3.1.1 Human perception.....	6
3.1.1.1 Gestalt Laws.....	6
3.1.2 Human cognition.....	9
3.2 Visual design guidelines.....	10
3.2.1 Typography.....	10
3.2.2 Graphical Images.....	10
3.2.3 Colour.....	10
3.2.4 Animation and audio.....	11
3.2.5 Composition.....	11
3.3 Dashboard design guidelines.....	11
3.3.1 Data preparation.....	12
3.3.2 Context and story.....	12
3.3.3 Visual information design.....	13
3.3.4 Data emphasis.....	13
3.3.5 Overview and details.....	14
3.3.6 Quality of end result.....	15
4 Methodology.....	17
4.1 Divergence.....	17
4.1.1 Interviews.....	18
4.1.1.1 Unstructured Interviews.....	18
4.1.1.2 Structured Interviews.....	18
4.1.1.3 Semi-structured Interviews.....	18
4.1.2 Observation.....	18
4.1.2.1 Semi structured or casual observation.....	19
4.1.2.2 Structured observation.....	19
4.2 Transformation.....	19

4.2.1 Affinity diagrams.....	19
4.2.2 Design Charrette.....	19
4.2.3 KJ technique.....	20
4.3 Convergence.....	21
4.3.1 Creating user scenarios using Personas.....	21
4.3.2 Prototyping.....	22
4.3.2.1 Low fidelity prototypes.....	22
4.3.2.2 High fidelity prototypes.....	22
4.3.3 Usability evaluation with or without a user.....	22
4.3.3.1 Heuristic evaluation.....	22
4.3.3.2 Usability Testing.....	23
5 Execution.....	24
5.1 Literature study.....	24
5.2 Expert interviews.....	25
5.2.1 Methodology.....	25
5.2.2 Interviewee backgrounds.....	25
5.2.3 Insights from the Interview.....	26
5.2.3.1 Head of product and product managers.....	26
5.2.3.2 The data analyst.....	27
5.2.3.3 The visual designer.....	28
5.2.4 Discussion.....	28
5.3 Essential requirements.....	29
5.4 Design workshop.....	30
5.4.1 Workshop setup.....	30
5.4.2 Methodology.....	32
5.4.3 Workshop results.....	32
5.4.3.1 Maintaining a dashboard composition.....	33
5.4.3.2 Following a uniform colour scheme.....	33
5.4.3.3 Creating a data driven dashboard.....	33
5.4.3.4 Minimizing clutter.....	33
5.4.3.5 Following a layout that supported readability.....	34
5.4.3.6 Conveying dashboard context.....	34
5.4.3.7 Highlighting key information.....	35
5.4.3.8 Highlighting relationships between visualizations.....	35
5.4.4 Workshop discussion.....	35
5.4.4.1 Maintaining a uniform and harmonious dashboard composition.....	35
5.4.4.2 Following a uniform colour scheme.....	36
5.4.4.3 Minimizing clutter.....	36
5.4.4.4 Creating a data driven dashboard.....	37
5.4.4.5 Following a layout that supported readability.....	37
5.4.4.6 Conveying dashboard context.....	37

5.4.4.7 Highlighting key information.....	37
5.4.4.8 Highlighting relationships between visualizations.....	37
5.4.5 Conclusion.....	38
5.5 Ideation.....	39
5.5.1 Ideation setup.....	39
5.5.2 Methodology.....	40
5.5.3 Ideation results.....	40
5.5.3.1 Colouring and Styling.....	40
5.5.3.2 Layout and alignments.....	40
5.5.3.3 Access to styling features.....	40
5.5.4 Discussion.....	41
5.5.4.1 Colouring and styling.....	41
5.5.4.2 Layouts and alignments.....	42
5.5.4.3 Access to styling features.....	42
5.6 Prototyping.....	42
5.6.1 Initial concept.....	42
5.6.2 Design of templates.....	44
5.6.2.1 Templates with four or fewer visualizations.....	44
Template 1: Bare minimum.....	44
Template 2: Dark template with grouping.....	45
Template 3: Effective use of decorative images.....	46
Template 4: Monochrome.....	48
5.6.2.2 Templates designed based on a densely populated CIO dashboard.....	48
Template 5: Similar colour scheme as Fig 5.9 with use of white spaces.....	49
Templates 6 and 7: Follow similar layout as Fig 5.9 with different colour schemes.....	50
Template 8: Blurred gradient.....	52
Template 9: Dark gradient.....	53
Template 10: Dark theme with muted colours.....	53
5.6.2.3 Discussion.....	54
5.6.3 Design of the styling framework.....	55
5.6.3.1 Styling flyout.....	55
5.6.3.2 Applying templates.....	56
5.6.3.3 Design of Layouts.....	57
5.6.3.4 Applying Layouts.....	58
5.6.3.5 Relationship between templates and layouts.....	59
5.6.3.6 Custom Styling menu.....	60
5.7 User testing.....	62
5.7.1 Methodology.....	62
5.7.2 Set-up.....	62
5.7.3 Test Results.....	62
5.7.3.1 Templates.....	63

5.7.3.2 Layouts.....	63
5.7.3.3 Relationship between Templates and Layouts.....	63
5.7.3.4 Custom Styling.....	63
5.7.4 Discussion.....	64
6 Final Concept and Recommendations.....	65
6.1 The final concept.....	65
6.1.1 Templates.....	65
6.1.2 Layouts.....	65
6.2 Final design.....	66
6.2.1 Templates.....	66
6.2.2 Layouts.....	67
6.3 Recommendations.....	68
7 Discussion.....	71
7.1 Persona.....	71
7.2 Execution.....	71
7.3 Planning.....	72
7.4 Literature study.....	72
7.5 Expert interviews.....	72
7.6 Design workshop.....	73
7.7 Ideation.....	73
7.8 Prototyping.....	73
7.9 User Tests.....	74
7.10 Final concept and recommendations.....	75
7.10.1 Templates.....	75
7.10.2 Layouts.....	75
7.11 Future work.....	76
7.11.1 Templates.....	76
7.11.2 Layouts.....	76
8 Conclusion.....	77
9 References.....	79
Appendix A.....	82
Appendix B.....	86
Appendix C.....	89
Appendix D.....	95

1 Introduction

“One of the greatest benefits of data visualization is the sheer quantity of information that can be rapidly interpreted if it is presented well.” - Ware, 2013

From this definition we understand that a data visualization is the concise representation of a large quantity of information. But good presentation of this information is necessary for its rapid interpretation. This consequence of good presentation can be further extended to a compilation of multiple visualizations organized as an ‘Information dashboard’. An information dashboard can therefore be defined as a concise medium of communicating a rich and often dense assortment of information in an instant (Ware, 2013). Well presented and organized dashboards aid in the rapid interpretation of information because dashboards can tap into the tremendous power of visual perception to communicate information (Few, 2006)

At contemporary organizations, managers require something that can help them in tasks like monitoring, examining, controlling organizational performance and decision making. Business Intelligence (BI) in the form of a dashboard helps to facilitate these key managerial tasks in a simple and efficient way (Few, 2006, Eckerson 2010, Su and Chiong 2011). In such a scenario, good looking dashboards not only make a good first impression but also highlight key performance indicators which can help in quick decision making (Few, 2006). Such organizations have data analysts or data authors who work on creating dashboards that help make organisational decisions (Cahyadi 2013). But it is important to keep in mind that the skill required to create useful data visualizations is different from that required to create well presented dashboards. Strong knowledge of statistical analysis and data science can help create useful visualizations like graphs and charts. But to create good looking dashboards, it is necessary to have a proper understanding of visual presentation, well grounded in the theory of human perception, and information design (Few, 2006). This implies that all data analysts might not have the skills required to create effective dashboards.

With the prevalence of BI tools, numerous academic and online sources attempt to provide guidelines for good dashboard design. This project aims to make use of these resources for providing support to data analysts to create good looking dashboards. This project was conducted at a data visualization and analytics product company which will be referred to as ‘The Company’ throughout the thesis report. All research and design was done pertaining to The Company’s data analytics software, referred to as ‘The Company’s tool’ throughout this project.

1.1 Research question

“What support would users of analytic software need to create compelling analyses based on best practices within dashboard design and visual design?”

1.2 Goal

The goals of this project are:

- a. To understand the essential requirements for creating good looking dashboards
- b. To identify opportunities to provide support required to design good looking dashboards
- c. To design a concept that provides concrete support within a data analysis tool to style compelling information dashboards which adhere to dashboard design and visual design guidelines.

1.3 Delimitations

Existing literature on dashboard design guidelines stress the importance of data preparation which involves cleaning up data to make it more suitable for creating visualizations. While it is a necessary topic, it involves extensive research in statistical analysis and data science. This is not explored through the project as it would make the scope of the project too wide. Similarly, guidelines regarding choosing the right type of visualization are omitted as this would require extensive research in data analysis and would make the scope of the project too wide. It is assumed that the users who will benefit from conclusions of this project have expert knowledge of data preparation and choosing the correct type of visualization.

1.4 Ethical concerns

Since the research is being carried out with an industrial partner, there may be reference to confidential material, like customer data and ideas for improvement of the product that are not yet released. The Company where the thesis project is being conducted have rules for employees on how to handle confidentiality and the same is applicable to this project. However, this project does not mean any harm, risk or exposure if the resulting ideas are implemented.

2 Background

When creating effective information dashboards it is often very important to customize the appearance. Styling can have a big impact on the impression and adoption of analysis. It can make insights come across clearly, and the analysis visually appealing. A professional look can affect the perception of quality and trust for the end users.

In some cases, medium to large organizations have a corporate standard that they need to follow to be able to present the result of the analysis. There can also be conventions within an organization that make styling important for the understanding of the analysis. In other cases, the data analyst might want to create analyses that look compelling without using a corporate standard.

Today it is possible to use styling on various data analysis tools but this is often limited to configuration of the appearance of visualizations rather than the overall look and feel. However, several academic and online sources exist that are intended to provide guidelines for effective dashboard design. Few (2006) and Tufte (1983) provide widely referenced dashboard design guidelines which speak in depth about visual features, information design and dashboard purposes. Ware (2013) describes key findings on human perception and cognition and how they affect the design of information visualization. Moore (1993) also describe the relevance of principles of visual perception to dashboard design. Wong (2010) provides a comprehensive list of visual design dos and don'ts while creating information graphics. Yau (2011) and Steele (2010) provide a step by step overview of several important aspects of dashboard design and speak of the use of storytelling through dashboards. In spite of the prevalence of this literature, data visualization software do not provide the necessary support required to create good looking dashboards and it is often up to the end users. This results in cluttered and often unpleasant dashboards.

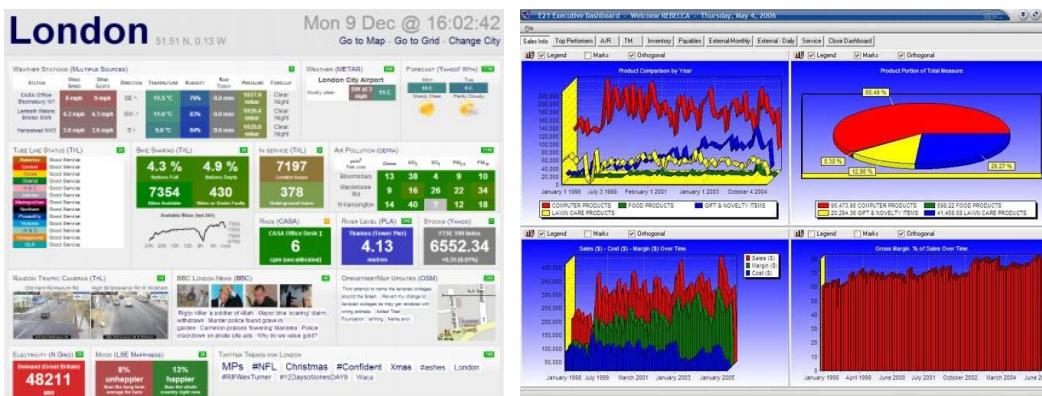


Figure 2.1: Examples of cluttered dashboards (source: <http://en.dwhwiki.info/charting/dashboard/data-pixel>)

Though, it is easy to obtain a list of dashboard design guidelines today, it is very difficult to realize them into effective and good looking dashboards, especially without a background in design. The users of data analytics software are often skilled in data analysis, but visual design is typically not a part of their skill set. Hence, the goal is to identify the right support in a data visualization software which can help users automatically apply dashboard design and visual design guidelines without the need to understand the principles of visual design. As a solution, this project explores the creation of good looking custom templates and layouts in a simple way.

2.1 Persona

This section presents a persona “Serena” who is considered as the prime beneficiary of the outcomes of this thesis project. This persona was created by The Company as one of the main users of their product and all qualities of the persona relevant to the background of this project are described here:



Figure 2.1: Serena, the strategic analyst

Serena, the strategic analyst

Serena works with upstream strategic planning at a large energy company. Her group is responsible for providing analysis in this area and does production forecasting. She offers visibility into data for managers on many levels. She narrates the data, pointing out the conclusions and highlights from her own analysis. It's common for her to create a presentation as an executive summary and that the interactive dashboard is mostly used for any follow up questions, especially from high-level managers who expect her to investigate for them.

Serena needs to combine data from multiple sources, and twist and turn data to get the right answers. Getting data into the right format is a big part of her time working with analytics. She maintains a number of analyses files. Some are stable and she is constantly working on new ideas trying out new ways to look at data, or new data she should look into and make use of. She tries to reuse as much as possible to avoid repetitive work. Especially the data access part since that is typically very time consuming. When she publishes to others, she reuses the same data sources, but typically needs to roll up data not to overwhelm users. The higher up you go in the organization, the less details they want to view. Data security is another important consideration. Managers further down need access to their peer's data.

Her analytics usage is periodic so sometimes she can spend days or weeks at a time digging into analysis tasks. It depends on the phase of a project or if there are certain review periods which could be monthly, quarterly or yearly. After a period of analysis, there may be a few weeks before she does it again. But while analyzing, she can stay focussed and get good chunks of undisturbed time. It is common to do summary reviews of the same type of data you work with on a regular basis. Her time is spent on analysis versus authoring is about 50/50. When learning to use new software she uses a trial and error approach. She often starts with an example and learns by tweaking it. This is especially true for things like queries and formulas. She had some training in the analytics software initially and then took it from there. She is motivated to learn and once she sets her mind to it, she is confident she will master the problem. She is curious about programming, and what it could do for her analytically, but she hasn't really tried it out.

The analyses she provides are often presented by her managers in meetings. Although data is not the star of these presentations, it is used to provide insights and backup conclusions. Sometimes she participates as an expert analyst in such meetings. She cares a lot about how her analysis is presented to others. She is concerned about how the data will be interpreted, as there have been misunderstandings in the past. She wants to be transparent about the origin of the data and provide necessary background to build trust. She has to respond to fire drills around analysis if a new problem arises. She is the go-to person for quickly assembling data and making sense of it. So even if fire drills are stressful, her analysis competence gives her high visibility in the organization. This is something she really loves about her job.

2.2 User scenario

This section describes a user scenario which aligns with the research question of the project. The persona "Serena" is used as a reference to understand the skills and ability of the user who would be involved in the scenario. The scenario is as follows:

"Serena has been analysing data at her company and has discovered interesting insights. She has created multiple analyses which convey different insights. She will be presenting her analyses to her colleagues soon and is faced with the task of placing all her visualizations on a dashboard to effectively and quickly convey all the insights. She also wants the dashboard to look modern and stylish and in accordance with her company's brand identity."

3 Theory

This chapter aims to provide an overview of the key aspects of dashboard design starting with human perception and cognition and moving to a concise summary of design guidelines from existing literature.

3.1 Human perception and cognition

The human visual system is extremely powerful and is governed by its own rules. Interpretation of a visualization and guidelines for good visualizations are based on the underlying principles of human perception and cognition. An understanding of the strengths and limitations of the visual system can help shape guidelines for displaying information. By following perception-based rules, we can present our data such that important and informative patterns stand out. If we disobey these rules, our data will be incomprehensible or misleading.(Ware, 2013)

To understand perception and cognition, it is necessary to understand important aspects of the visual system. The human visual system comprises of the eye and the brain processing visual information parallelly. At higher levels of processing, perception and cognition are closely interrelated but the eye and brain have their own specific rules which can largely influence information processing.(Ware, 2013)

3.1.1 Human perception

Part of data analysis is about finding patterns in data that were previously undiscovered and making useful inferences from these patterns. Pattern recognition is governed by the rules of human perception and the strengths and limitations of the eye. Knowledge of pattern perception help to shape design principles stating how data can be organized so that important structures can be perceived. This leads to faster and better interpretation of data.

3.1.1.1 Gestalt Laws

One of the first attempts at understanding pattern perception was made by a group of German psychologists who produced a set of laws for pattern perception (Ware, 2013). They called these the *Gestalt laws*, where the word 'gestalt' stands for pattern in German. The laws along with images inspired by Ware (2013) are as follows :

Proximity

Things that are closer together are perceptually grouped together. In dashboard design, it is necessary to place symbols and glyphs representing related information closer together.

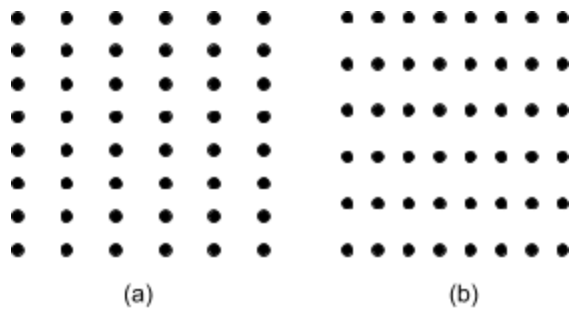


Figure 3.1: The proximity between the dots make (a) look like columns of dots and (b) like rows of dots

Similarity

Similar elements tend to be grouped together. Similarity plays a major role in encoding information on dashboards. Colour and texture are perceived by separate channels and hence elements of the same colour or the same texture are seen to be similar but different from each other.

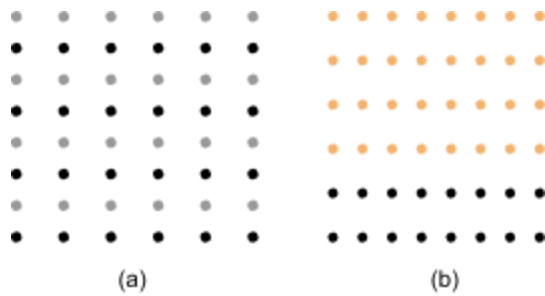


Figure 3.2: Colour and texture perceive the grouping of dots from Figure 1 differently. (a) The dots that were previously perceived as columns are now perceived as rows.

Connectedness

Connectedness is a strong grouping principle where connected elements are grouped together. Connecting graphical objects by lines is a very powerful way of expressing a relationship between them.

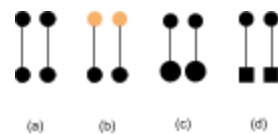


Figure 3.3: Connectedness is more powerful than (a) proximity, (b) colour, (c) size and (d) shape

Continuity

We are more likely to construct visual entities out of visual elements that are smooth and continuous, rather than ones that contain changes in direction. This is useful when translated to

displaying large networks of nodes where it is important to identify the source and destination of connected lines.

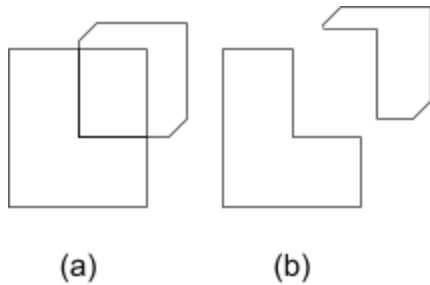


Figure 4: (a) looks like a combination of a square and a polygon but (b) shows how the actual Figures look without the intersection.

Symmetry

Symmetry helps to simulate a stronger sense of a wholistic Figures. Symmetry helps to make pattern comparisons easier and is strongest along the vertical and horizontal axes.

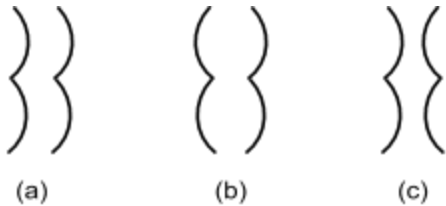


Figure 3.5: it can be seen that the lines in (b) and (c) look more closely associated due to their symmetry as compared to (a)

Closure and common region

There is a perceptual tendency to close contours that have gaps in them. Putting related information within a closed contour groups them together. For example, a border or boundary around graphs that need to be compared helps group them better.

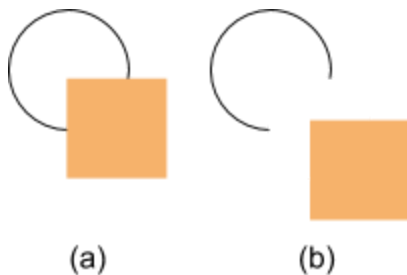


Figure 3.6: it is perceptual tendency to close the circle in (a) despite the actual Figure being an arc (b)

Figure and ground

A Figure is an object of focus that is perceived as the foreground whereas ground is the background. With a combination of closure, common region and layout, graphical patterns which need focus can be perceived as Figures rather than as ground. This is necessary when convex shapes need to be highlighted as they draw more focus to the background.



Figure 3.7: In (a) the colour surrounding the shape is interpreted as the foreground whereas in (b) the shape in the centre itself is seen as the foreground.

3.1.2 Human cognition

The main factor that influences information cognition is memory and attention. Human memory can be subdivided into iconic memory, visual working memory and long term memory (Ware, 2013).

Iconic memory is a short-term image store that holds what is on the retina. This can be viewed as the first level of filtering information. The more something stands out from its background, the longer it stays in the iconic memory and is transferred into the visual working memory. An understanding of the iconic memory can help make decisions regarding how to draw attention to specific regions on a dashboard. It is the iconic memory that necessitates emphasis of data that is important and de-emphasis of that which is unimportant.

The visual working memory holds information acquired during immediate attention. However, information in the visual working memory is made meaningful when combined with experiences stored in the long term memory. It is hence necessary to give context to the information on a dashboard to ensure proper correlation between experiences stored in the long term memory and information obtained from the visualization. This ensures clarity in the train of thought and quick interpretation of information which will result in effective analysis.

Long-term memory is the information that we retain from everyday experience, perhaps for a lifetime, but it should not be considered as separate from working memory. Information retained in the long-term memory greatly influences decision making and is driven by knowledge of past experience.

3.2 Visual design guidelines

Strong visual presentation of information on an interface can greatly affect how effectively it can be interpreted (Grabowski,1991; Mukherjee & Edmonds, 1994). Reading speed is strongly influenced by the organization of content on the screen (Galitz,1989) and when large quantity of information is organized well, information can be quickly interpreted (Ware, 2013). It is hence necessary to follow some key principles of visual design while creating information rich material.

Lee and Boling (1999) present a comprehensive literature study of screen design guidelines and suggest the following framework:

3.2.1 Typography

Typography includes the selection of typeface, the placement of text with respect to other objects on the screen and the use of signals and cueing. In order to enhance readability, typography must be:

- Consistent
- A mix of upper and lower case
- Spaced appropriately between words and lines
- Highly contrasted with the background.
- Left justified
- Limited to a maximum of two different typefaces on the screen

3.3.2 Graphical Images

Graphical images include symbols, diagrams and illustration. When used appropriately, they can provide functional guidance, aesthetic charm and corporate identity. Graphical images must be:

- Simple and clear with not too much detail
- Always included with the purpose of instruction, motivation or focussing attention.
- Labelled where required
- Relevant to the viewers prior knowledge and not offensive
- According to existing symbolic convention if part of circuits etc.

3.2.3 Colour

Colour is one of the most effective ways of enhancing information processing, content organization and increasing interest in an information display. The significance of colour varies with age, intelligence, education and cultural backgrounds of a reader. On information displays, colour must be:

- Used conservatively, with a maximum of five plus or minus two colours per screen
- Consistent across all devices
- Used selectively to manipulate attention with bright colours

- A combination of cool, dark and low saturated images for backgrounds and hot, light and highly saturated colours for foreground
- Used in accordance with socio-cultural significance
- Used with higher levels of brightness for a younger audience.
- Used with different levels of saturation for the colourblind.

3.2.4 Animation and audio

Animated presentations can display complex processes which can be difficult to visualize. Audio can be categorized into voice/ speech, music and sound/natural effects. When audio accompanies information displays, it helps to draw attention to different parts of the screen, supports with reading and can be used to provide a sense of temporality through narration. The following guidelines apply to the usage of animation and audio:

- Small and simple animations used sparingly
- Animations used as a visual analogy for instruction of problem solving
- Use speech with subtitles on the screen.
- Use calm music to create a relaxing atmosphere and loud sounds for alarm and warning messages.

3.2.5 Composition

Composition involves the combined usage of typography, images, colours, animation and audio on the screen and the overall visual effect of the screen. Composition must:

- Follow the aesthetic principles of visual design like
 - Unity and Harmony - When all the elements on the screen come together to convey meaning as a whole.
 - Balance and Symmetry - When there is an even distribution of visual weight on the screen it is said to be balanced. Symmetry is a way of achieving balance where elements are distributed along an axis to mirror each other.
- Use screen space economically and parsimoniously with a simple and clear message.
- Avoid the use of distracting and unnecessary elements as screen elements above the minimum required will be experienced as annoying or distracting
- Be consistent in appearance, location and behaviour of screen elements such that elements of similar function share similar appearance, location and behaviour.

3.3 Dashboard design guidelines

Dashboards today go beyond their utility in Business Intelligence and are prevalent in the fields of entertainment, art and journalism. Due to its wide scope of application, guidelines regarding dashboard design are not only limited to academic literature. Guidelines for designing good looking dashboards can be found in several online resources as well as in company reports. However, the purpose of dashboards across all these applications remain the same: A concise presentation of data with emphasis on key indicators that help in analysis and decision making.

Existing dashboard design guidelines from academic literature, can be divided into data preparation, providing context, visual detailing, data emphasis, overview and details and quality of end result.

3.3.1 Data preparation

Raw data is complex. Understanding this level of complexity requires training and experience. Transformation of this complex raw data into a concise dashboard requires preparation. Cahyadi (2013) writes about the importance of identifying business drivers and metrics that make a difference and it is necessary to identify these metrics early. This helps to plan the context that frames the purpose of the dashboard. Therefore it is necessary to take the time to understand the data and learn the context of the numbers before moving to the design of the dashboard (Yau, 2011). However, this project does not focus on providing support for initial preparation as the chosen persona has significant expertise in this matter.

3.3.2 Context and story

In dashboard design, the term 'Context' is applicable at every level of granularity. Context in the dashboard overview is necessary to prepare the readers. This helps them understand the story a dashboard is trying to draw their attention to. At a lower level, context is necessary to understand the metrics that a graphic is highlighting. Existing literature speak of the importance of context and also provide guidelines on how to enhance context through proper visual presentation and data emphasis (Few, 2006, Cahyadi 2013). In order to present context in a meaningful way, it is necessary to know your audiences. It is also important to gauge their knowledge and level of experience with the data. For an audience with little knowledge of the data, context is the most important factor to help them understand the highlighted metrics as well the data as a whole. However, with audiences who have experience with the data in question, it is unnecessary to add detailed descriptions. A good way to achieve the right level of complexity is to use audience vocabulary for descriptions (Few, 2006). In the process of understanding audience vocabulary, the knowledge the audiences possess about the data becomes clear. Tufte (1983) also speaks of the significance of an accessible level of complexity of detail to enhance the visual quality of a dashboard.

While context in a dashboard helps a reader to understand information better, storytelling helps to remember the information a reader has understood. Yau (2011) explains that every data point is like a character in a book and it is up to the analyst to find out more about its past, present and future. It is necessary to find the relationships and interactions between the data points. This literal 'connection of dots' can help create a narrative which can give the dashboard a temporal flow. Steele and Llinsky (2010) further expand on this by saying that the most effective visualizations will make themselves a pivotal point in a narrative within the user's minds. Hence, visualizations connected to one another in the form of a narrative on an information dashboard can be retained in the memory of a reader better.

Providing context highlights the purpose of a dashboard (Cahyadi, 2013) and also helps the audience to understand the limitations of the dashboard. Providing a narrative structure further helps a reader remember the insights from an information dashboard better (Yau 2011).

3.3.3 Visual information design

In existing literature, guidelines regarding visual detailing are the most comprehensive. Dashboard visual guidelines discuss the correct use of colour, typography and visualization.

Appropriate use of colour in the design of dashboards enhances visual significance and quality of a dashboard. On a biological level, colours help to enhance perception by emphasizing details (Yigitbasioglu, 2007). However, there is a fine line between emphasis and overemphasis with colour and care must be taken to use colours in a non-intrusive way. Wong (2010) and Few (2006) suggest the use of muted colours for information dashboards with saturation levels found in nature. Such 'natural colour schemes' are easy on the eyes and promote readability without overemphasis. However, Steele and Llinsky (2010) recommend the use of bright colours to attract attention to different parts of the dashboard. It is hence essential to identify the usage scenario of the dashboard as both of the recommendations above are valid in different scenarios. If a dashboard is purely meant for attracting attention, like at the reception of a company where people tend to walk past very quickly, bright colours would be more appropriate. However, if the Dashboard is meant to be looked at for longer periods of time and draw conclusions from, muted colours would be more appropriate.

Typography affects the readability of a dashboard. However, it should not take the centre stage as data is the focus (Wong, 2010). Type should be designed to provide description where necessary without distracting the audience from the data. Simple and non-stylized fonts help to achieve this (Wong, 2010).

Few (2006) identifies one of the main issues with dashboard design as the misuse of the type of visualization. Most visualizations are meant to be used for specific purposes and when they are not used effectively, the data becomes unreadable. For example, Ware (2013) recommends a pie chart be used only when two values of a whole need to be compared. If a pie chart is used to compare more than 5 values (Ware, 2013) it becomes unreadable. In such a case, a bar chart could be used. This misuse of visualization greatly affects usability and interpretation of the dashboard's core message. Data displayed using concise and often small media that communicate the data and its message in the clearest and most direct way possible are most effective (Few, 2006). This project does not focus on providing support for choosing the correct visualization, as the chosen persona has significant expertise in this matter.

3.3.4 Data emphasis

Tufte (1983) and Few (2006) explain data emphasis as a multi-step process. This involves emphasising relevant data and de-emphasising what Tufte refers to as 'chartjunk'. Tufte explains the necessity to maximize the data-ink ratio in a visualization, where data-ink is the

information per unit space per unit of ink in printed data charts. Few extends Tufte's arguments to digital dashboards by translating data-ink to data pixels. Few describes data emphasis as a two step process which involves emphasizing data pixels and reducing non-data pixels. Both steps involve the use of good visual design practices.

Emphasis of data-pixels refers to the use of good visual design practices to highlight exceptions in the data on the dashboard. This involves effective use of gestalt laws like colour to enhance the perception of exceptions in the data (Yigitbasioglu, 2012). Large texts of information can also be summarised to highlight what is directly connected to the data on the dashboard. Few (2012) also explains that emphasis of data-pixels happens when unnecessary non-data pixels are removed. De-emphasizing non-data pixels requires eliminating unnecessary scale labels, gradients, metaphors and graphics like images on information dashboards. Figure 3.8 shows how a legend can be made to look less cluttered by de-emphasizing the non-data pixels.



Fig 3.8: (a) represents a legend with unnecessary clutter like borders and labels and (b) represents a clean legend with reduced non-data pixels, where the borders and labels have been removed and the text is made lighter.

Visual clutter caused by improper use of images also greatly affects readability and causes unnecessary distractions. Few (2006) explains that graphics serve merely as decoration. Hence little to no use of images on information dashboards is recommended. Few (2006) also advises against the use of metaphors while designing dashboards as metaphors distract viewers from the data rather than adding value. In his paper 'Dashboard Design: Taking a Metaphor too far', Few (2005) explains "Cute displays get boring fast". Visual clutter that arises from the use of metaphors falls under Few's (2006) label of 'useless decoration' and Brath's (2004) label of 'unnecessary gaudiness'. Data emphasis can thus be achieved by highlighting important information on the dashboard and removing unnecessary data clutter.

3.3.5 Overview and details

Before the advent of digital dashboards, executives used charts alongside large and tedious reports to make projections for their business. This often involved continuous cross-referencing between the graphs and the reports which wasted time and effort. Today, interaction within

digital dashboards targets this issue by allowing a smooth transition between overview and details. Interaction is essential for BI software to support a variety of audiences ranging from top level executives to heads of departments. Top level executives are generally concerned with a holistic perspective of the data and require a complete overview of critical information at all times. However, managers of certain departments would want to see more data pertaining to their department as well as the overview (Cahyadi, 2013). In order to maintain an effective single-screen dashboard, it is necessary to include interactivity to overcome the lack of space and incorporate a way of drilling down and filtering. Cahyadi (2013) refers to this as the zoom-in zoom-out feature. The zoom-out view of the dashboard provides a more holistic perspective of the data while the zoom-in view provides more details with respect to the departments. In this way different levels of granularity can be achieved with the use of an interactive dashboard.

Interactivity can also allow for drilling down on data to find the root cause of issues (Cahyadi, 2013). This is necessary to have logical connections between cause and effects within a company's Figures so that the issues can be proactively tackled (Yigitbasioglu, 2007).

3.3.6 Quality of end result

The final but important feature of a dashboard is the compactness and quality of the end result. Most literature speak of the necessity to limit the entire dashboard to a single screen to ensure compactness and easy processing of information (Few 2006, Cahyadi 2013, Yigitbasioglu 2007, Ericson 2010). This also means avoiding scrollable and multi-page dashboards which make it difficult to keep track of the information flow. Few (2006) and Ericson (2010) mention the use of interactivity as a way of organizing data to avoid tabbed and scrollable dashboards. However, limiting all the data a dashboard should convey on a single screen can be difficult. To ensure readability and an effective flow of information through the dashboard, a logical way of organizing the information is necessary. A proper mapping of the different information to the different regions of the dashboard can further enhance the readability of information on the dashboard. Few (2006) describes the following layout (Figure 3.9) to be followed while placing information on the dashboard:

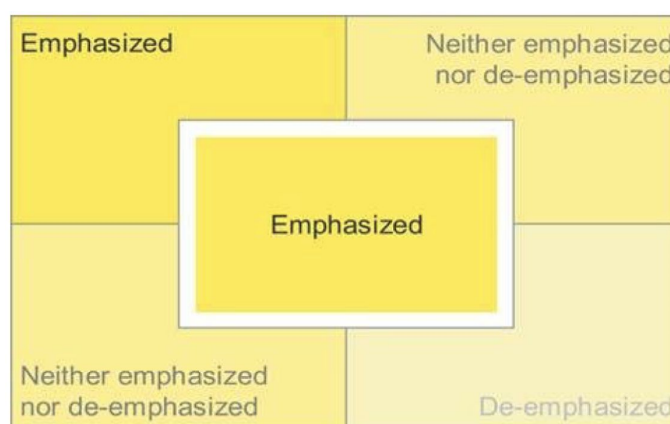


Fig 3.9: Few's (2006) degrees of visual emphasis vs regions of the dashboard

Few (2006) explains that readability of information decreases from the left hand top corner to the right hand bottom corner. It is described most effective to place important information on the left hand top corner. He also explains that information in the middle of the dashboard is only highlighted when it is differentiated from its surrounding information with the use of white spaces. He recommends non-data but necessary information, like a company logo, to be placed at the right hand bottom corner of the dashboard. It is also important to note that the principles of visual perception and the gestalt laws like colour, proximity, size and connectedness can further enhance data pixels and promote readability of information.

4 Methodology

This chapter describes the research and design methods that were considered throughout this thesis project. Details of how the methods are used will be described in the execution section of this report.

The double diamond methodology (Design Council, 2006) involves two main phases of ‘defining the problem’ and ‘designing the solution’ and this project follows Jones method of design thinking which includes two iterations of Divergence, Convergence and Transformation during these two phases. (Jones, 1992).

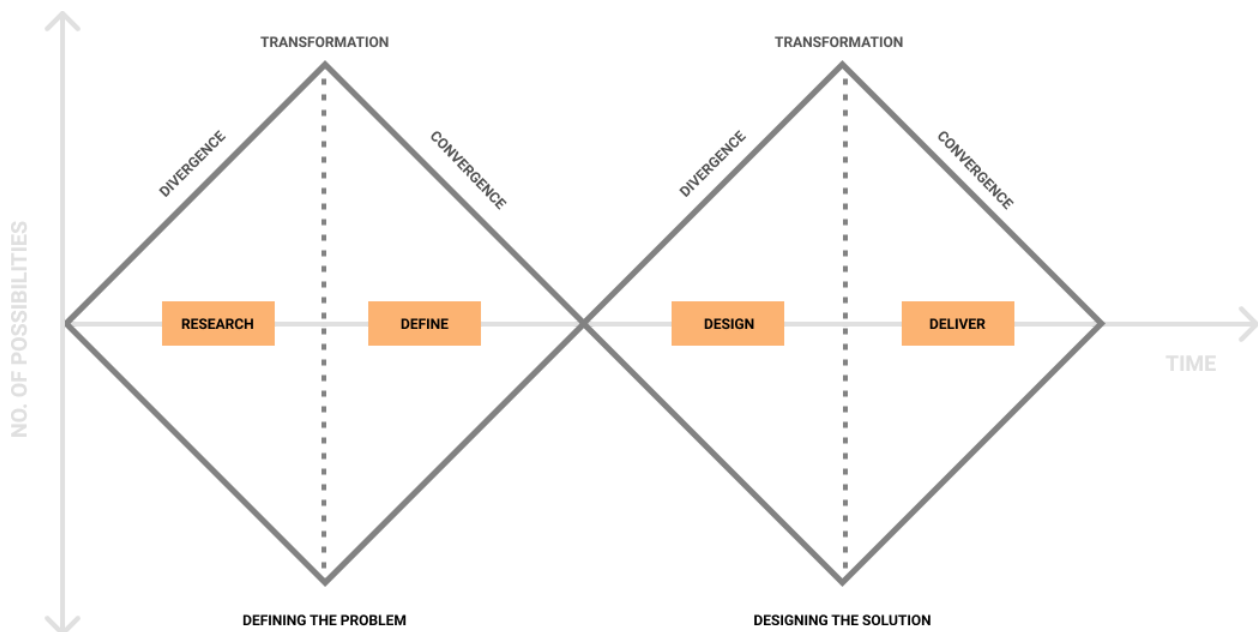


Figure 4.1: The Double Diamond model with two cycles of divergence transformation and convergence (based on Design Council, 2006)

The following sections contain a list of methods segregated based on their applicability in the Divergence, Transformation and Convergence phases. Multiple methods under each phase are listed, however, only a subset of the methods listed are made use of, in this project.

4.1 Divergence

Jones (1992) describes Divergence as “...the act of extending the boundary of a design situation so as to have a large enough, and fruitful enough, search space in which to seek a solution.” This phase involves design methods that are exploratory and expand the problem space to its limits. In this phase, it is necessary to identify facts and a context in order to understand

consequences and paradoxes of a design problem. (Jones, 1992). The common methods conducted during this phase are interviews and observations.

4.1.1 Interviews

Blessing & Chakrabarti (2009) describe Interviews as asking questions to collect thoughts and ideas about the past, present and the future events and experiences. Interviews can be categorized into unstructured, structured, semi-structured (Preece et al., 2011).

4.1.1.1 Unstructured Interviews

Unstructured interviews are explorative and the interviewer has little control over the process. They typically involve the interviewer asking open ended questions and the interviewees have the freedom to answer as briefly or as in detail as they please (Preece et al., 2011). Despite this freedom from structure, the interviewer must have a plan of things to be covered as the direction the interview takes might be unpredictable (Preece et al., 2011). A benefit of unstructured interviews is that the interviewee might bring up aspects that the interviewer did not consider but at the same time it can be time-consuming to analyse this rich data (Preece et al., 2011).

4.1.1.2 Structured Interviews

Structured interviews consist of “closed questions” which are short and clearly worded questions which require precise answers. Such an interview is most useful when the goal of the research is clear and specific question pertaining to the research can be identified. (Preece et al., 2011).

4.1.1.3 Semi-structured Interviews

A semi-structured interview consists of a list of open and closed questions and is hence a combination of both unstructured and structured interviews (Preece et al., 2011). The interviewer begins the interview with a list of planned questions and then probes the interviewee till there is no more interesting information on that subject (Preece et al., 2011).

4.1.2 Observation

Bill Moggridge (2016) labels “Observation” as the best way to learn about people in the context of a design problem. It involves looking at what people do rather than asking them what they did. The quality of the data acquired through observation is highly dependant on the skill of the observer. Observation can be performed in several different ways and the type of observation depends on the type of situation. Semi-structured and structured observations are explored in the following sections

4.1.2.1 Semi structured or casual observation

This technique is conducted in the exploratory phase of the design process and is conducted to collect baseline information through immersion in a topic that is new to the designer (Martin & Hanington 2012). The researcher may have a guiding set of questions but observes with an open mind. Departures from the plan are allowed with the occurrence of unexpected events during the observation.

4.1.2.2 Structured observation

Structured observations are more formal and a prestructure is established before conduction. This involves the use of worksheets, checklists or other forms of codifying behaviors, observed artifacts or events. This is more ideal when the environment and behavioural elements are predefined. (Martin & Hanington 2012)

4.2 Transformation

Transformation occurs after the research phase and involves externalising ideas in order to eliminate, combine, simplify, transform, or modify them (Jones, 1992). Some of the useful methods in this phase are affinity diagramming, design charrette and KJ analysis.

4.2.1 Affinity diagrams

Affinity diagramming is a process used to externalize and meaningfully cluster observations and insights from research, keeping design teams grounded in data as they design (Martin & Hanington 2012).

This process involves grouping sticky notes into categories into a “bottom-up” process for building affinity diagrams. The categories are formed after grouping rather than starting with premade categories. This process is useful when there is a large quantity of information that needs to be categorized. This also helps to externalize tacit information and discuss ideas more freely with team members. The process begins with recording the various topics of information on sticky notes. The notes are then posted to the wall. Then the team begins the rigorous process of interpreting notes and considering the underlying significance of each. Notes that share a similar intent or affinity are clustered together (Martin & Hanington 2012)

4.2.2 Design charette

A Design Charrette is a workshop style ideating technique which helps with cross pollination of design ideas (Martin & Hanington 2012). The participants can have vastly different skills and can involve both design and non-designers like users, engineers etc. This method is most useful when a problem space needs to be thoroughly explored and a wide range of ideas need to be

explored in a short time period. The ideas generated in this session can at best be rough drafts and lo-fi prototypes (Martin & Hanington, 2012).

On their website, The Nielsen Norman group (2018) describe a clear and concise step by step guide on how to conduct a Design Charrette:

Step 1- Gather all the participants in a room.

Step 2- Give everyone a few sheets of plain paper and a pen.

Step 3- Write a goal or a design challenge on the whiteboard.

Step 4- Communicate the charrette process, which is:

- Each person sketches his or her own ideas for 5 minutes.
- Each person works alone. No talking once sketching begins.
- When the 5 minutes are up, each person gets 2 minutes to show his or her ideas and explain the reasoning behind them.
- The group may then ask questions of each sketcher, spending one more minute on each person.

Step 5- The person running the meeting has to keep time and be diligent about it.

Step 6- At the end of the charrette, the UX designer collects the papers and uses the ideas generated to help derive a design.

4.2.3 KJ technique

The KJ technique is a way for a group to organize ideas and information and helps to build consensus within the group (Martin & Hanington, 2012). One of the advantages of the KJ technique is that it is conducted silently and a holistic assessment of ideas can take place as there is no single speaker moderating the process (Martin & Hanington, 2012). Spool (2004) lists an eight-step process that can be done with any size group in less than one hour:

Step 1 - Determine the focus question

The focus question drives the result and they can be along the lines of the following questions: *“Who are our users?”*, *“What features do users need?”* or, *“what goals does users have when they come to our site?”*

Step 2 - Organize the group

Bring together a group of people from different backgrounds in an organization and set up a time limit for the technique to be executed.

Step 3 - Put opinions on sticky notes

The participants must each come up with as many ideas as possible and write each idea on a separate sticky note.

Step 4 - Put sticky notes on the wall

At random, participants place sticky notes on a wall for others to see. If more ideas come up at this time, the participants can write them on more sticky notes and add them to the wall.

Step 5 - Group similar items

Find similar sticky notes and create groups by pasting the notes on another wall. This step is complete when all the notes are transferred from the first wall to the next.

Step 6 - Naming each group

Use a second color sticky note and name the groups. A group can have more than one name.

Step 7 - Voting for the most important groups

Everyone gets to vote on which group they find the most important to answering the focus question. This is done in three stages where each participant first chooses the three groups that seems the most important and writes these down on a paper. The next stage is to rank the choices from most important to least important. In the third stage each participant marks three X's on the sticky note with the name of the group that was most important, two X's on the second one and one X on the third one.

Step 8 - Ranking the most important groups

Now you grab the sticky notes with the group names that have X's on them and place them on a whiteboard. They should be ordered with the sticky note that has the most X's at the top, and in an ascending order. The top three or four ranked groups should be the most important things to consider answering the focus question (Spool, 2004).

4.3 Convergence

The Convergence phase begins with a defined problem, variables and objectives. The designer's aim reduce the secondary uncertainties progressively until only one of many possible alternative designs is left (Jones, 1992).

4.3.1 Creating user scenarios using Personas

Cooper (1999) describes personas as putting a "face on users". This practice-based approach involves creating characters with multiple attributes and individual histories to replace a one-dimensional user with limited attributes (Turner, 2010). Personas are presented with a short descriptions along with a given name and a photograph of the character. To give a more compelling impression of the lifestyle of the persona, supplementary pictures can also be provided pertaining to their activities.

User scenarios capture typical examples of interactions between the product to be designed and the user. Their concrete, narrative style of expression makes them very effective for eliciting requirements and for validating behavior models (Damas 2005). When integrated with personas, scenarios can illustrate how different target audiences navigate through the same situation, which help with formulating solutions for different situations (Muller, 2003).

4.3.2 Prototyping

Houde and Hill (1997) explain that prototypes are the core means of exploring and expressing designs for interactive computer artifacts. They can be created at various levels of resolution for development and testing of ideas within design teams and with clients and users (Martin & Hanington, 2012). Based on the level of resolution, prototypes can be divided into low fidelity and high fidelity prototypes:

4.3.2.1 Low fidelity prototypes

Lo-Fi prototyping is common throughout the early ideation process. This can include paper prototypes of concept sketches, storyboards or sketch models.

4.3.2.2 High fidelity prototypes

Hi-Fi prototyping is used for producing more refined results. This is often done when a concept is concretized and the look of the hi-fi prototype often resembles that of the finished product. In software design, high-fidelity usually implies an interactive prototype capable of providing a real user experience or feedback (Martin & Hanington, 2012).

4.3.3 Usability evaluation with or without a user

Usability is crucial in design. It is emphasized above everything as it is a requirement to reduce various user errors (Tan, 2009) Usability evaluation helps to curb these errors to create well designed products. There are several evaluation techniques which have been developed and incorporated in design and can be carried out with or without the user. Two such techniques are heuristic evaluation which is conducted without users and usability testing which needs to be conducted with the user.

4.3.3.1 Heuristic evaluation

A heuristic evaluation is described as an informal usability inspection method that requires evaluators to assess an interface against a set of agreed-upon best practices, or usability “rules of thumb” (Martin & Hanington, 2012). It is usually performed by usability specialists who have specific expertise in the kind of interface that is being evaluated (Nielsen, 1992). The most commonly used usability heuristics are the nine heuristics proposed by Nielsen (1990):

- Simple and natural dialogue
- Speak the user's language
- Minimize the user memory load
- Be consistent
- Provide feedback
- Provide clearly marked exits
- Provide shortcuts
- Good error messages
- Prevent errors

4.3.3.2 Usability testing

Usability testing focuses on people and their tasks and seeks empirical evidence about how to improve the usability of an interface (Martin & Hanington 2012). Nielsen Norman group (2018) define Usability testing as a way of watching real customers interact with an interface to determine actionable findings required to redesign a site or application. It can be conducted after the design phase and through multiple design iterations. The problems revealed by a usability test helps the designers understand the difference between using a prototype themselves versus when it is used by the intended end user (Caroll & Mack, 1984).

Jacobsen (1998) describes the the situations or errors that an evaluator should aim to rectify when identified during the usability test, as follows:

- When the participant understands the task but cannot complete it within a reasonable amount of time.
- When the participant understands the goal, but has to try different approaches to complete the task.
- When the participant gives up or resigns from the process.
- When the participant completes a task but not the task that was specified
- When the participant expresses surprise or delight
- When the participant expresses frustration, confusion, or blames themselves for not being able to complete the task
- When a participant asserts that something is wrong or doesn't make sense
- When a participant makes a suggestion for the interface or the flow of events.(Jacobsen 1998)

5 Execution

This chapter explains how the different phases of the project were conducted and executed in chronological order. At the beginning of the project, a project proposal was made which included a brief time plan of the phases that would be conducted. This time plan included multiple general phases along with suitable methodologies that could be used during each phase. The time plan was revised a few times and finalised by the end of the literature study phase. The final time plan can be seen in the Appendix A.

5.1 Literature study

The literature study was conducted for four weeks with different literature sources surrounding the fields of information design and visual design. For each piece of literature, summaries were created to highlight areas that required to be further explored and subsequently, literature regarding these areas was found and the process was repeated for four weeks. By this time, patterns had started to appear regarding overlapping information design guidelines. Once these overlapping areas were identified, they were categorized into overarching topics through affinity diagramming (Section 4.2.1) as shown in Figure 5.1. After creating the overarching categories, a spreadsheet was created including these categories with the subtopics that made up each category. Important points were added as notes to each subtopic from the literature summaries, to help with easy referencing later on. The spreadsheet helped to provide a good overview of the topics that were essential for this project comprising of topics under human perception and cognition, dashboard design and visual design. A summary of the subtopics under these three topics was created and is presented in the Theory (Section 3).

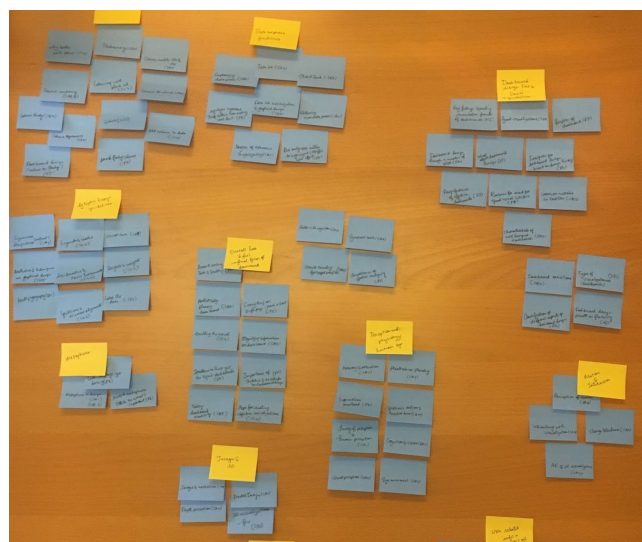


Fig 5.1: Affinity diagramming of literature topics

	A	B	C	D	E	F	G	H	I	J	K	
1	Visual Design Guidelines				Dashboard design guidelines				Human perception and cognition			
2	Data Emphasis Guidelines	Graphic design guidelines	Colour guidelines	Quality of end result- overall look and feel	Dashboard do's and don'ts	Steps involved in Dashboard design	Types of dashboards	Metaphors	Pattern recognition	Brain: Cognition	Eye: Perception	
3	Emphasizing data pixels(CB5)	Aesthetic techniques in graphic design of dashboards(CE8)	Why bother with colour(CC4)	Avoid using tabs and scrolling(PH)	Key findings regarding presentation formats and dashboards(PJ) including relevant literature	Dashboard design through a number of steps(PG)	Dashboard variations(CB2)	Cute displays get boring(PK)	Pattern recognition(CA5)	Memory and Attention (CA11)	Visual perception(CB4)	
4	Data Ink (CE4)	Fonts and typography (CL1)	Colour theory(CB4)	Everything on a single page- zoom in and zoom out (P-J)	What affects dashboard design(PJ)	Steps for creating effective visualizations(CC2)	Types of dashboards in visualizations (CD1)	Metaphors in design(CA1, CB3)	Gestalt laws(CA6)	Information overload(PG)	Eye movement(CA5)	
5	Highlight important stuff rather than making users do it (PH)	Gridlines and number alignments(CL2)	Colour appearance and use in Dashboards(CA4)	Building the visual (CC2)	Reasons for need for good visual interface(PF)	Importance of sketches and mockups (PF)	Avoid metaphors and design presets vs flexibility(PJ)	Visual encoding for rapid perception(CB4)	Theory of perception and human perception(CA1)	Cognition and vision(CA11)		
6	Data Ink maximization and graphical design(CE6)	Zero baseline and Y axis increments (CL2)	Dashboard design (Colour vs flashy) (P-J)	Location areas around the dashboard that are and aren't emphasized(CB5)	Characteristics of well designed dashboards(CB5)	Iterations to help get the right dashboards(PF)	BSC- Balance score card dashboards - definition		Preattentive processing(CA5)			
7	Chart Junk (CE5)	Legends and labels(CL2)	Avoid flashy colours(PH)	Small pattern visualization is a large information space(CA11)	Design features of effective dashboards(PJ)	Testing dashboard usability(CB7)			Epistemic action and reaction time(CA10)			
8	Reducing non-data pixels(CB5)	Visual cues(CD9)	Add colour to data (CC4) more details about luminosity, hue		Common mistakes in dashboards(CB3)	Classification of different aspects of dashboard design(PG)						

Fig 5.2: Literature topics categorization on spreadsheet

5.2 Expert interviews

This section describes the expert interviews that were conducted during the formative stages of the project. The purpose of the interviews was to get an understanding of the requirements for designing good-looking dashboards, both from The Company's perspective, as well as their customer's point of view. Although customers were not directly interviewed, four of the experts chosen were involved in interacting with customers on a regular basis and they were asked questions pertaining to customer interactions.

5.2.1 Methodology

The interviews were conducted with 5 experts from The Company. Each interview conducted was semi-structured and thirty minutes long. Three of the interviews were conducted in person and two were conducted remotely over a web based voice call service. All interviews were audio recorded and a note taker was present for three interviews.

5.2.2 Interviewee backgrounds

The participants for the interviews were selected because of their broad and diverse areas of expertise in terms of The Company's data analysis tools. The experts included the head of product, the product manager of visual analytics, the manager of user experience (UX) and technical communications (TC), the lead visual designer and a data scientist within The Company. The head of product and the managers were involved in interacting with customers and had a good knowledge of their customers' requirements. The head of product who managed other product managers, focussed on speaking to customers, support, sales and figuring out what requirements to prioritize. The product manager worked with visual analytics, specifically with finding problems and opportunities in the market pertaining to visual analytics. The manager of UX and TC worked on identifying and prioritizing issues regarding user experience and usability. The data scientist's role also involved interacting with customers and she helped data scientists from client companies analyse their data and follow best practices of

dashboard design within the tool. The visual designer did not directly interact with customers but worked with other visual designers and the UX team to create a framework for visual styling of a dashboard within the tool.

5.2.3 Insights from the interview

This section highlights the key points which were brought up by the interviewees. Three sets of questions were created and the interviews were structured around these questions. The questions can be found in Appendix B

5.2.3.1 Head of product and product managers

The interviews with the head of product and the managers were centered around customer feedback on dashboard styling within The Company's tool. All three interviewees mentioned that customers often compared the quality of the resulting dashboards on their tool to competitor tools.

"They generally comment on the quality of the end result and ease of use" - The head of product.

The head of product said their customers used these two features for benchmarking their tool against competitor tools. The product managers of visual analytics said that good looking end results were especially important to certain business sectors like the beauty industry.

"The beauty industry have styling in their DNA, it is very important to them how the end result looks." - Product manager of visual analytics

They all mentioned that the lack of proper styling features have resulted in them losing customers to competitors. When asked about what features they would like to include or change within the tool, the product managers mentioned multiple points.

"The absence of ugliness." The product manager of visual analytics

This meant identifying the details that could make the dashboard look ugly like crowded or truncated scale labels or inflexible legends. He said targeting those issues and identifying ways to limit excess detail on the dashboard should be prioritised. The manager of UX also mentioned that providing too much flexibility with lots of styling settings would give the users more opportunities to make incoherent dashboards.

"They would touch everything" - The manager of UX when asked about providing multiple settings for styling a dashboard.

He said that the tool must be designed with a limited number of options and a workflow that would automatically aid in good design practices. He also mentioned that users who lacked design knowledge could find it difficult to apply design guidelines while styling a dashboard. He mentioned that in such a case, it was much more impactful to work from example dashboards which followed good dashboard design guidelines because this could help users understand how guidelines were applied. However, the head of product mentioned that while it was good to provide good dashboard styling features, it was important to keep in mind that all features must be data-driven as their tool is much more than just beautiful dashboards.

“At the end of the day, it’s all about the data. Aesthetics is one thing, but data is the core of the product.”- The head of product.

5.2.3.2 The data analyst

The data analyst was interviewed about the different tools or references she used when she designed dashboards.

“a good dashboard is not that which is just beautiful but also something that is clean and modern and easy to understand.”- The data analyst when asked to define a good dashboard.

She was also asked about the best practices she followed while designing a dashboard, to which she mentioned the following points:

- a. Hide things you don’t need. For example, data panels, access labels, dropdowns are not required to be shown.
- b. Think about layout of the page and plan the content such that there is not too much clutter
- c. Think of what you want to communicate on that page and highlight the important information.

She said that the quality of the end result of the dashboard is limited by time. In such a case, she said it was necessary to make it look good by reducing the effort and thereby time taken.

“Analysts lack both visual design skills and the ability to put themselves in the dashboard reader’s shoes.”-The data analyst when asked about what support analysts would require to create good looking dashboards.

She said that the analysts struggled with figuring out a proper layout for the dashboard. Analysts seemed to include too many visualizations on the dashboard while she believed the maximum should be four. She mentioned that she often worked from example dashboards she found on The Company’s community page as they gave her a good starting point. When asked what feature she would like to include in the tool to help with styling, she spoke of the need for a template panel which had different themes for users to choose from which would greatly reduce time and effort.

5.2.3.3 The visual designer

The questions for the visual designer were centered around best practices in visual design and design principles for dashboard design. The designer mentioned key principles he followed to create good looking dashboards. He stressed the importance of:

- a. Harmony and coherence of all elements on the dashboard
- b. Applying a design only if it has a valid purpose
- c. Highlighting key information that needs to be conveyed.
- d. Removing unwanted clutter from the dashboard
- e. Choosing a uniform colour scheme
- f. Choosing a limited number of font sizes and type faces.

He said that he spent most time on composition and making sure everything was aligned. He also stressed the importance of modifying different characteristics like colour, composition, layouts, alignments etc. step by step and iteratively.

“A dashboard is well designed when it is easy to find and manipulate something without having to look for it.” - The visual designer when asked to define a well designed dashboard

He says that this is impossible when there is too much noise on the dashboard which is usually caused due to too many colours, too much information and improper structure. He also mentioned that it is necessary to understand visual design principles to understand how to apply dashboard design guidelines. To help the users who don't understand visual design, he believed it is necessary to give them a head start by showing them the right way to apply spacing and achieving balance on the dashboard.

5.2.4 Discussion

The interviews were essential in understanding The Company's as well as their customers' perspectives of good looking dashboards. It helped to provide a general sense of the features that were necessary to make dashboards look good. It was clear that providing good end results after styling a dashboard was essential to The Company as the lack of it made them lose their customers to competitors. It could be concluded that they required a dashboard styling solution that could help their users save time and effort. They stressed the importance of providing their users with a good starting point to create a clean and good looking dashboard along with an interaction flow that helped them to automatically apply dashboard design guidelines within the tool. They also required any formulated solution to be data-driven as it was the core of their product.

5.3 Essential requirements

The essential requirements were identified as a result of the literature study and the expert interviews. These requirements were identified as bare minimum when creating good looking dashboards based on dashboard design guidelines (Section 3.3), visual design guidelines (Section 3.2) and the discussion during the interviews (Section 5.2). Hence to create a good looking dashboard, it was deemed that the dashboard must:

- a. Follow a uniform and harmonious composition
It is essential to maintain balance and consistency of all the elements on the dashboard as this assures a pleasant experience for the reader (Sections 3.2.5, 5.2.3.3).
- b. Follow a uniform colour scheme
A uniform colour scheme can enhance visual significance, quality of the dashboard and increase interest of the reader in the information displayed (Sections 3.2.3, 3.3.3, 5.2.3.3).
- c. Always be data-driven
It is necessary that the the resulting dashboard is always data-driven because the data is the core of the dashboard and must always be prioritised over the aesthetic appeal (Section 5.3.2.1).
- d. Minimize clutter
Unnecessary clutter like redundant labels, gridlines, dark borders etc. can create noise on the dashboard and removing or reducing them, can help to identify key information much faster and without distractions (Sections 3.3.4, 5.2.3.2, 5.2.3.3)
- e. Follow a layout that supports readability
A clear and logical way of organizing the information on the dashboard is necessary to ensure readability. A suitable content structure for all the information on the dashboard can make it easy to find necessary information without having to search for it (Sections 3.3.6, 5.2.3.3).
- f. Provide a clear context for the information
A clear context is necessary in the dashboard overview to prepare the reader for what to expect on the dashboard. It also helps a reader remember the analysis presented on the dashboard, more effectively (Section 3.3.2).
- g. Highlight key information and relationships between data
Since the purpose of the dashboard is to quickly interpret the results of an analysis, highlighting key information and relationships can help with this (Sections 3.3.4, 5.2.3.2, 5.2.3.3).

These requirements were defined in a general sense because different literary sources explained different ways of achieving these requirements. The following sections aim to identify specific ways of achieving these requirements within a data analysis tool.

5.4 Design workshop

Based on the user scenario described (Section 2.2) a workshop was planned to identify ways in which the essential requirements (Section 5.3) for a good looking dashboard could be satisfied. The goal was to identify what support would be required to help users satisfy these essential requirements.

The design workshop was conducted at two separate instances with two groups of participants. One group involved six employees of The Company who were familiar with The Company's tool and the second group involved six students at Chalmers University who had no prior knowledge of the tool.



Fig 5.3: Workshop conducted at The Company (a) and with students at Chalmers University (b)

5.4.1 Workshop setup

Each workshop was set up the same way and conducted for 25 minutes each. The participants were given the task of styling a dashboard for a fictional supermarket "Fresh Inc." based on a sample fruit sales dataset. As in the User Scenario (Section 2.2), it was assumed that the data analysis was already performed and participants were required to focus solely on styling the dashboard. Each participant was presented with a sheet of A4-sized paper along with elements which were cutouts of premade visualizations, filters and images based on the sample dataset. These cutouts were provided in sets of three different colour schemes, orientations and sizes. The visualizations included sales information about six fruits and vegetables: bananas, apples, pears, cucumbers, lettuce and tomatoes. As a starting point, the participants were given the following problem statement: 'Fresh Inc. want to know how bananas have been selling

compared to other fruits and vegetables'. To make the dashboard data-driven, the participants were asked to keep in mind the following data-related questions while designing their dashboard:

To observe in what way participants conveyed dashboard context.

- a. What is this dashboard about? Is it possible to tell immediately by looking at the dashboard, what it is about?

To observe how participants highlighted key information

- b. What sells the most?

To observe how participants highlighted relationship between visualizations

- c. How do the total sales per month change in comparison with the sale of Bananas every month?

The participants were required to make note of the steps they took while creating the dashboard. After 25 minutes, each participant was asked to describe their dashboard and how it answered the data related questions.



Fig 5.4: Workshop setup

5.4.2 Methodology

The purpose of the workshop was to observe what the participants prioritised while styling their dashboards and compare it with the essential requirements. The observations were semi-structured (Section 4.1.2.1) where the participants were required to complete a task and were observed with an open mind and a guiding set of questions as to what steps the participants undertook while styling their dashboards. The goal was to not interfere when the participants completed the task but they were free to ask questions as and when required. During the observation, the essential requirements were cross referenced to see if the participants:

- a. Maintained a uniform and harmonious composition
- b. Created a dashboard that was data-driven
- c. Followed a uniform colour scheme
- d. Minimised clutter
- e. Followed a layout that supported readability

The data-related questions were also given to participant to see how they

- f. Conveyed context of the information on the dashboard
- g. Highlighted key information and relationships between the visualizations

The workshop was followed by structured interviews where each participant was asked to describe their dashboard design and how their dashboard answered the data-related questions provided to them.

5.4.3 Workshop results

The results of this workshop were based on the observations conducted during the workshop and interviews conducted after the workshop. The workshop yielded contrasting results between the two groups. The participants from The Company, who had knowledge of The Company's tool, designed their dashboards with the capabilities of the product in mind. The interaction on all their dashboards was limited to the visualization, similar to The Company's tool. However the students who did not have knowledge of the tool, designed the dashboard based on websites they used and based on their experience with presentation tools like Microsoft Powerpoint.

The quotes mentioned throughout this section are labelled from I,II, III, IV for participants from the UX team and V,VI,VII for participants from Chalmers. It should be noted that these participants are a subset of the total number of participants who were involved in the design workshop. The dashboards created by the participants have been shown in the Appendix C. The following observations were made based on the essential requirements.

5.4.3.1 Maintaining a dashboard composition

All participants took time to understand the different visualizations before they proceeded with their design. Only one student made a sketch of what he wanted the dashboard to look like before he picked up the different elements to place on the dashboard. All others directly picked up the elements with no specific design in mind. It was observed that the final composition of the dashboard the participants came up with was based on trial and error.

5.4.3.2 Following a uniform colour scheme

While picking elements to place on the dashboard, participants either chose all visualizations of the same colour or picked an image and then choose visualizations based on the colours of the image. Most participants chose all visualizations of the same colour scheme. While some did not notice the difference in the colour of visualizations until it was discussed, some participants chose different colours based on the information the visualization was trying to convey:

“I chose the colour based on what went with the fruit I wanted to highlight. Since I wanted to highlight Bananas, I chose the brightest yellow” (I)

It was observed that almost all participants chose a uniform colour scheme across the visualizations and found it very easy to do so because of the premade colour schemes that were provided to them.

5.4.3.3 Creating a data-driven dashboard

It was observed that participants were mainly involved in two tasks, answering the data-related questions and making the dashboard look good. It was also observed that participants switched repeatedly between the two tasks. Even if it seemed difficult to answer the data related questions at first, it was seen that most participants were able to answer the data-related questions in the end. One participant explained:

“I started by keeping the question in mind but if it was not possible to answer the question, then maybe I focussed on making it look good and then go back”(II)

Hence, two main tasks were identified when the participants designed their dashboards, the data-driven task which involved selecting the right visualizations and the styling task which involved choosing the right colour scheme and layout, and the participants would switch between the two tasks and accomplish them iteratively.

5.4.3.4 Minimizing clutter

Since the pre-styled visualizations and filters already contained minimal clutter with clean legends, no borders and plenty of white spaces between the visualizations, almost all participants automatically created dashboards which had minimum clutter.

5.4.3.5 Following a layout that supported readability

It was observed that choosing the desired layout for arranging the visualizations was done iteratively by the participants:

“After I checked if my dashboard answered the questions, I asked myself ‘does it look ok?’ and kept changing the positions till it made sense”(III)

It was also observed that some participants had a clear idea of how they wanted the flow for the reader to be:

“I designed my dashboard from left to right because people find it natural to read from left to right” (I)

5.4.3.6 Conveying dashboard context

To convey the purpose of the dashboard, most participants at The Company felt a title and an image were both required:

“The image is to immediately understand that the dashboard was about fruits but the title could be more specific to the department that was using the dashboard like, for example, the sales team of Fruit Inc.”(I)

Additionally, the students felt that along with the title, creative and interactive pop ups could help convey the information on the dashboard better. One of the participants who designed the dashboard like a responsive website said:

“I would like fruits to pop up from the sides interactively as I scroll” (V)

Except one participant who was the visual designer at The Company, all others included images on their dashboards either to make the dashboard more attractive or to convey the purpose of the dashboard. When asked to explain, the visual designer said:

“I want my data to do all the talking, so I avoided images as they would distract” (IV)

Some participants from the student group also included images within the visualizations and created interactive icons on the screen that provided annotations and a story-like narrative to their dashboards:

“I included images on the pi chart because I felt it could be tiring to read from the legend” (VII)

5.4.3.7 Highlighting key information

It was clear that the sales data pertaining to bananas needed to be highlighted on the dashboard. There were multiple ways that the participants did this. Some participants from both groups pasted images of bananas on their dashboard, while the rest felt the colouring scheme of the visualizations was sufficient to convey that bananas were the focus.

“I chose the visualisations by looking at the colours which made the bananas stand out the most, because it was the focus of the workshop” (VI)

5.4.3.8 Highlighting relationships between visualizations

Out of the visualizations provided to the participants, two were related; *total sales of all fruits* and *total sales per fruit* needed to be compared to answer the data related question “How do the total sales per month change in comparison with the sale of Bananas every month?” By following Gestalt laws (Section 3.1.1.1), there were two ways of grouping these visualizations to show they were related: By colour and by proximity. To group by colour, the two visualizations would have to follow one colour scheme and the rest of the visualizations would have to follow another colour scheme. To group by proximity, the two visualizations could be placed closer together than the other visualizations on the dashboard.

It was interesting to see that none of the participants grouped the visualizations by colour. All participants who identified that the visualizations needed to be grouped, grouped them by placing the visualizations in close proximity.

5.4.4 Workshop discussion

This section contains further discussion of the results from the workshop and how they relate to the specific guidelines. It was observed that the application of the specific guidelines was not easy without proper knowledge and experience of dashboard design and visual design. These guidelines could only be achieved by providing proper support to automatically apply the guidelines within the data analysis tool. This section discusses the important findings from the workshop and also provides details about the specific guidelines to make them easier to apply.

5.4.4.1 Maintaining a uniform and harmonious dashboard composition

It was observed that most participants did not plan a composition for their dashboard but arrived at it by trial and error. However, one participant who planned his dashboard composition

beforehand, did not have to spend time changing it later as he had a clear idea of what he wanted the dashboard to look like. It is difficult to visualize what the dashboard end result would look like beforehand without the proper design knowledge. Hence to achieve a uniform and harmonious composition on a dashboard, a list of example dashboards could be provided to be used as inspiration. The essential requirement regarding dashboard composition can hence be made into a specific guideline for the current user scenario, in the following way:

G1: Provide a list of example dashboards to help achieve uniform and harmonious composition on the dashboard.

5.4.4.2 Following a uniform colour scheme

During the workshop, it was observed that providing the participants with pre-styled visualizations with predefined muted colour schemes helped to save time while choosing a colour scheme to apply for the entire dashboard. It also helped them to create uniformity on their dashboard as they chose all visualizations of the same colour to place on their dashboard. The essential requirement regarding colour scheme can hence be made into a specific guideline for the current user scenario, in the following way:

G2: Provide multiple predefined colour schemes to achieve a uniform colour scheme on the dashboard.

5.4.4.3 Creating a data-driven dashboard

The workshop showed that the participants roughly followed two steps while creating a dashboard:

- Data-driven tasks that include picking the visualizations to include
- Styling tasks that involve picking colour scheme and deciding a layout

It was observed that data-driven tasks were given more priority by the participants but styling was time-consuming. To ensure that the dashboard was data-driven, it was necessary to easily switch back to data-driven tasks from the styling tasks. Thus, integrating a compact styling framework as an easily accessible menu in the data analysis tool would ensure that the focus of the dashboard is the data. Thus, providing the flexibility to seamlessly switch between the styling and picking visualizations would help users focus more time on what matters to them which are the data-driven tasks. The essential requirement regarding data-driven dashboard can hence be made into a specific guideline for the current user scenario, in the following way:

G3: Provide an easy way of integrating the styling tasks into the data analysis process to make the dashboard data-driven.

5.4.4.4 Minimizing clutter

It was seen that providing participants with pre-designed visualizations and filters without borders, redundant legends and labels automatically helped them to automatically create un-cluttered dashboards. Since the styling task can take place at any point during the analysis process, it is necessary to be able to declutter the dashboard at any point during the data analysis process. Applying a minimal and pre-designed style to an empty dashboard can provide a clean starting point to users who prefer to style their dashboards first. Applying a minimal and pre-designed style to a populated dashboard can help to declutter a dashboard after all the data-driven tasks are completed. Providing this option to apply a minimal and pre-designed style either to an empty or a populated dashboard can provide the flexibility to automatically declutter a dashboard at any point of time. The essential requirement regarding minimizing clutter can hence be made into a specific guideline for the current user scenario, in the following way:

G4: Provide users with the flexibility to apply a predefined and minimal style to both an empty or a populated dashboard to automatically minimize clutter.

5.4.4.5 Following a layout that supports readability

It was observed that the participants spent most of their time deciding on a layout to arrange the elements on the dashboard. Even by the end of the 25 minutes, some participants were unhappy with the layout they had finished with and felt they needed more time. It was clear that providing pre-designed layout options to choose from could help them save time as well as effort. Furthermore, participants noticed that arranging information from left to right would increase readability. Adding to that, the different layout options can be designed according to Few's degrees of visual emphasis (Figure 3.3.6) to further enhance readability. The essential requirement regarding layouts can hence be made into a specific guideline for the current user scenario, in the following way:

G5: Provide users with multiple layout options, designed according to Few's degrees of visual emphasis, to achieve a dashboard layout that encourages readability.

5.4.4.6 Conveying dashboard context

As per dashboard design guidelines, the title is essential to convey context and purpose. All dashboards created by the participants were observed to have titles. A title could hence be considered as an essential element on the dashboard while providing help with layouts. The essential requirement regarding context can hence be made into a specific guideline for the current user scenario, in the following way:

G6: Provide space for a descriptive title on a dashboard to help a reader understand immediately what the dashboard is about and convey a clear context.

But it is important to note that almost all participants chose to use images in their dashboards to convey context. Images on dashboards could not be completely removed as companies that use data analytics software include logos and brand specific images on their dashboards. Hence it was necessary to provide a design solution that allowed users to **include images, if any, in a non-intrusive way.**

5.4.4.7 Highlighting key information

It was observed that participants were able to recognise that bananas were highlighted through the color scheme of the visualizations. A contrasting colour was used to highlight data regarding bananas. Hence, a solution that included well-designed colour schemes with contrasting colours for key information and exceptions could make it easy to highlight key information. The essential requirement regarding highlighting key information can hence be made into a specific guideline for the current user scenario, in the following way:

G7: Provide contrasting colours in each colour scheme to highlight key information.

5.4.4.8 Highlighting relationships between visualizations

It was observed that all participants chose close proximity to show that two visualizations were related. However, close proximity might be difficult to identify when a dashboard is densely populated. A more powerful way of showing relationship between two visualizations, could be to apply the Gestalt law of connectedness which is seen to be more effective at conveying a relationship than proximity (Section 3.1.1.1). Allowing the option to group related visualizations into a single connected block could be an effective way of highlighting a relationship between them. The essential requirement regarding highlighting relationships can hence be made into a specific guideline for the current user scenario, in the following way:

G8: Provide the option to group visualisations into a single connected block to highlight relationships between them.

5.4.5 Conclusion

The specific guidelines identified for creating good looking dashboards within a data analysis tool are as follows and labelled from G1 to G8:

G1: Provide a list of example dashboards to help achieve uniform and harmonious composition on the dashboard.

G2: Provide multiple predefined colour schemes to achieve a uniform colour scheme on the dashboard.

G3: Provide an easy way of integrating the styling tasks into the data analysis process to make the dashboard data-driven.

G4: Provide users with the flexibility to apply a minimal and pre-designed style to both an empty or a populated dashboard to automatically minimize clutter

G5: Provide users with multiple layout options, designed according to Few's degrees of visual emphasis, to achieve a dashboard layout that encourages readability.

G6: Provide space for a descriptive title on a dashboard to help a reader understand immediately what the dashboard is about and convey a clear context.

G7: Provide contrasting colours in each colour scheme to highlight key information.

G8: Provide the option to group visualisations into a single connected block to highlight relationships between them.

The ideal dashboard would be one that followed a uniform colour scheme, included white spaces for readability and had minimal use of images. Out of all the participants, only one participant, the visual designer at The Company, created a dashboard in accordance with these criteria. One of the main observations was that most participants relied on instinct and trial and error while styling their dashboards while the visual designer designed the dashboard out of experience and design knowledge. This necessitated the need for these specific guidelines to be incorporated into the core of the tool such that users would automatically follow the guidelines without having to learn how to apply them.

5.5 Ideation

This section describes the ideation session which was conducted at The Company with the UX team at The Company and describes the main ideas which were brought up during the session.

5.5.1 Ideation setup

The ideation session was conducted for 30 minutes following the design workshop at The Company. The method employed was a modification of the Design Charrette (Section 4.2.2). The participants were given a question to ideate upon and were required to sketch out their ideas in pairs. After 10 minutes of discussion, each group had to present their ideas for a minute and the remaining participants could ask questions after their presentation.

This ideation session was a great way to generate several ideas and insights about making dashboard styling easier. Since it followed the design workshop, participants had a good idea about the context of the problem and were able to come up with several ideas that targeted issues they had encountered in the design session. However, the ideation session overshot 30 minutes as the discussion, after every group presentation, exceeded the allotted time.

5.5.2 Methodology

Following the design workshop, the participants began the ideation session with the following question:

“What support for styling would you need, to create the dashboard you just designed?”

Next, the participants were paired and required to list their ideas based on the question above. After ten minutes of ideation, the groups took turns to present their ideas for a minute. Every presentation was followed by discussions as well as a general discussion towards the end of the design session where participants chose ideas they all agreed on. The entire ideation session lasted for 40 minutes.

5.5.3 Ideation results

This section provides an overview of the ideas that were discussed in the previous section. Based on the results of the ideation, this section is divided into the following subsections: Colouring and styling, layout and alignments and access to styling features.

5.5.3.1 Colouring and Styling

Most participants felt that pre-styled templates which could be seen in presentation tools like Microsoft Powerpoint, could help them with creating beautiful dashboards quickly and easily. They felt this would help save time and effort and would allow them to give more time to data analysis. They also felt they needed flexibility to apply a style at any point during the data analysis. It was also required to include some way of choosing colour schemes directly from an image. They said that this would make it easy to transfer brand colours from a company website for example, from just a screenshot of their company’s homepage.

5.5.3.2 Layout and alignments

The participants came up with the idea of separate templates for just layouts options where users could pick different arrangements and permutations of visualizations. They also recommended the idea to make the layout options dynamic, such that they would rearrange as and when new visualizations were included on the dashboard.

5.5.3.3 Access to styling features

The discussion regarding access to styling features took two paths: a designer mode and a styling toolbar. One way was to have different modes like ‘analysis mode’ and ‘designer mode’ with separate access to analysis tools and design tools. This would allow users to focus on one task at a time, either analysis or styling, without having to worry about the other. The second way of accessing styling features was to have a styling toolbar included as any other toolbar along with other analysis-specific tools. This would allow the users to focus on the analysis task and have the styling as just an feature which could be accessed at any point during the analysis

process. The second option was more preferable as it would allow the dashboard to be data-driven and the styling could be a part of the analysis process which could be accessed at any point flexibly.

5.5.4 Discussion

This section presents a discussion of the ideation results with the features that can be implemented. This section is divided into *Colouring and styling*, *Layouts and Alignments* and *Access to styling features and concept*

5.5.4.1 Colouring and styling

A good solution for easy styling and colouring could be pre-styled templates. Providing multiple designs for the users to choose from, would serve as example dashboards to help achieve a uniform composition on the dashboard. Allowing the flexibility to apply templates to both an empty dashboard and a populated dashboard can provide either a clutter-free starting point or a clutter-free end point to the dashboard. The result would be a dashboard with minimal clutter in both cases. Each template could also be designed with a unique and uniform colour scheme, to automatically with one or more contrasting colours, to highlight key information easily. Each template could also provide space for a descriptive title to ensure that the context of the dashboard is conveyed. Users could also be given the option to customise the templates to apply a company's brand identity by picking a colour scheme and fonts from an image. Such a solution would provide the support to apply the following specific guidelines automatically:

G1: Provide a list of example dashboards to help achieve uniform and harmonious composition on the dashboard.

G2: Provide multiple predefined colour schemes to achieve a uniform colour scheme on the dashboard.

G4: Provide users with the flexibility to apply a minimal and pre-designed style to both an empty or a populated dashboard to automatically minimize clutter

G6: Provide space for a descriptive title on a dashboard to help a reader understand immediately what the dashboard is about and convey a clear context.

G7: Provide contrasting colours in each colour scheme to highlight key information.

Along with these specific guidelines, it is important that every template also follows all the essential guidelines mentioned in section 5.3 as each template can be considered as an "example dashboard".

5.5.4.2 Layouts and alignments

Providing the option to choose between recommended layouts would be a great way to save time and effort of the users. The users could also be able to easily customise their dashboard layout with the help of alignment tools like grids and rulers. All layouts could also be provided with a space to input a title to highlight the need for providing context. The layouts could also include options where some visualizations could be grouped together to show relationships between them. Support with layouts would help to apply the following specific guidelines:

G5: Provide users with multiple layout options, designed according to Few's degrees of visual emphasis, to achieve a dashboard layout that encourages readability.

G8: Provide the option to group visualisations into a single connected block to highlight relationships between them.

5.5.4.3 Access to styling features

It was clear that the participants required the flexibility to switch back and forth between dashboard styling and analysing data. A seamless solution that would allow for quick access to dashboard styling features during the analysis process, would keep the dashboard data-driven. Thus including a panel that would allow for easy access of styling features within the tool as and when required, would be the most helpful. Such a solution would help to apply the following specific guideline automatically:

G3: Provide an easy way of integrating the styling tasks into the data analysis process to make the dashboard data-driven.

5.6 Prototyping

During this stage of the project, a high fidelity prototype for dashboard styling support in a data analysis tool was created. The prototype was interactive and created in Figma which is a browser-based interface design tool. The main focus of the prototypes was to see how dashboard styling support could be incorporated in the tool. Prototypes were created iteratively based on regular feedback and recommendations from members of the UX team.

5.6.1 Initial concept

The ideation session revealed the need for a styling framework which mainly provided support with colouring and styling as well as layouts and alignments. Based on these ideas, the initial concept was formulated, consisting of **pre-styled templates** and **layouts** as a solution for achieving good looking dashboards.

The idea behind the templates was to provide users with different styles which could be applied automatically, to help users save time and effort. The template designs were also informed by the essential requirements identified after the literature study and the expert interviews. The templates hence consisted of a list of example dashboards, each designed with the following features:

- a. A unique colour scheme consisting of at least one contrasting colour to highlight key information
- b. A unique composition consisting of a clear structure or overall arrangement of all the dashboard elements for readability, proper use of white spaces, borders and images where relevant
- c. A unique combination of fonts which would promote readability

The layouts were designed to provide support with arranging visualizations uniformly on the dashboard. This consisted of a list of different permutation options for the visualizations on the dashboard. Each layout was designed to have the following features:

- a. A space for a title which would provide context
- b. A unique arrangement for the visualizations on the dashboard

During the prototyping stage, the layouts were only explored on a conceptual level as it was assumed that the different permutation options for the visualizations could be achieved algorithmically, for example, with the use of the Bin Packing problem (Lee 1985). It is important to note that the concept of templates and layouts overlapped because each template was also designed to have a unique overall layout of its own. An overall layout in the templates was necessary to achieve a unique composition. Hence, the templates were designed to provide support with a unique overall content structure and the layout permutations were made more specific to provide support with only visualization arrangements on the dashboards.

Once the concept of templates and layouts was defined, a styling framework was designed to incorporate the templates and layouts into a data analysis tool. The prototyping was hence divided into two parts: design of templates and design of the styling framework.

The design of templates involved prototyping different custom-made template designs based on dashboard design guidelines and visual design guidelines. After the custom made templates were created, they were shared with the UX team at The Company for feedback.

The design of the styling framework involved prototyping the interaction and access points for applying the design templates, layouts and other styling features. This design took inspiration from the ideas generated during the ideation phase for creating a styling framework to create good looking information dashboards. The design of layouts was also explored as part of the styling framework on a conceptual level as it was assumed that the different permutations for arranging visualizations could be achieved algorithmically.

5.6.2 Design of templates

The design of templates began with a review of various dashboards found on online communities dedicated to dashboard design, to provide inspiration for styling. A total of ten template designs were prototyped with unique colour schemes, composition and fonts. Each template was designed by applying the essential requirements described in section 5.3. The templates were divided into two groups based on the density of information on the dashboards. The first four templates consisted of up to four visualizations based on the fruit sales data from the design workshop. The last six templates comprised of eight visualizations and were based on Stephen Few's (2006) CIO dashboard shown in Figure 5.9. The following sections explain the features of the ten templates that were designed based on dashboard design and visual design guidelines. They are divided into templates with up to four visualizations and templates with more than four visualizations.

5.6.2.1 Templates with up to four visualizations

The first four templates comprised of visualizations based on the fruit sales dataset reused from the design workshop. Initially, a total of four visualizations were created- percentage sales per fruit (pie chart), total sales per fruit (bar chart), total sales of all fruits per month (line chart) and sales per month for each fruit (line chart) as seen in the Appendix C. Different combinations of these visualizations were used on the Templates 1 to 4.

Template 1: Bare minimum

The first design shown in Figure 5.5 was created considering bare minimum guidelines required to create a good looking and readable dashboard. This design was created by applying the essential requirements (Section 5.3) in the following way:

- a. Always be data-driven: This is done by sizing the visualizations to be large enough to draw more focus than the other elements on the dashboard. Distinction between data and non-data elements have also been provided with the effective use of colour which refers to the background of the 'filters' block coloured slightly darker than the visualization blocks.
- b. Follow a uniform and harmonious composition: This is achieved by placing related information on the same row and following a hierarchy of increasing level of detail from top to bottom.
- c. Follow a layout that supports readability: This is done by placing the visualizations in decreasing order of importance from left to right and placing The Company logo in the left hand bottom corner. White spaces are also included between the elements for readability.

- d. Follow a uniform colour scheme: This dashboard uses a muted blue colour scheme with a contrasting yellow to highlight key information.
- e. Provide a clear context for the information: The title of the dashboard placed on top helps to provide context.
- f. Highlight key information and relationships between data: This is done through the yellow colour which contrasts with the blue in the visualization.
- g. Minimize clutter: This dashboard only contains one block of explanatory text with minimal scale labels.

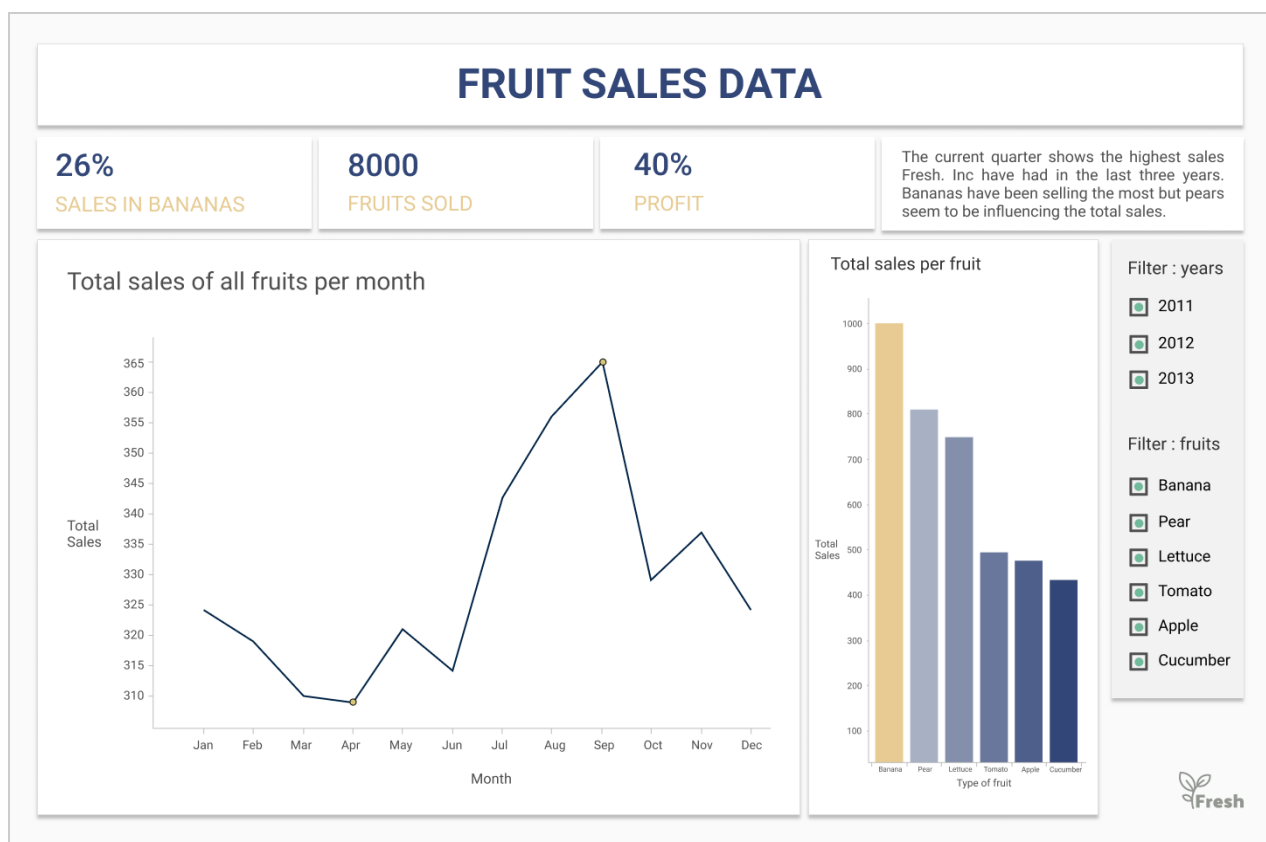


Fig 5.5: Template 1: Bare minimum

Template 2: Dark template with grouping

This template was created to show how a dark theme could be applied effectively to convey information. Along with the basic dashboard design guidelines listed above, this dashboard also follows a combination of two gestalt principles of proximity and connectedness (Section 3.1.1.1) to show grouping of visualizations that are related. The two visualizations ‘Total sales of all fruits per month’ and ‘Sales per month for each fruit’ are connected to each other via a single background area which shows that they are related graphs. The dotted line connecting the two

further shows that those particular data values that it passes through must be compared between the two visualizations. This was inspired from one of the dashboard designs created during the workshop (Appendix C).

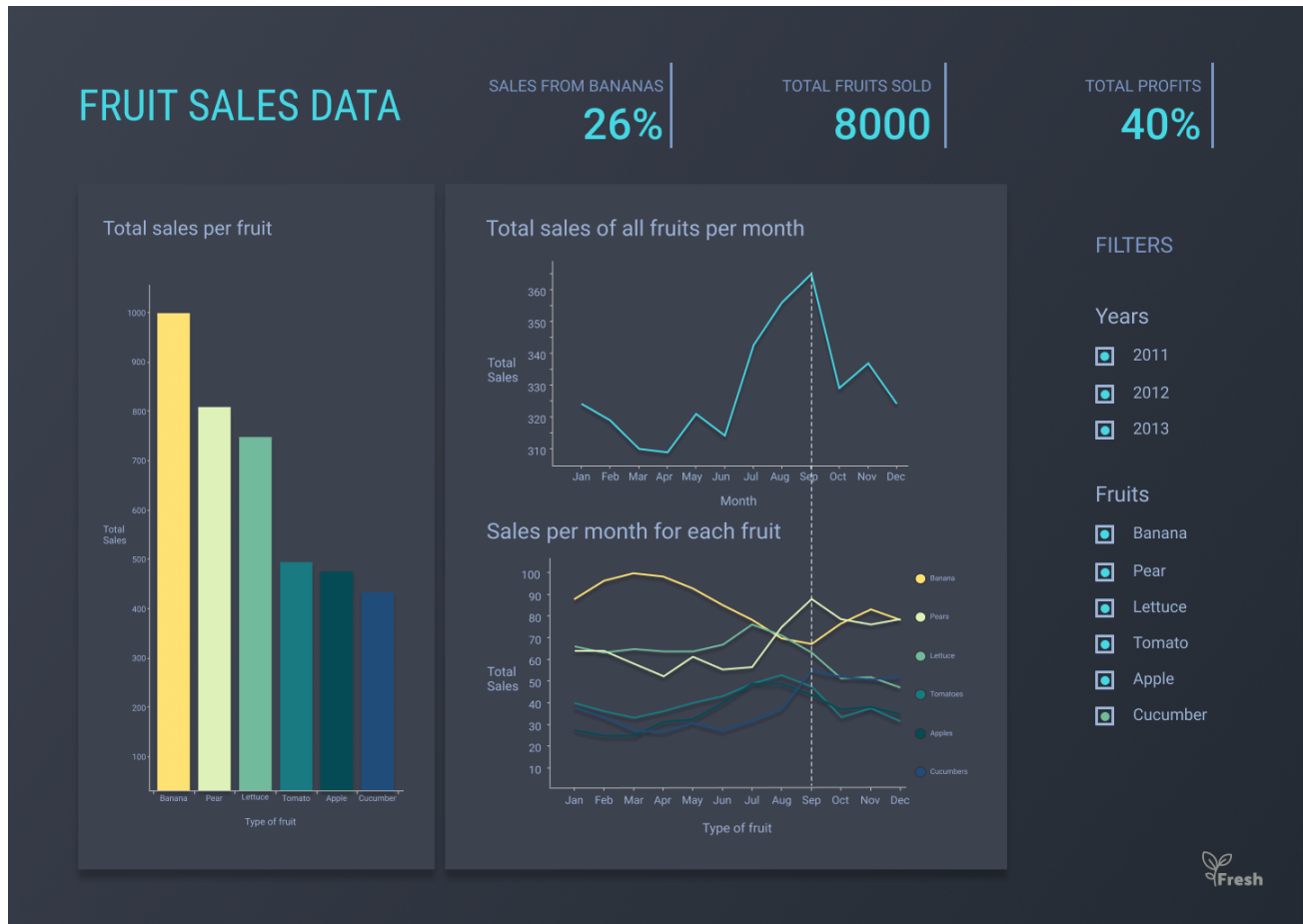


Fig 5.6: Template 2: Dark template with grouping

Template 3: Effective use of decorative images

This template (Figure 5.7) follows all the essential requirements listed under section 5.3 but also explores the use of images to make the dashboard more attractive. The design workshop revealed that all participants wanted to use images on their dashboards as the data was about fruits and the images of fruits would help to immediately provide context of the dashboard. They also felt that images made dashboards look more attractive and interesting. However, most did not know how to use images effectively on their dashboards. The purpose of using an image based background was to show how a decorative image could be used effectively without interfering with the data readability.

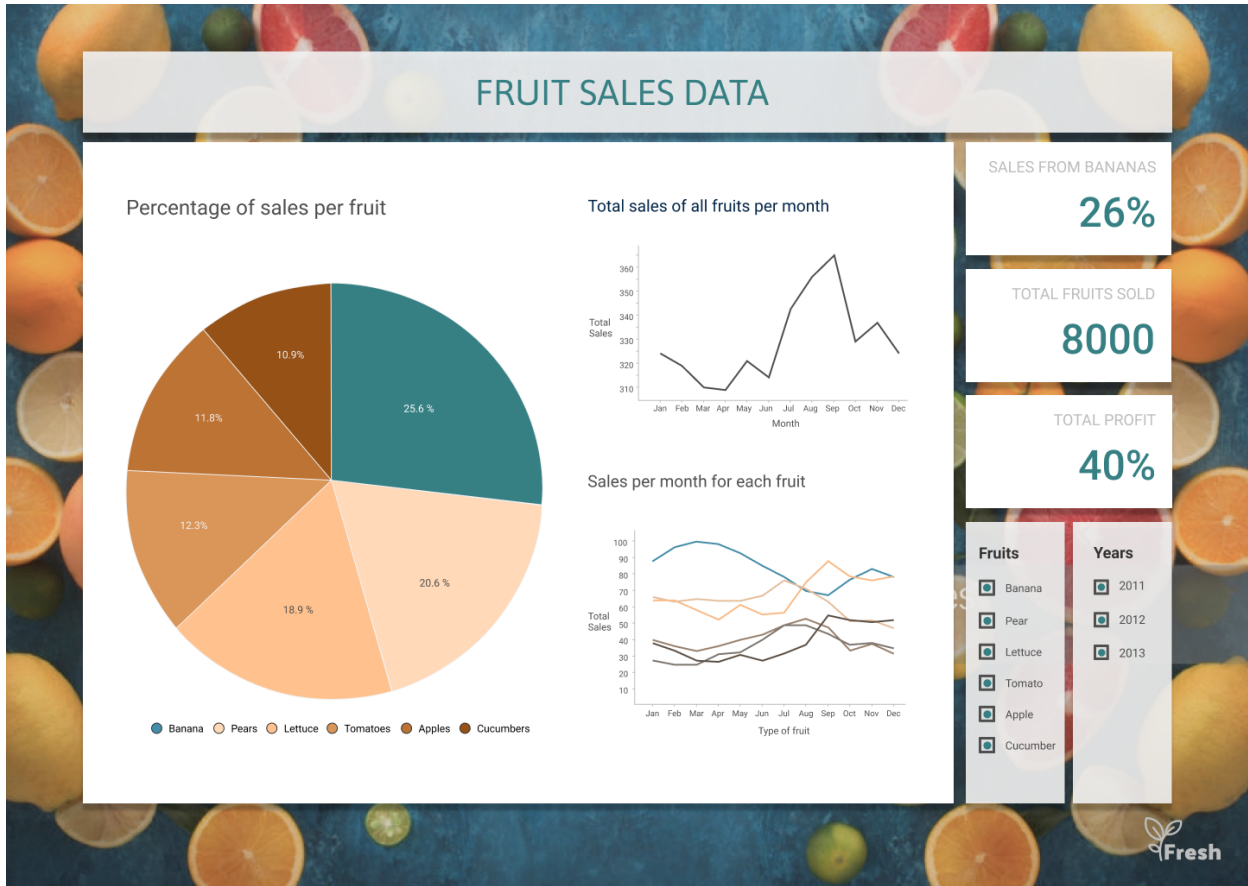


Fig 5.7: Template 3: Effective use of decorative images

This dashboard draws focus to the information in the centre, by using the gestalt principle of Figure and ground. Since the information area in the middle of the dashboard is brighter than the background image, it appears in the foreground prominently. The visualizations are also coloured based on the colour scheme of the image, which helps to maintain uniformity across the dashboard. An inconspicuous background that is low in saturation and brightness can help to convey the context.

When the UX team was asked for their feedback about the decision to use images as background, one of the members had an interesting point:

“I don’t find the image distracting because the colours melt in very well. But I fear that when there is a wall of dashboards, which I’ve seen companies display, it might be too much. If it was a stand-alone dashboard I think the image would not be distracting because the colours look nice.”

This was a valid point to note, because such a dashboard used alongside multiple similar dashboards could result in data de-emphasis and visual clutter. Another point to note is that such a design might not work with all images, it is necessary for the user to pick a coherent image with the right level of brightness, colour balance and saturation to achieve a readable dashboard.

Images must hence be used carefully, depending on the context in which the resulting dashboard will be displayed. This template could also be provided with a list of generic alternate images to choose from to apply a background image more specific to the information on the dashboard.

Template 4: Monochrome

The template in Figure 5.8 was designed to show how a stylish and modern dashboard could be designed using monochromatic colour scheme. This design uses the colour white to highlight key information on the dashboard.

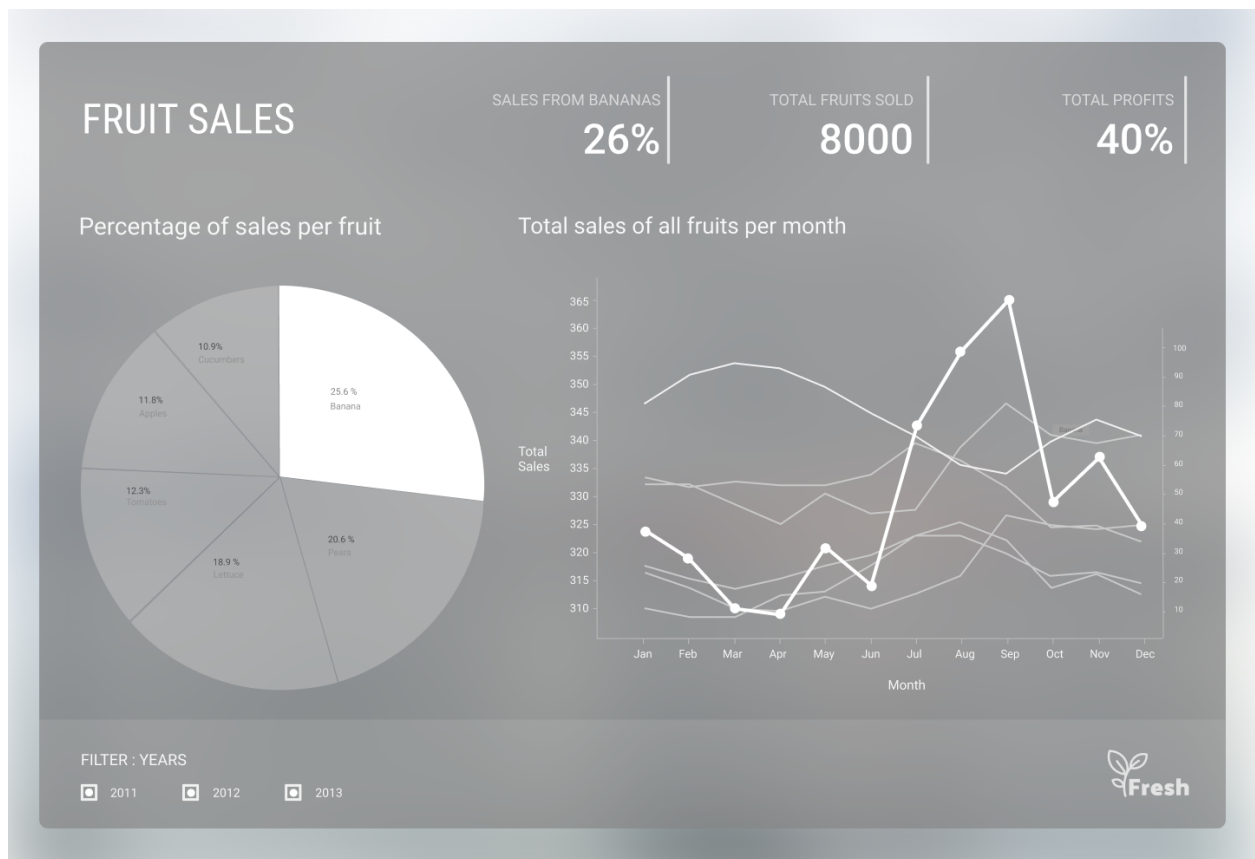


Fig 5.8: Template 4: Monochrome

5.6.2.2 Templates designed based on a densely populated CIO dashboard.

This section describes alternative templates for Few's (2016) CIO dashboard shown in Figure 5.9. The designs created based on this dashboard reuse the same structure as the CIO dashboard. However, they explore alternate methods of emphasizing data and alternate colour schemes. This is to give the CIO dashboard a modern feel through different colour schemes. The templates also explore different colour schemes to identify which would most effectively aid in the readability of densely populated dashboards.

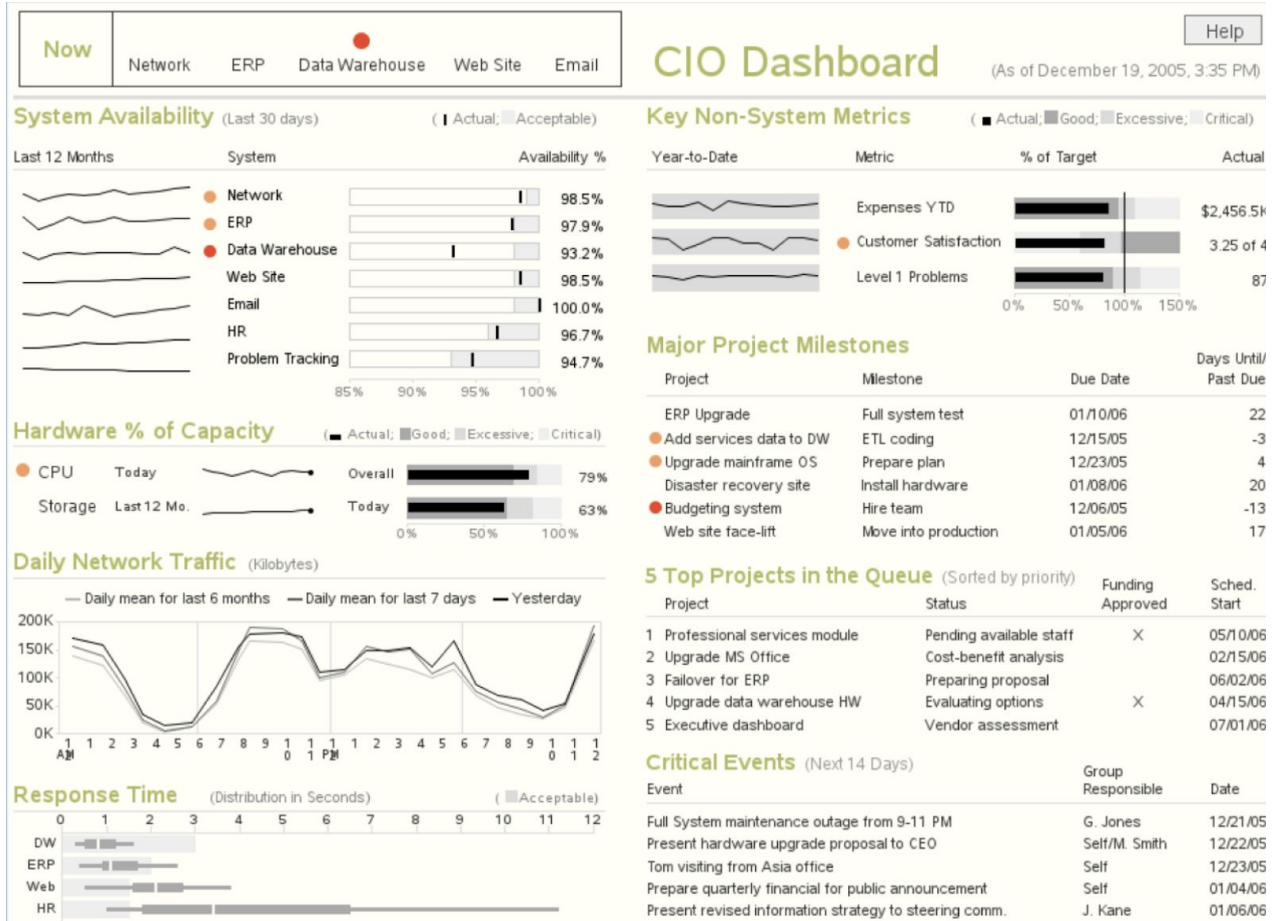


Fig 5.9: CIO dashboard (Few 2006)

Template 5: Similar colour scheme as Figure 5.9 with use of white spaces

The template in Figure 5.10 shows how white spaces help to make data on the dashboard more readable. A consistent colour scheme, which is reused from the original dashboard (Figure 5.9) with an increased saturation value for green, gives the template a modern feel. The number of typefaces used are limited to two and titles of the visualizations are represented clearly.

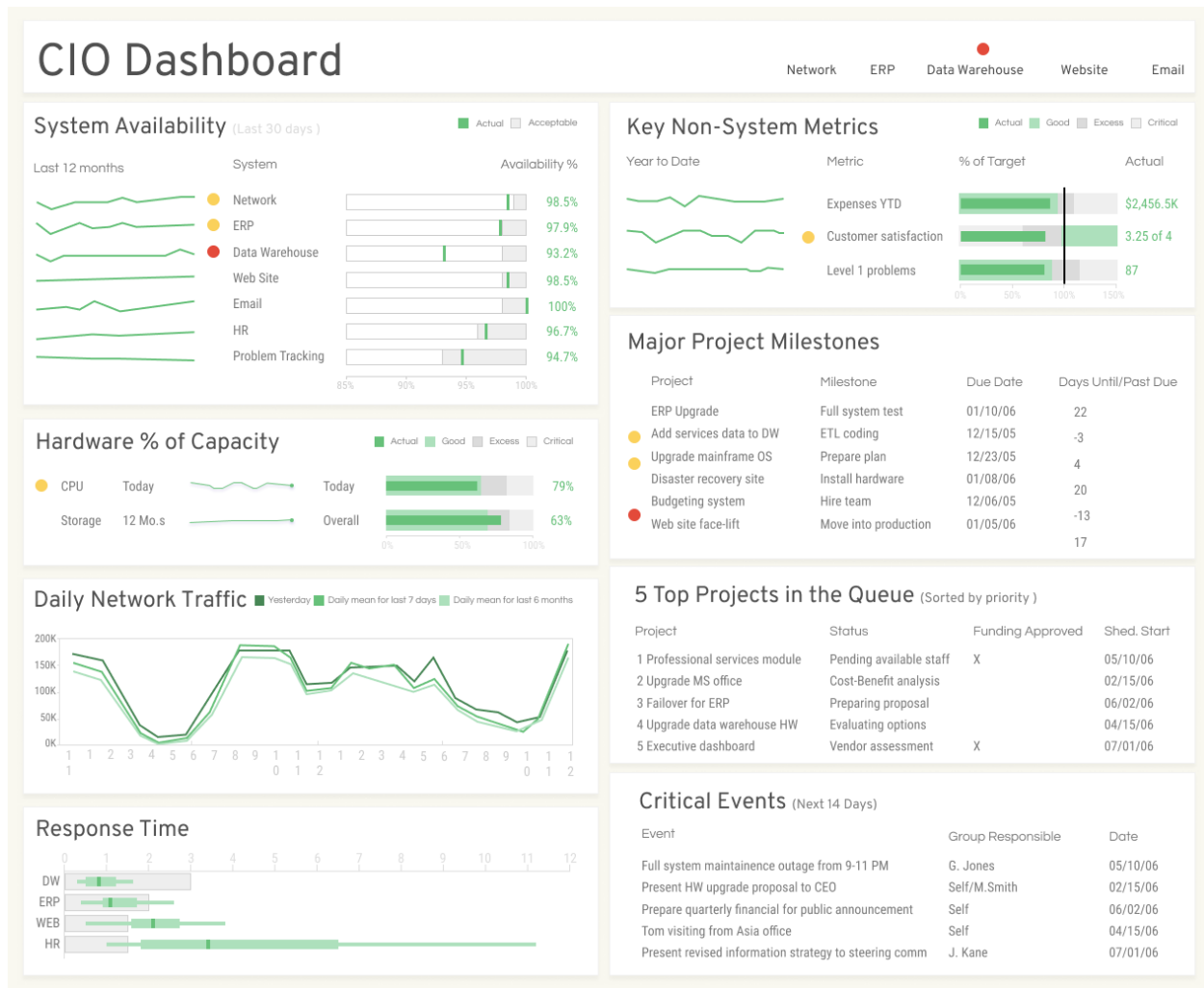


Fig 5.10: Template 5: Similar colour scheme as Fig 5.9 with use of white spaces

Templates 6 and 7: Follow similar layout as Figure 5.9 with different colour schemes

The templates in Figures 5.11 and 5.12 represent how visual clutter can be reduced by using a light colour for the background and saturated colours to highlight the data. Both alternatives provide a clean and modern look to the dashboard. Although the two templates look similar, some members of the UX team at The Company saw them as different:

“The dark blue (Figure 5.11) makes it look more professional and the light blue(Figure 5.12) makes it look more modern. I expect companies will use the dark blue theme (Figure 5.11)”

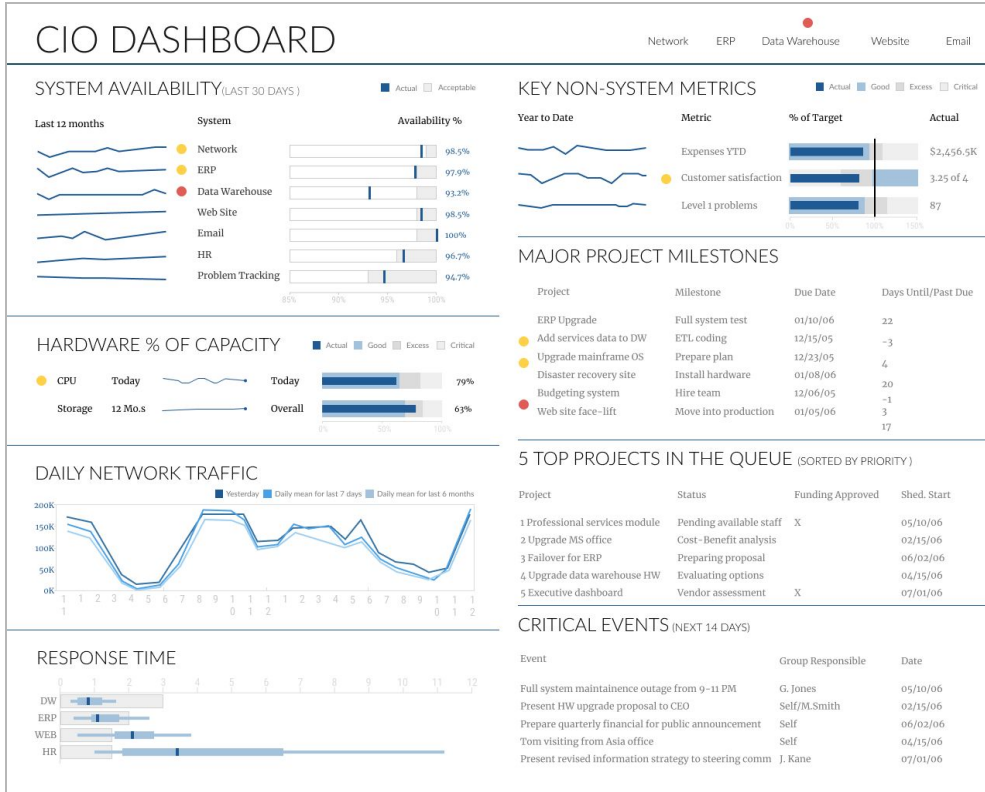


Fig 5.11: Template 6: Professional colour scheme

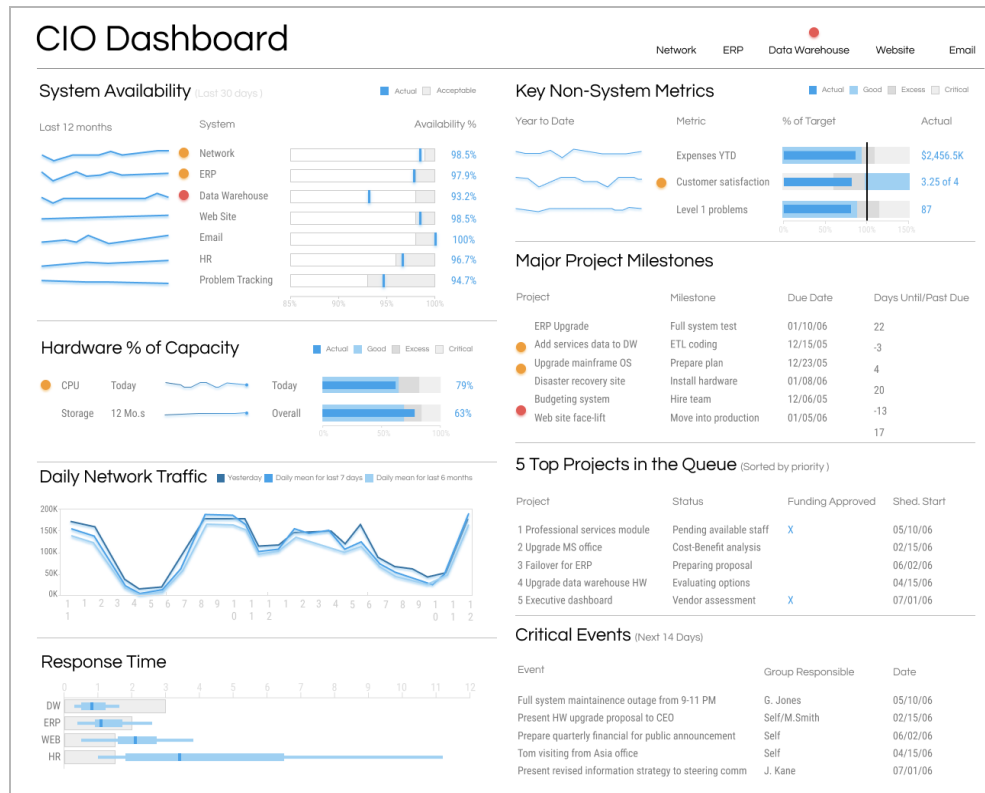


Fig 5.12: Template 7: Modern colour scheme

Template 8: Blurred gradient

This template explored a blurred gradient on the sides of the dashboard to draw focus to the center of the dashboard. This gradient was explored to provide a modern look with clean data structuring.

However, feedback from the members of the UX team showed that the bright blurred gradient was very tiring on the eyes and was very distracting when used on a densely populated dashboard. This was because the colour saturation on the sides was more than the saturation in the centre which made it look like the dashboard was in the background and the gradient strips were in the foreground (Gestalt- Figure and ground Section 3.1.1.1).

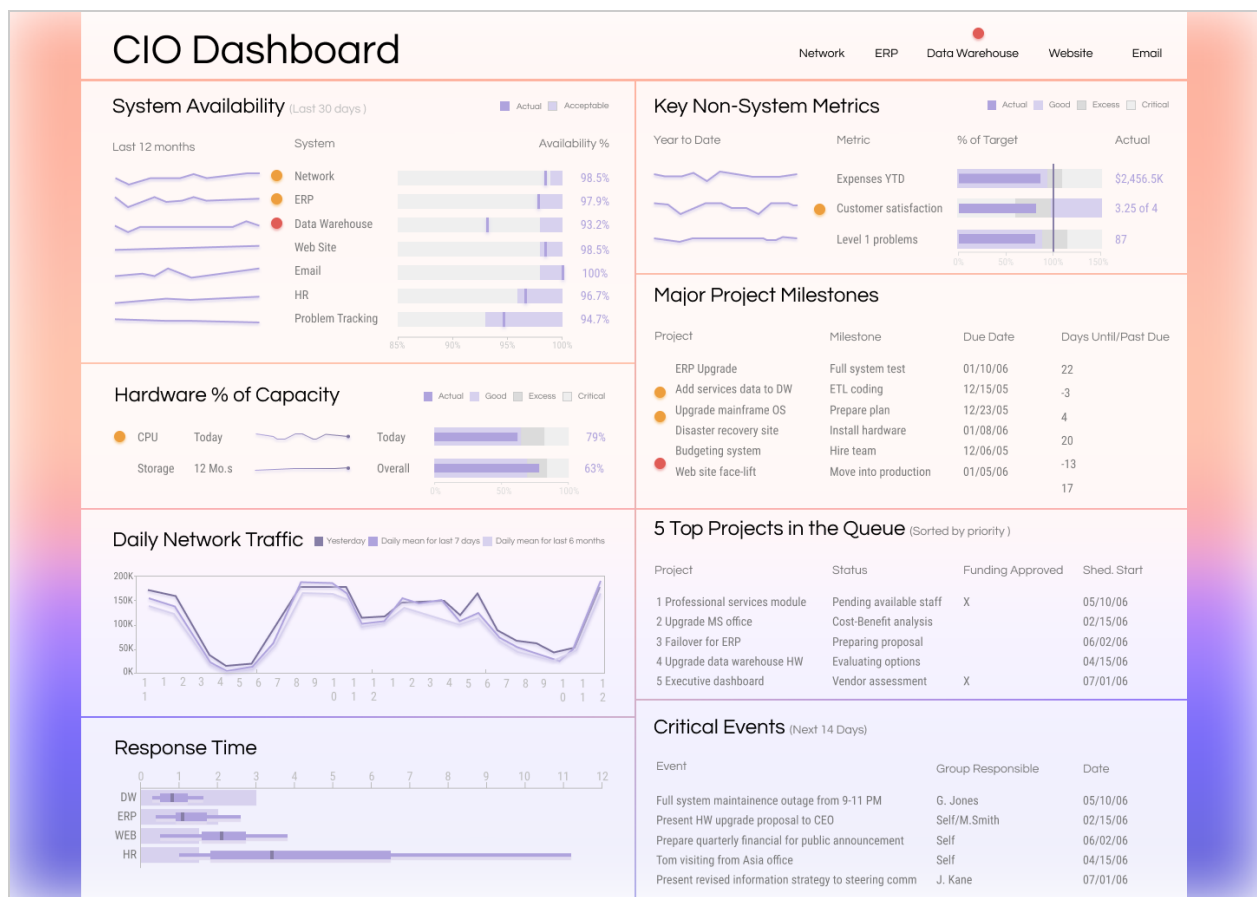


Fig 5.13: Template 8: Blurred gradient

Template 9: Dark gradient

Based on the feedback on Template 8, a similar style of dashboard was created with thinner gradient strips and lower colour saturation as shown in Figure 5.14. It was immediately visible that the dashboard was the focus and the gradients around the dashboard seemed to be in the background. The use of a bright yellow within the visualizations helped to highlight key information and draw attention.

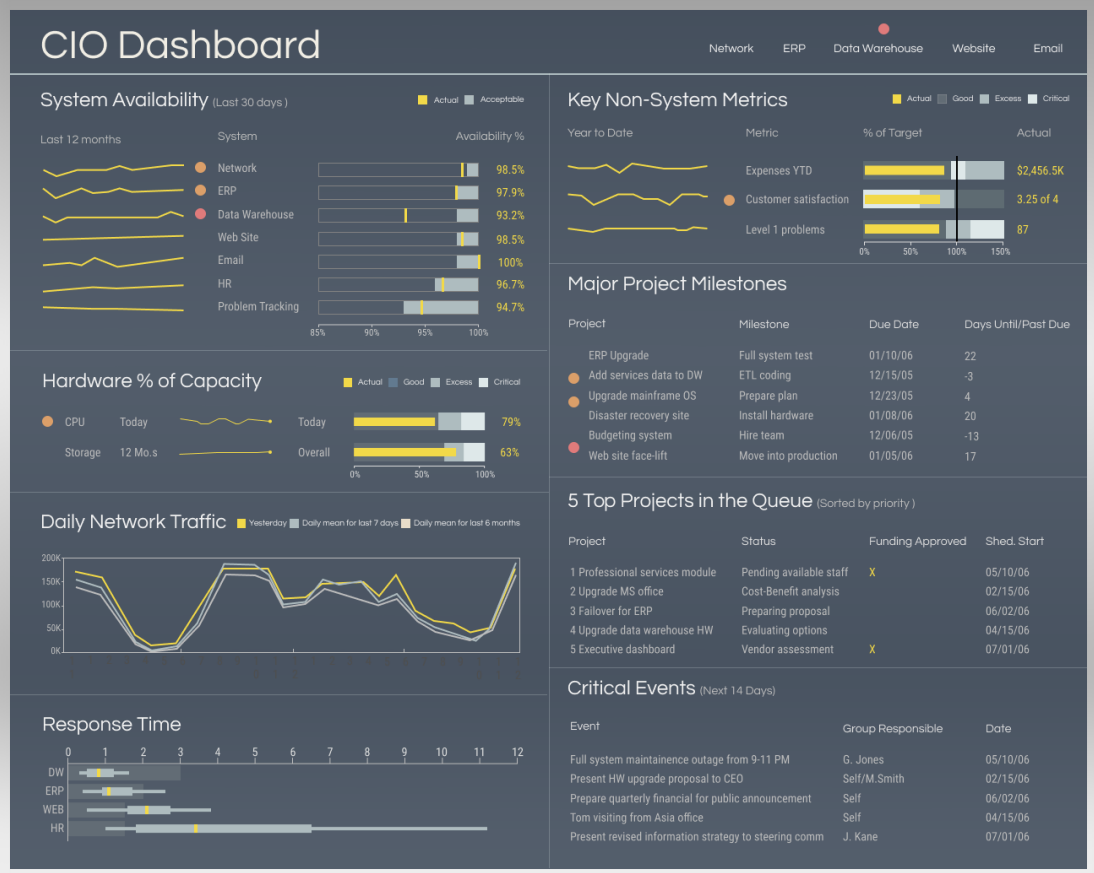


Fig 5.14: Template 9: Dark gradient

Template 10: Dark theme with muted colours

This template was explored to see how muted colours affected readability on a dark background. It could be seen that the difference in saturation between the muted colours and the background was not very high. This resulted in the visual weight of the background to be more than that of the foreground which made it difficult to read the information in the foreground which can be seen in the Figure 5.15

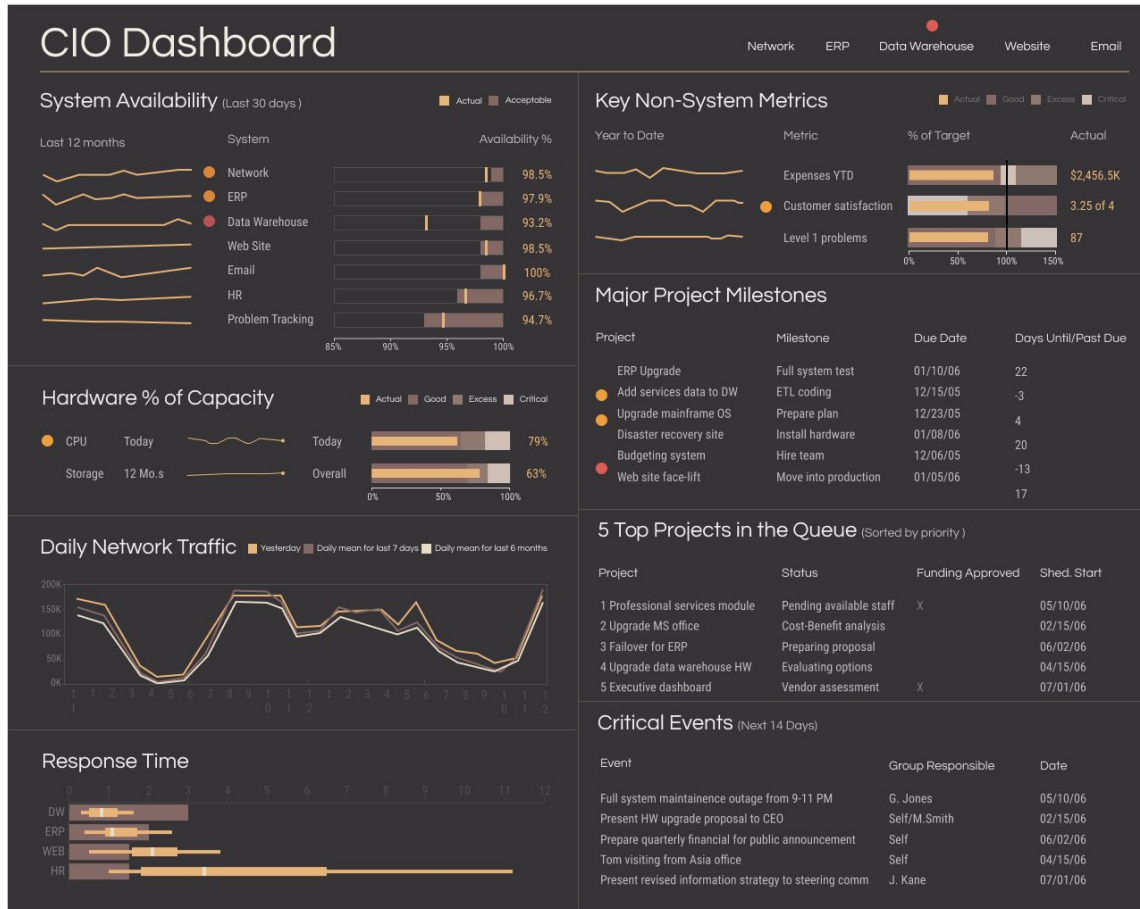


Fig 5.15: Template 10: Dark theme with muted colours

5.6.2.2 Discussion

The different templates designed in this section provided great insight into understanding how to apply design guidelines to style a dashboard. An important issue noticed was that the design guidelines were easy to understand but difficult to apply. It required trial and error and a large number of examples of well designed dashboards to identify the right way of applying dashboard design guidelines. This could be extremely time-consuming for a data analyst whose focus is analysing data. With analysts lacking experience in visual design and dashboard design, it is very difficult to achieve the desirable result. Hence templates would serve as a powerful and efficient solution for applying dashboard design guidelines automatically and create good looking dashboards.

Further, feedback from the members of the UX team on the templates revealed that the application of dashboard design guidelines varied with the density of content on a dashboard: Visual design guidelines suggest the use of a combination of cool, dark and low saturated images for backgrounds and hot, light and highly saturated colours for foreground. However, on densely populated dashboards it was more effective to use light colours in the background and bright and saturated colours in the foreground. It was also seen that the use of saturated colours

in the foreground was more effective to highlight key areas on a densely populated dashboard. Another observation made was that graphical images needed to be used cautiously based on if the dashboard was presented stand-alone or with other dashboards.

5.6.3 Design of the styling framework

After the templates were designed, a styling framework was required to support the templates in an analysis tool. Along with the templates, during the design workshop (Section 5.4) and ideation phase (Section 5.5), other capabilities were identified which could help with designing good dashboards. This included help with content arrangement through layouts and the potential to customise a template to apply a company's brand identity easily. Subsequently, three main features were identified which needed to be designed: Templates, layouts and custom styling. Templates referred purely to styling and colouring, layouts referred to content arrangement and custom styling referred to creating customized templates or modifying an existing template.

The styling framework was designed iteratively with regular feedback from members of the UX team at The Company. After the first set of designs was prototyped, a usability test was conducted for the design. The final design for the styling framework was prototyped based on the results of the usability tests. The following sections describe some of the the design concepts which were explored within the styling framework.

5.6.3.1 Styling flyout

Discussions with the UX team during the ideation phase made it clear that there were more advantages to having the styling features accessible as and when required, rather than having a separate mode for it in the tool. It was discussed that having a styling flyout menu that can be opened and closed as and when required would be a suitable way to access the styling features.

A similar interaction with a flyout menu was already present in The Company's tool and this design followed the same UI pattern. Based on the idea of a flyout, two concepts were prototyped. One where two separate flyouts were designed for templates and layouts (Figure 5.15(a)) and one where templates and layouts were added as tabs into the same flyout (Figure 5.15(b)). After feedback from a critique session, it was decided to proceed with a single flyout with tabs for templates and layouts (Figure 5.15(b)) as it offered a single access point for the dashboard styling features and would be easy to switch between templates and layouts. Thus by providing a seamless way of accessing the styling options during the data analysis process, The following specific guidelines was satisfied:

G3: Provide an easy way of integrating the styling tasks into the data analysis process to make the dashboard data-driven.

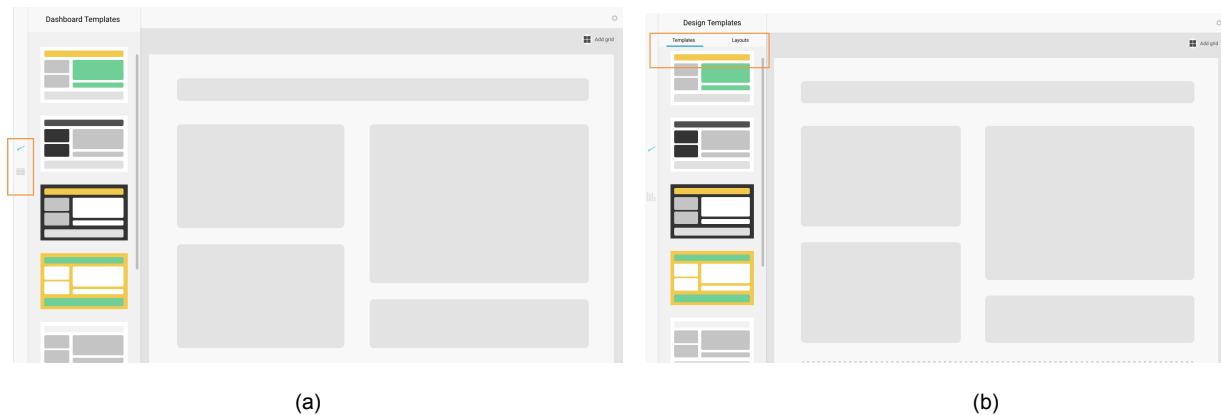


Fig 5.15: UI of the styling flyout are explored here: (a) shows templates and layouts as two separate flyouts and (b) shows them combined into a single flyout with tabs for each . There is also a visualization icon included to add visualizations onto the dashboard.

5.6.3.2 Applying templates

The templates designed in Section 5.6.2 each consisted of their own unique colour scheme, composition, fonts and minimal style. If a user were to apply a template to their dashboard, they would have to click on a template of their choice from the templates tab in the styling flyout. Clicking on a template would apply the colour scheme, composition, fonts and style of the chosen template to their dashboard, as seen in Figure 5.16. The template would also modify the overall structural composition of the elements on the dashboard, but the position and alignment of the visualizations on the screen would remain the same.

Due to the unique composition, unique colour scheme, minimal clutter and a descriptive title present in each template, the list of templates provided in the styling framework satisfied the following specific guidelines:

G1: Provide a list of example dashboards to help achieve uniform and harmonious composition on the dashboard.

G4: Provide users with the flexibility to apply a minimal and pre-designed style to both an empty or a populated dashboard to automatically minimize clutter.

G2: Provide multiple predefined colour schemes to achieve a uniform colour scheme on the dashboard.

G7: Provide contrasting colours in each colour scheme to highlight key information.

G6: Provide space for a descriptive title on a dashboard to help a reader understand immediately what the dashboard is about and convey a clear context.

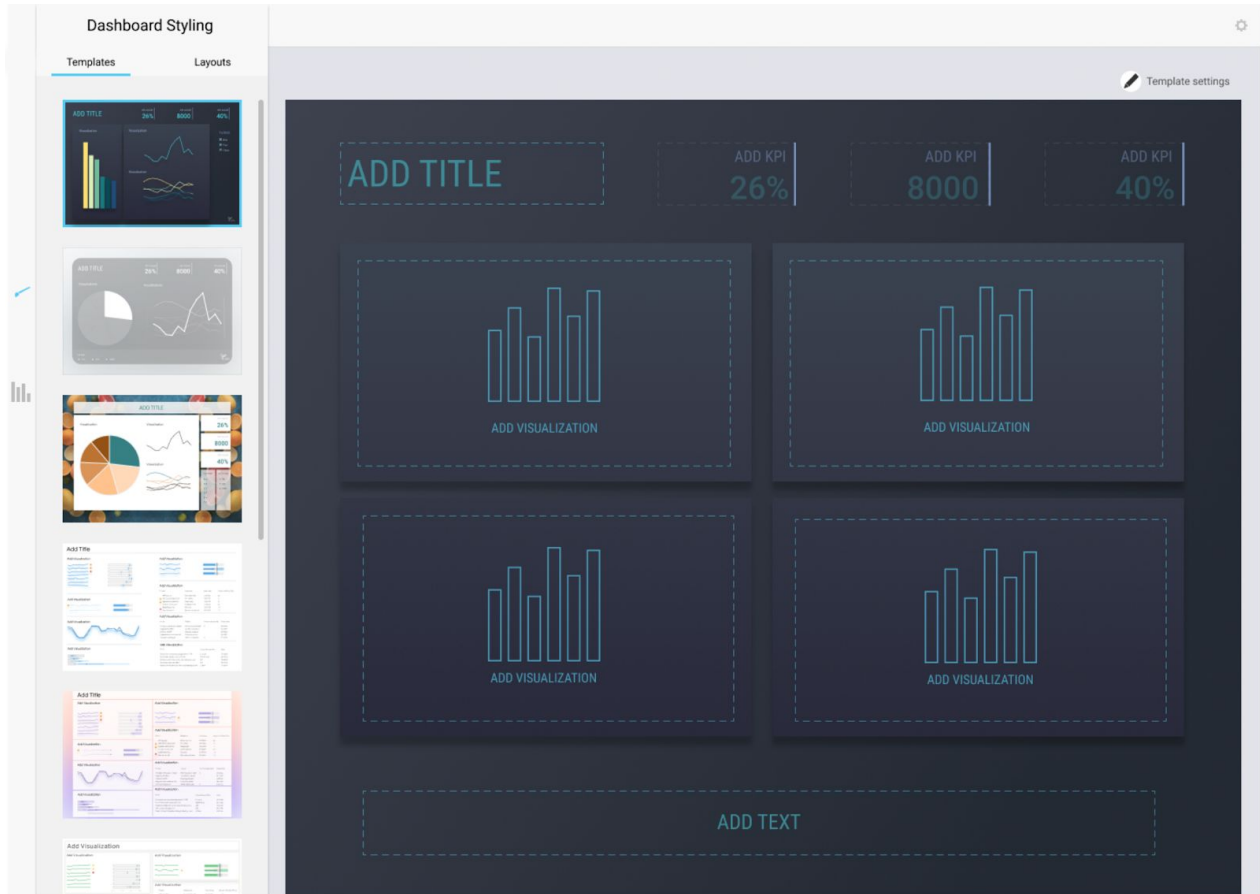


Fig 5.16 : Templates tab displaying a list of templates to apply.

5.6.3.3 Design of Layouts

Layouts were designed to provide users with arrangement and alignment options of visualizations on their dashboards. Two ways of representing layouts were explored. One way was to include visualizations added on to the dashboard in the layout suggestions, as shown in Figure 5.17(a). An alternate design included visualizations as generic icons in the layout suggestions as shown in Figure 5.17(b)

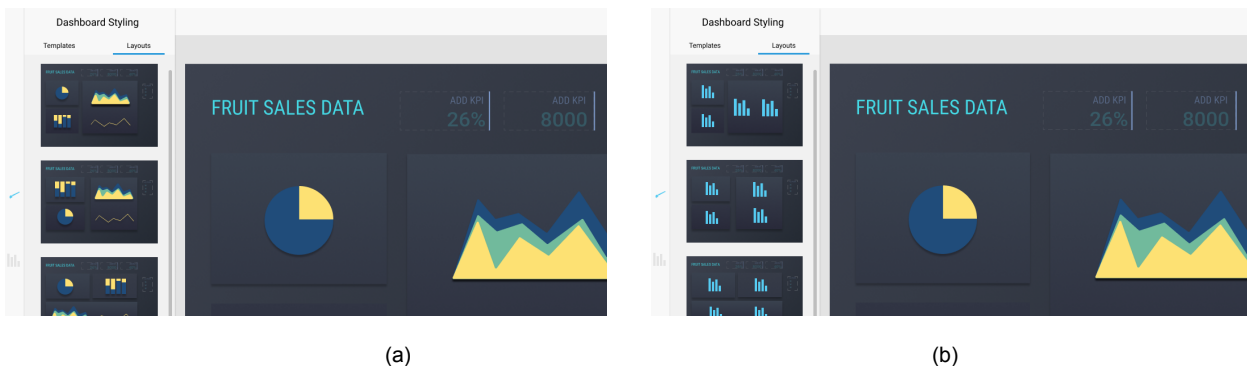


Fig 5.17 : Layouts shown with the visualizations (a) and layouts shown without visualizations and with a generic icon instead (b)

After feedback from a critique session, it was seen that the representation with generic icons (Figure 5.18(b)) for visualizations was better as the number of layout permutations would be much fewer. The users would choose a layout which would randomly assign the visualizations a position in the chosen layout. They could then swap positions of the visualizations achieve the positioning they desire.

5.6.3.4 Applying Layouts

The concept of layouts was designed to provide options for arranging the visualizations on a dashboard. Each layout would also follow Few's degrees of visual emphasis (Figure 3.9). The layouts tab in the styling flyout, hence contained different permutation options for the visualizations on the dashboard. However the overall structural composition of the dashboard would not be modified if a layout were applied, as this was the property of a template. Figure 5.18 shows the layout options before a template is applied to the dashboard. It can be seen that layouts and templates can hence be applied independent of each other.

Thus providing multiple layout options which could be easily accessed from the styling flyout satisfied the following specific guideline:

G5: Provide users with multiple layout options, designed according to Few's degrees of visual emphasis, to achieve a dashboard layout that encourages readability.

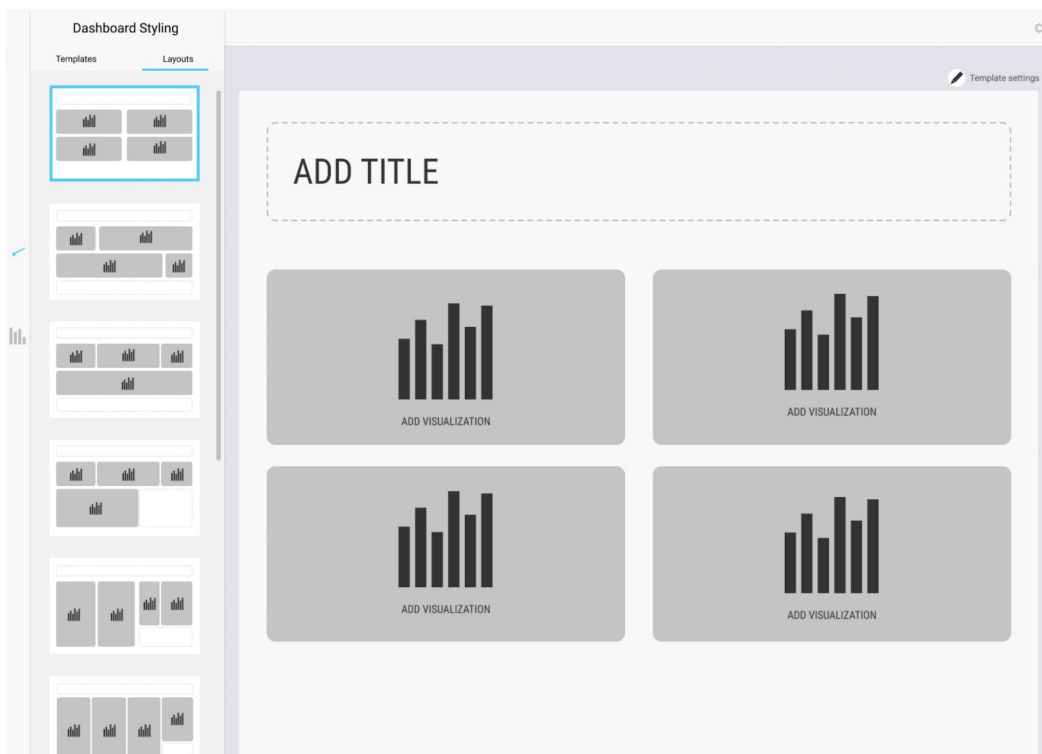


Fig 5.18 : Templates tab displaying a list of templates to apply

Grouping visualizations

It was inferred from the design workshop (Section 5.4.4.8) that the Gestalt law of connectedness (Section 3.1.1.1) could be used to show grouping of visualizations that are related. Especially on a dashboard, the visualizations can be connected by placing them on a connected background area. One way of providing support with grouping can be done through the layout options, where different ways of grouping visualizations could be shown within every layout option. Thus a user would just have to choose a layout option which had their preferred way of grouping. Figure 5.19 shows the different groupings included in the layout options. This concept would hence satisfy the following specific guideline:

G8: Provide the option to group visualisations into a single connected block to highlight relationships between them.



Fig 5.19 : Layouts including options where visualizations are grouped together.

5.6.3.5 Relationship between templates and layouts

In order to provide maximum flexibility to users, the styling flow was decided to be non-restrictive. Which meant that there was no specific order in which the templates and layouts would need to be applied. Applying a template would not change an existing visualization layout and vice versa. Keeping this flexibility in mind, a design was prototyped such that templates and layouts in the flyouts tab would adapt to each other as shown in Figures 5.20 and 5.21

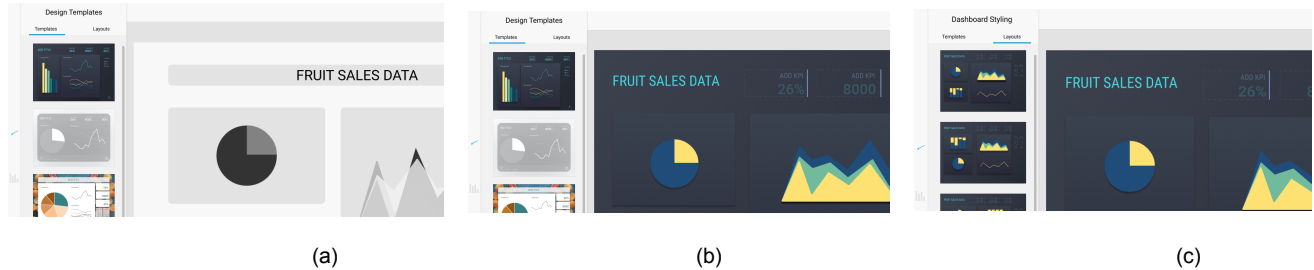


Fig 5.20 : Process of layouts adapting to templates (a) before template is applied (b) after template is applied (c) layouts adapting to templates.

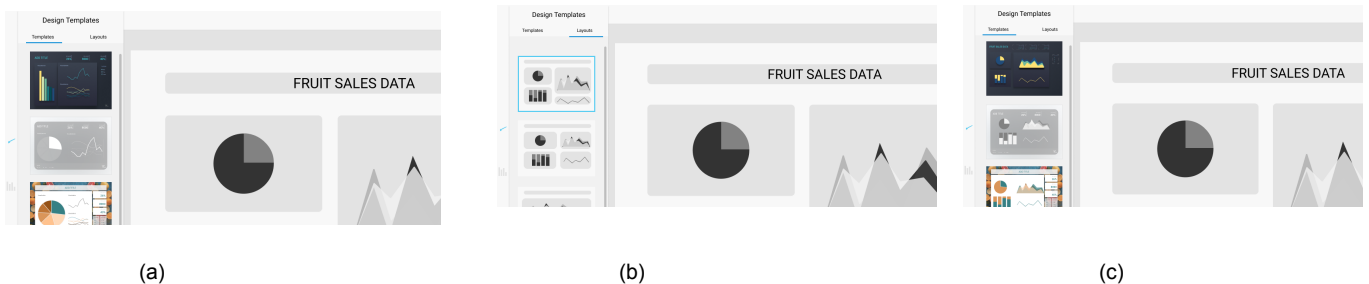


Fig 5.21: Process of templates adapting to layouts (a) before layout is applied (b) after layout is applied (c) templates adapting to layouts.

This received good feedback during one of the critique session with the UX team, and was seen as a valuable feature that encouraged flexibility in styling.

5.6.3.6 Custom Styling menu

This section describes the ideas generated for two main features of the custom styling menu: Menu access point and Menu options.

Menu access point

Custom styling referred to editing an existing template to incorporate a company's brand identity. This focussed mainly on changing colours, text sizes and spacing between elements. Keeping these requirements in mind, two concepts were prototyped. The first concept followed a design similar to The Company's product, where the settings to edit properties of visualizations individually was on the right hand side of the screen as a settings menu (Figure 5.22(a)). This settings menu could be accessed by clicking on the template styling icon present on top of the dashboard space. The second design concept included custom styling within the template tab in the styling flyout (Figure 5.22(b)).

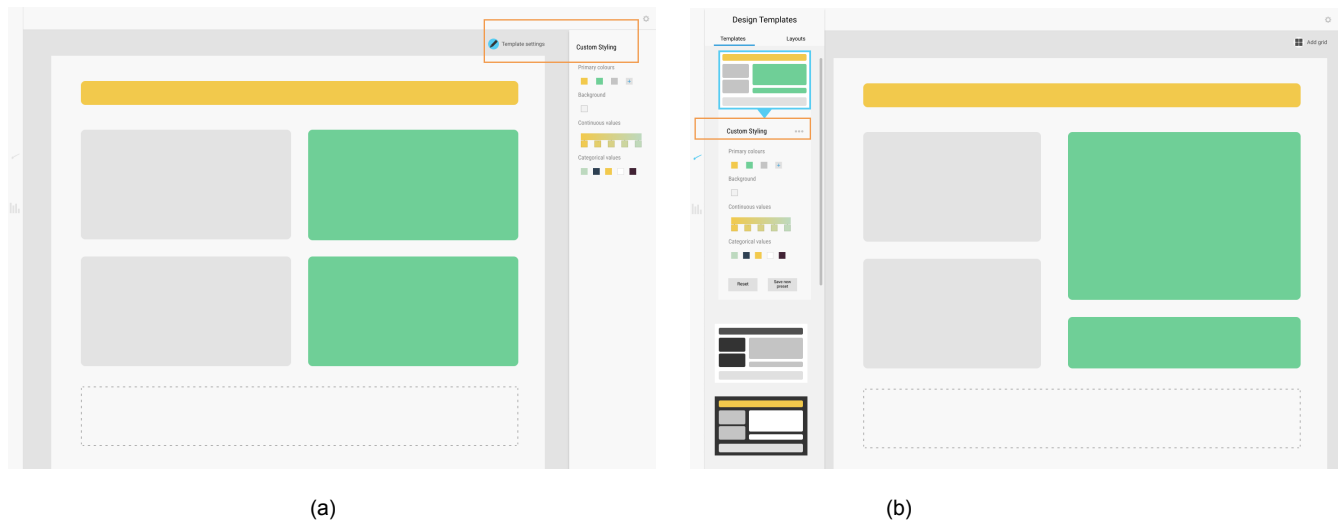


Fig 5.22 : Custom styling menu access points (a) on the right of the screen through a template setting button above the dashboard and (b) under the template flyout menu.

After feedback from a critique session with the UX team, it was decided to go with the design as shown in Figure 5.22(a) as it was similar to the design in The Company's tool. Furthermore, it seemed that the template settings icon would be very obvious and could be accessed with a single click.

Menu options

Since custom styling would mainly involve modifying colours to fit a company's brand identity, these features were given priority while designing the menu options. The menu was designed with the idea that the user would only have to provide the colours they preferred and all elements on the screen would automatically adjust based on this input. The menu was designed with three tabs: *General*, *Visualizations* and *Text areas*. The *General* tab allowed for input of company colours, which is represented as template colours in Figure 5.23(a). This would automatically change the colour scheme across the dashboard, including the colour scheme of the visualizations and the text colours to match The Company colours. The *Visualizations* tab (Figure 5.23(b)) contained options to apply a default colour scheme to all the visualizations which would override the changes made by changing the template colours in the *General* tab. This included the colouring options for the visualizations as well as the visualization backgrounds. The colouring options for the visualizations were different depending on if the data in the visualization was continuous (a range of data values) or categorical (discrete data values). These colours were automatically modified once The Company colours were input in the general tab. The *Text areas* tab Figure 5.23(c) modified all the text related features on the dashboard. This included changing colour and size of the text on the dashboard which would override any changes made in the *General* tab. This enabled the flexibility to either just change the template colours in the *General* tab to automatically make changes across the entire dashboard, or individually modify all the details in the *Visualizations* and *Text areas* tabs.

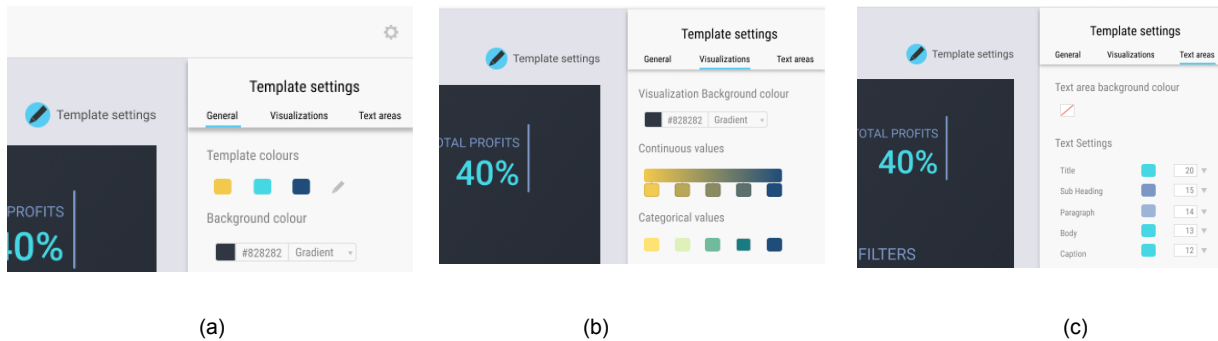


Fig 5.23 : Custom styling menu tab options, (a) General tab (b) Visualizations tab (c) Textareas tab

5.7 User Testing

This section describes the user tests that were conducted after the first design was conceptualized.

5.7.1 Methodology

The user tests were conducted with nine participants where five were employees of The Company who had experience with The Company’s tool and four were students who had no experience with The Company’s tool. A list of predefined tasks were created (Appendix D) and an interactive workflow was prototyped. Each participant was required to independently interact with the testable prototype and was asked to perform one task at a time. Each test lasted for thirty minutes and a note taker was present for four tests. The remaining five tests were audio recorded and transcribed after the tests.

5.7.2 Set-up

The same prototype was tested for both sets of participants but the test was conducted with two slightly different introductions for the two participant groups. The design concept was explained to the employees in relation to The Company’s tool but the styling framework was explained as a standalone tool to the students. After the introduction, each participant followed the same set of tasks and tested the same workflow. The tasks involved exploring the templates, layouts, relationship between templates and layouts and custom styling.

5.7.3 Test Results

This section presents a concise summary of the results of the user tests and is divided into the following subsections: *Templates*, *Layouts*, *relationship between Templates and Layouts* and *custom styling*.

5.7.3.1 Templates

Eight out of nine participants understood that the purpose of the templates was primarily to apply a style to the dashboard. However, since the templates varied in number, arrangement and type of visualizations, some participants found it difficult to understand the difference between the functions of the templates and layouts. Hence, it was necessary that all the templates displayed the same number and arrangement of visualizations to convey that the templates only made modifications regarding colours, fonts and composition.

5.7.3.2 Layouts

All participants understood that the layouts presented different arrangement options for visualizations on the dashboard, but there were some changes that were suggested which could make the layouts more useful. In the design concept tested, the layouts suggested permutations of visualization starting with one visualization even if there were multiple visualizations on the dashboard. Participants suggested having layout permutations only equal to or greater than the number of visualizations that were already on the dashboard. This would make it easier to find a suitable layout for the given set of visualizations without the need to scroll endlessly.

In the prototype tested, the layout options were presented by replacing visualizations with generic icons to reduce the number of permutations options (shown in Figure 5.21 (b)). Some participants were concerned that the generic visualization icon might not be able to convey exactly which visualization would go where when they applied a layout. A solution for this could be hover previews over a chosen layout that would show how the layout would affect the visualizations on the dashboards when applied. The desired positioning could be achieved by swapping positions of the visualizations as required, after applying the layout.

The design presented had layout permutations which included grouping of visualizations (Figure 5.22). All participants found it more intuitive to group the elements directly on the canvas rather than from the layouts. One of them reasoned that it would take forever to scroll and find the grouping that he wanted. Hence it would be more appropriate to separate the layout and grouping features with layouts limited to placements and arrangement of elements and grouping to be done by directly interacting with the screen.

5.7.3.3 Relationship between Templates and Layouts

Based on the feedback from the tests, it was seen that dynamic adaptation of layouts to templates was preferred but not templates to layouts. This is because the test participants felt that an unaltered template would give them a clear idea of their starting point. They also observed that multiple presentation tools worked in a similar way.

5.7.3.4 Custom Styling

The general response to the custom styling was negative as the participants found it difficult to understand the connection between the different elements (General, visualization and tabs)

immediately. Participants also found it difficult to understand how the colours were related across the tabs. However, they were able to understand their relationship better after they interacted with the different settings under each tabs. The primary issue was the placement of the custom styling. All the participants expected it to be placed within the styling flyout on the left.

A possible solution to these issues is to place the settings on the left hand side, under the template flyout. The tabs would also need to be rearranged to group the elements that directly influenced each other under a single tab. The tab grouping could be changed to colour, font and spacing where colour had all the features that were modified when company colours were applied, font had text specific features like size, typeface etc. and spacing contained controls to change spacing between the elements on the dashboard

5.7.4 Discussion

It was clear that most participants saw the Templates and Layouts to be used only after they had worked on a couple of visualizations and analyses. They expected the Templates and Layouts to help with styling their dashboards and not dictate how they would be analysing their data. This is an important finding which emphasizes the need for a flexible and an iterative workflow while incorporating the styling framework into a data analysis tool.

6 Final Concept and Recommendations

This chapter presents the final concept and recommendations that resulted from the project. They are based on the findings from the different phases in the execution section.

6.1 The final concept

This section presents a concept for the dashboard styling feature in a data analysis tool based on findings in this project regarding the concepts of templates and layouts. These concepts were considered most important regarding the research question, “What support would users of analytic software need to create compelling analyses based on best practices within dashboard design and visual design?”

6.1.1 Templates

Most analysts rely on intuition or examples of other dashboards while creating their own. But often, they do not follow design guidelines which make their dashboards cluttered and difficult to understand. A set of pre-styled templates which can be applied to a dashboard to automatically apply visual design and dashboard design guidelines, is a compact solution to help analysts create good-looking information dashboards. Multiple templates with a unique colour scheme, overall content structure, minimal style, descriptive title and uniform composition can be included in an analytic software to provide users with the flexibility to choose a style that would best fit their needs. Providing the option to customize the templates to apply a company’s brand identity, would make the templates even more useful. A simple way of transferring brand specific colours and fonts onto the templates can provide the flexibility to achieve the desired dashboard styling.

6.1.2 Layouts

Along with styling capabilities, it was seen that users also required help with arrangement options for visualizations on the dashboards. Layouts would satisfy this requirement by providing different permutations of the visualization position and alignments on the dashboard for the users to choose from. The overall content structure of a dashboard not be affected by applying a layout and only the arrangement of the visualizations would be modified.

6.2 Final design

Based on the concept described in section 6.1, the following design for the styling framework in a data analysis tool was developed, as a result of this project. A compact styling solution was designed where all the features pertaining to styling could be found in a compact flyout within the data analysis tool. This flyout could be accessed at any time during the data analysis process in order to provide maximum flexibility to the analyst. The flyout consisted of two main tabs: *Templates* and *Layouts*.

6.2.1 Templates

The templates tab contains a list of pre-designed templates (Figure 6.1) , each with unique colour scheme, overall content structure, minimal style, descriptive title and uniform composition which are designed based on the specific guidelines (Section 5.4.5) identified during this project. A custom styling menu (Figure 6.2) was also designed to provide users with the option to customise a template with colour schemes and fonts specific to their company's brand identity. This custom styling menu is designed with three tabs, colour, text and spacing, which would help to modify colour scheme and fonts and spacing between the elements on the dashboard, respectively.

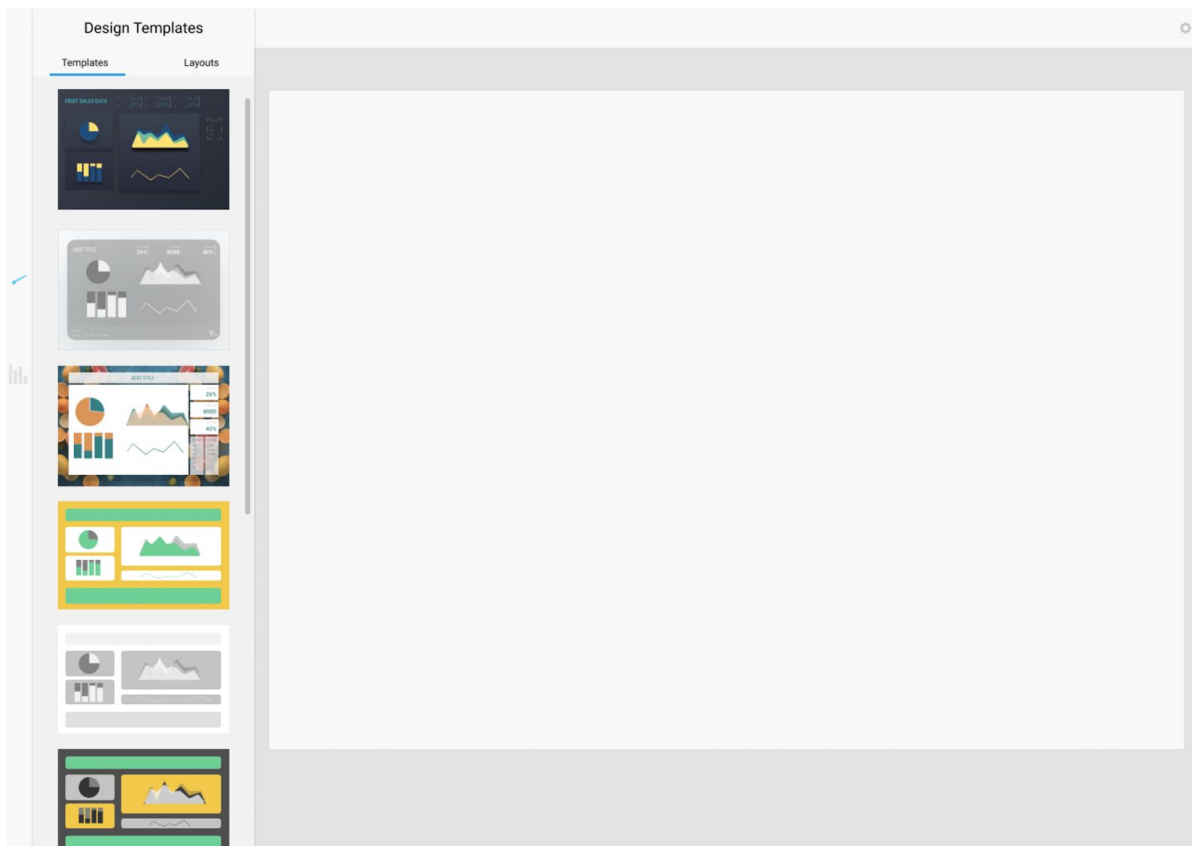


Fig 6.1 : Templates final design

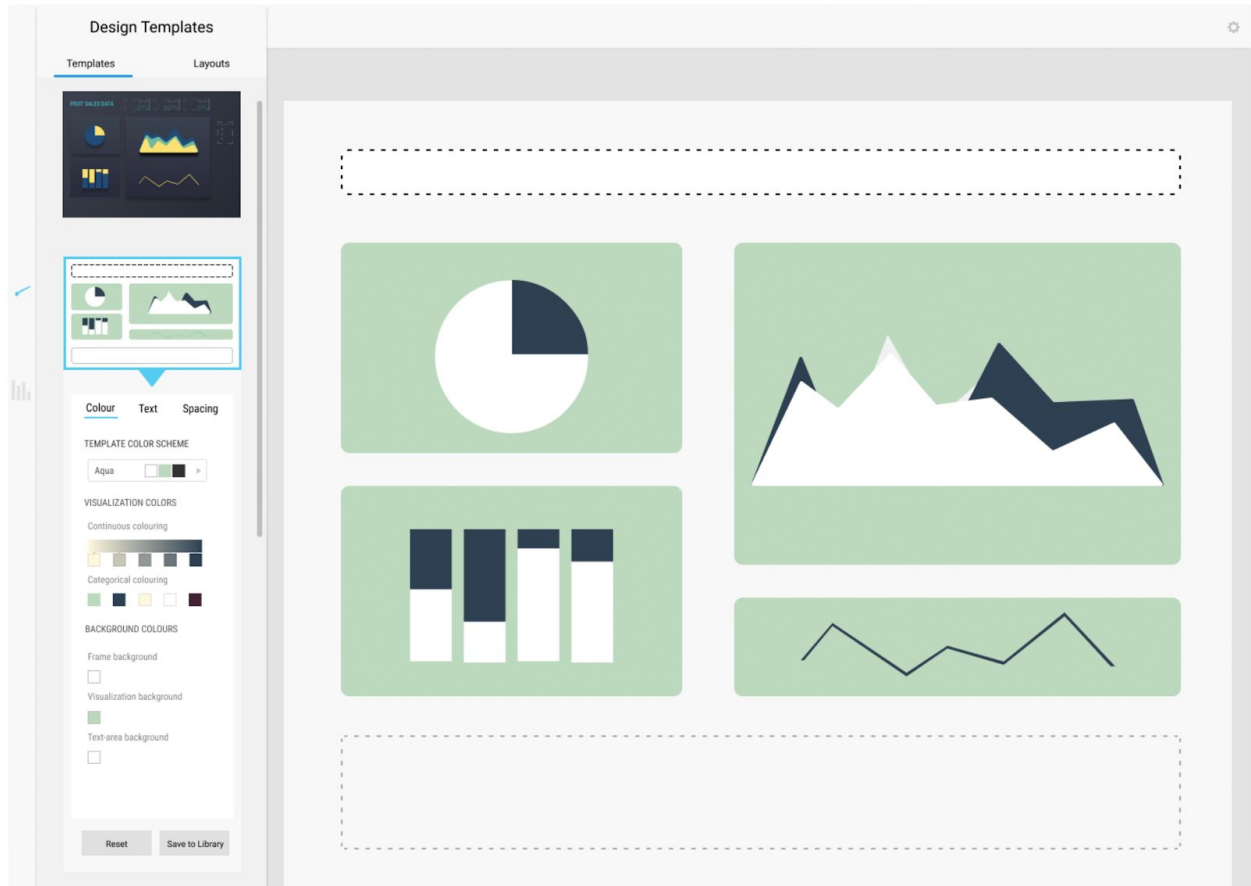


Fig 6.2 : Custom styling menu

6.2.2 Layouts

The layouts tab (Figure 6.3) contains a list of different permutations options for visualization on a dashboards. The visualizations are represented with generic icons and hovering on a layout option would provide a preview of the specific arrangement of the visualizations, if the layout were applied. The number of visualizations displayed on the layout options would always be equal to or greater than the number present on the dashboard.



Fig 6.3 : Layouts final design

6.3 Recommendations

Based on insights from the different stages of the of the project, a list of recommendations were identified and are listed below:

Allow application of styling features at any point during the data analysis process for flexibility

A data analysis tool is always data-driven and styling an analysis is part of the data analysis process. Providing access to dashboard styling at any point in the dashboard creation process would allow an analyst to focus on the styling as much or as little as they prefer and focus more on the data. Furthermore, this flexibility would allow them to style their dashboard according to the insights from their data rather than draw insights based on styling.

Allow for easy switching between Templates and Layouts and their application in any order

Providing an easy way to switch between templates and layouts by giving them the same level of hierarchy helps to understand that templates and layouts can be applied in any order to achieve the same result. The changes made to the dashboard by applying one would not overwrite the changes made by the other.

Adapt layouts to templates but not vice-versa

When all layouts adapt to the colour scheme and styling of a chosen template, it can be easy to understand that layouts are meant specifically for providing assistance with arrangement of the

visualizations on the dashboard. It also conveys that any changes to the template made after choosing a layout would not modify any template related changes applied before it. However, keeping the look of the templates constant and not adapting it to the layouts would help provide a good reference to the starting point of the styling process.

Design all templates with the same type of visualizations to clearly convey their styling capability
Providing templates with the same layout of visualizations, which includes similar visualization type as well as positions and alignments of the visualizations can help to clearly understand that the templates are meant specifically for styling pertaining to colours and composition on a dashboard.

Design templates with the colour schemes that match the information density on the dashboard
Muted colours work well when used with sparsely populated dashboards. However, on densely populated dashboards it was more effective to use light colours in the background and bright and saturated colours in the foreground. This helps to highlight exceptions which are otherwise easy to miss on dense dashboards.

Design templates with backgrounds that match the use case of the dashboard i.e. standalone or used with other dashboards

Usage of images as dashboard background works well if the dashboard is presented standalone. However, if the dashboard is displayed amongst other dashboards, it is more useful to use a plain or single colour background as it causes less distraction.

Display layout permutations with generic icons for visualizations to make the layout permutations independent of the type of visualization

When generic icons are used while displaying layout permutations for the visualizations, the number of unique combinations of arrangement of visualizations with respect to each other would be reduced. Hence a desired layout arrangement can be achieved by applying the layout and then the user can directly interact with the visualizations space to swap the visualizations into the positions they prefer.

Allow hover previews for every layout option to view the default positioning of the visualizations if the layout is applied to a populated dashboard

When generic icons are displayed as visualizations, it is difficult to know exactly which visualization would be placed where when the layout it applied to a populated dashboard. In such a case, hovering over a layout can help to preview the default positioning of the visualizations with respect to each other to get a sense of how their dashboards would look. After application of the layout, the user can swap the layout positions as they please without affecting the layout they had previously chosen.

Allow the option to group multiple visualizations through direct interaction on the dashboard.

Gestalt law of connectedness is a powerful way of grouping related elements (Section 3.1.1.1). This law can be applied to dashboard design to convey that two visualizations are related. By

merging two visualizations into a single block, it can be easily shown that visualizations are related. Such a grouping can be directly done on the dashboard by interacting with visualizations that need to be grouped. For example, one way of interacting would be selecting two visualizations which are related and clicking on a “merge” icon which could merge the visualizations. A “split” icon can also be provided for splitting merged visualizations, in case of errors and changed relationships between visualizations. This concept can further be extended to grouping multiple visualizations to convey complex relationships.

Allow customisation of template colours and fonts to fit a company’s brand identity

It is often the case that companies have specific styling requirements in terms of colours and fonts that must be used on any documents produced by them. In such a case, providing the option to customize a template to fit a company’s standards can help to easily apply their brand identity to the dashboard. Hence a custom styling capability for the styling templates is essential.

7 Discussion

This chapter presents a discussion of the limitations, ethical concerns and future work regarding the different phases of the project.

7.1 Persona

Only one persona was chosen at the start of this project, namely “Serena”, an expert analyst (Section 2.1). The characteristics of Serena were based on The Company’s description of her role as a typical user of their tool. Due to this, all her qualities were described to be professional characteristics and no personal characteristics were described. This was an advantage for the project, as it helped to describe a very specific user scenario with its application in a professional setting, based on the persona’s expertise and the background of the research. It also helped to narrow the scope of the project. However, for future work, it would be interesting to see how different personas with both professional as well as personal characteristics can help to create various user scenarios.

7.2 Execution

This project aimed to understand “What support users of analytical software would require to create compelling analyses which follow visual design and dashboard design guidelines”. Based on this research question, the project was subdivided into different phases to understand the problem space, research existing solutions and explore new solutions. During this process, The Company’s data analysis tool was also explored to understand the present state of dashboard styling in the tool. However, The Company’s tool is a very powerful data analysis tool and only a few features which were relevant to the project were explored in detail. Based on the research question and with knowledge of the tool’s existing users, a persona was selected to identify a suitable user scenario. The persona was defined to be an expert in the data analysis process and it was assumed that the results of this project would not address the process of creation of information visualization and data exploration. Based on this, only specific features within the styling framework of the tool were explored and features regarding data preparation and creation of visualizations were not explored in detail. It is also important to note that while identifying the persona and the user scenario, different application contexts of the created dashboards were not explored in detail and the project was done considering the resulting dashboards to be used standalone.

There were no ethical issues with this project in the sense that it could mean any harm, risk or exposure from the project being implemented. However, when doing the research, there were references to confidential material, like customer data and ideas for improvement of the product

that had not been released. The Company had rules for employees on how to handle confidentiality in these situations and the same were followed.

7.3 Planning

The project was planned within the first two weeks and was revised over the next couple of weeks to add more details in terms of methodology and results. The plan was practical and allowed enough buffer time for unexpected delays. However, certain phases were planned back to back, every week, and there was little time for documentation. Since the project was conducted by one student, proper time was not anticipated for documentation and backlogs from one phase were carried over to the next a few times. As a result some key findings that were not immediately obvious were not explored fully in the subsequent phase. A key learning from this was to understand the need to allot explicit time for documentation such that key findings from one phase could be used to shape the following phases.

7.4 Literature study

The literature study was conducted for four weeks and at the end of the literature study categories for interesting literature were created through affinity diagramming. Theoretically significant categories were compiled into a spreadsheet and this acted as the basis of the project's theory section. Since the project was conducted by one student, the affinity diagramming was done from a single point of view, albeit in iterations. Hence the categories created were not critiqued as rigorously as they would have been if the affinity diagramming was conducted by a group. Although data preparation and creation of visualizations were not the focus of the thesis, literature regarding these topics was explored to get a holistic picture of dashboard creations. However, this was limited to a brief review of user requirements for data preparation and information design guidelines for the creation of visualizations. Conducting an extensive study of the two topics would have highlighted the concerns from these phases which would affect the dashboard styling end result.

7.5 Expert interviews

The expert interviews were planned a week in advance with a specific list of questions (Appendix B) for the different experts interviewed. The interviews were very helpful to understand both The Company's point of view as well as the customer's point of view because customers of The Company could not be directly interviewed. However, interviews with users of The Company's tool would be able to provide more specific information about their difficulties with styling on a data analysis tool as the experts were only able to provide a general opinion of their user's concerns. This phase exceeded its allotted time period of one week due to scheduling issues with one of the tests which was conducted remotely. Furthermore, the documentation of the interviews was time-consuming but conducted alongside the following phase.

7.6 Design workshop

The design workshop was conducted to understand if the participants followed dashboard design guidelines while creating dashboards and also to identify opportunities where support could be provided to help create good-looking dashboards. Two separate workshops were conducted, one with the UX team at The Company and one with the students at Chalmers University. The workshop was divided into two phases involving creating dashboards and discussion about the created dashboards. At The Company, the dashboard creation exceeded the allotted time and the discussion phase was cut short because of it. However, the excess time helped to identify the need to provide support with layout arrangement as this was the most time-consuming activity during the workshop. The participants were observed throughout the dashboard creation process. Since there were a total of 6 participants at each workshop, all working at the same time, with only one student observing them for insights, there could have been missed opportunities for identifying insights. Additional observers at the workshop could have helped to avoid such missed opportunities. Another valuable addition to the workshop could have been to conduct it with data analysts who are familiar with the product. This would have helped to identify exactly the support required for users that fit the persona's description. However, The Company did not have any data analysts at their office who could have participated in the test.

7.7 Ideation

The ideation session was conducted with the UX team at The Company immediately after the design workshop. This was advantageous for idea generation as the participants each had a fresh memory of where they struggled while creating their dashboard and were able to ideate around those problem areas. It also helped the participants to clearly understand the scope of the problem and their ideas were within the scope of the problem. However, due to this constant reference to a context which the participants had already been in, ideas were only generated for the problems that they faced which resulted in very few ideas out of the box. A possible solution to this could be invite more participants to the ideation session who don't have knowledge of the concept to create a more broader set of ideas.

7.8 Prototyping

The design and prototyping section was planned for four weeks and conducted with regular feedback from members of the UX team at The Company. The feedback sessions were essential to understand the impact of several decisions made in the design and if it fit well with the features of the existing tool. The feedback sessions also provided useful insights on how existing UI patterns in The Company's tool can be reused to maintain a uniform interaction flow. The prototyping session was divided into two parts design of templates and design of the styling framework. Through the workshop and ideation session, it was identified that participants required assistance with layouts as well. However, layouts were not explicitly prototyped but

general layouts with different visualization arrangements were prototyped on a conceptual level. This is because it was assumed that the permutations of visualization areas can be algorithmically generated using algorithms like the Bin Packing problem (Lee 1985).

The design of templates was the most time intensive part of the prototyping phase. Even though the specific guidelines were referred to create the templates, the direct application of the guidelines was difficult without experience applying them. However, it could be observed that the templates got easier to design after a few had already been created and the guidelines were also easier to apply. This throws light on an important finding that dashboard design guidelines are easy to understand but difficult to apply without the right visual design knowledge and experience.

One of the issues that arose while designing the styling framework was that the styling concept itself was very broad within the tool and although several potential areas of improvement were identified, the scope had to be narrowed to just template and layout support. For example, text-areas which are generic blocks of text, images or visualizations which can be styled was a broad concept whose properties were endless. A design was prototyped by identifying the properties of a text-area and different ways of using its features effectively on dashboards, was explored. Since the text area in itself was a broad feature with multiple capabilities, it was not pursued after the first couple of design iterations. Towards the end of the prototyping session, two versions of each concept were prototyped and presented to the UX team for feedback on the alternatives that would most suit the product. This feedback session helped to finalize on the design that could be tested as well as pitfalls within the design that could be fixed before the user tests. Such a feedback session was essential to finalize on concepts which required testing to validate usability.

7.9 User Tests

After the concepts were finalized, an interaction flow for the styling framework was created and tested with five employees from The Company and four students at Chalmers University. It was interesting to see that the difference in the participant backgrounds elicited different reactions to certain parts of the design. The participants from The Company compared the styling framework to the existing framework in the tool and suggested areas of improvement based on that. However, students who had no experience with the tool, suggested areas of improvement based on presentation tools they had used which followed a similar template-layout styling option.

A pilot test was conducted before the actual tests to identify bugs in the interaction flow. The pilot test was essential to understand areas that needed to be fixed in the prototype tested, to make the interaction easier. The tests required the participants to interact with the prototype directly and the feedback from the participants were recorded by the note taker who was present for four tests and five tests were audio recorded and transcribed later. However, since there was no video recording of the participants, insights pertaining to interaction could not be

recorded and were described from memory in the documentation. The documentation and changes to the design based on the feedback took an extra week to implement and was not initially planned. This delayed the completion time of the project by a week.

Further reflection on the results of the tests revealed that the usability issues encountered by the participants might not fully represent the issues that a data analyst who is familiar with the tool might encounter. This is because none of the participants were data analysts and might have had different priorities while exploring the tools as compared to a data analyst who would have been able to provide more insightful feedback about which feature of the design would truly affect their daily working process of creating analyses. Future tests for the design could involve data analysts who fit the target user group, as participants.

7.10 Final Concept and Recommendations

The concept and recommendation section presents the end result of this project and concludes that templates and layouts provide the support necessary to make compelling analyses and good looking dashboards. However, additional considerations can be made to the templates and layouts to make them more effective:

7.10.1 Templates

Presently templates were designed considering only a single use case of it being applied on a dashboard which would be presented stand-alone. However, multiple use cases can be explored to create templates. For example, design templates that can be applied to dashboards which need to be displayed alongside other dashboards as a grid would require a different level of information density than a standalone dashboard. Providing templates specific to the usage would give more room to create versatile dashboards.

7.10.2 Layouts

The concept of templates and layout overlap in a sense that templates also recommend an overall content structure for the dashboard, and the layouts are specific to arrangement of visualizations. This could be made more distinct to strongly convey the difference between the templates and the layouts. However, including structure permutations also in the layouts, could result in in too many options for the user to scroll through. To avoid this, a third tab called structure could be created along with the templates and the layouts, to provide different arrangement options for the overall content structure of the dashboard. But research is required to understand how the hierarchies and order of implementation of the tabs would change if the “structure” tab were implemented. Presently, the layouts recommended suggest permutations regarding just the visualizations on the dashboard. However, providing support for multiple different elements like text boxes, images, key performance indicators, etc. would help to provide a more comprehensive idea of how information on dashboards can be arranged.

7.11 Future work

This section contains further reflections and ideas about future additions to the concept of *Templates* and *Layouts*, which could potentially make them more useful.

7.11.1 Templates

With the concept of templates, there is opportunity to find multiple use cases of a dashboard and create a unique templates for each case. This would help to make the templates more specific to a user's requirements. In the prototypes created, multi-page analyses have not been explored but it was discussed to have the same template apply to every page of the dashboard if it were applied. However, this concept can be explored further to make more detail-oriented templates which drill down and zoom in on features as one steps through the hierarchy of multi-page analyses. Templates can also be made to include interactivity which could make them more interesting to a reader. This could involve creative annotations to allow for storytelling through data on the dashboard, pop-ups for images which are revealed as and when required etc. However, interactivity must be accommodated into the dashboard design carefully to ensure that the dashboard remains data-driven.

7.11.2 Layouts

Customization of layouts is an opportunity to make the concept of layouts more powerful. Customization could involve a user creating their own layouts and then saving the layouts to the library in order to reuse them later. Users could also create data-specific layouts, for example, for a news article, a user can create a layout with a title, three textarea columns placed side by side and an interactive visualization. These layouts can be specific to the use case and provide flexibility to the users to create a layout that suits their data the most. Grouping of similar visualizations into a visualization block can also be done in a more efficient way by providing a merge tool and a snipping tool. This would allow users to merge multiple visualizations that are related and edit grouping using a snip tool that would un-merge two visualizations. However, the specific guidelines identified through this project (Section 5.4.5) are not limited to their application as templates and layouts and could be applied to find other solutions to provide support with dashboard styling.

8 Conclusion

The project was conducted to answer the research question “What support would users of analytic software need to create compelling analyses based on best practices within dashboard design and visual design?”. The results of this project show that **the concept of Templates and Layouts, built into a styling framework within a data analysis tool, based on the specific guidelines identified through this project**, can provide the support required to create compelling analyses. The concept of *Templates* and *Layouts* complement the specific guidelines and provide a way to concretize them and help users apply them.

This project was conducted at a data visualization and analytics product company, referred to as ‘The Company’. In the initial stages of the project, essential requirements for a good looking dashboard were identified as a result of the literature study and expert interviews. Through observations from the design workshop, the requirements were concretized into specific guidelines which explained possible solutions to achieve the essential requirements. These guidelines, which were used as the basis for the design of the final concept, are as follows:

G1: Provide a list of example dashboards to help achieve uniform and harmonious composition on the dashboard.

G2: Provide multiple predefined colour schemes to achieve a uniform colour scheme on the dashboard.

G3: Provide users with the flexibility to apply a minimal and pre-designed style to both an empty or a populated dashboard to automatically minimize clutter

G4: Provide an easy way of integrating the styling tasks into the data analysis process to make the dashboard data-driven.

G5: Provide users with multiple layout options, designed according to Few’s degrees of visual emphasis, to achieve a dashboard layout that encourages readability.

G6: Provide space for a descriptive title on a dashboard to help a reader understand immediately what the dashboard is about and convey a clear context.

G7: Provide contrasting colours in each colour scheme to highlight key information.

G8: Provide the option to group visualisations into a single connected block to highlight relationships between them.

During the project it could be seen that dashboard design guidelines and visual design guidelines, though present in various literary sources, were rarely applied while creating dashboards. This is because these guidelines were easy to understand but difficult to apply without the proper design skill and experience. Due to time constraints and lack of design knowledge, analysts give dashboard styling the least priority in their data analysis process, which results in unreadable and cluttered dashboards. With the support of pre-designed templates and layouts, analysts can easily and quickly create good looking dashboards that suit their requirements. With this in mind, a styling framework was designed as a menu that could be accessed at any time during the data analysis process to provide the users with the flexibility to switch seamlessly between the data-driven tasks and the dashboard styling tasks. Furthermore, analysts also have the option to modify templates to include their company's colour scheme and fonts and apply the same to their dashboards. This compact solution of *Templates and Layouts along with the specific guidelines* could provide the support to create compelling analyses which follow dashboard design guidelines and visual design guidelines.

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Appendix A

Time Plan

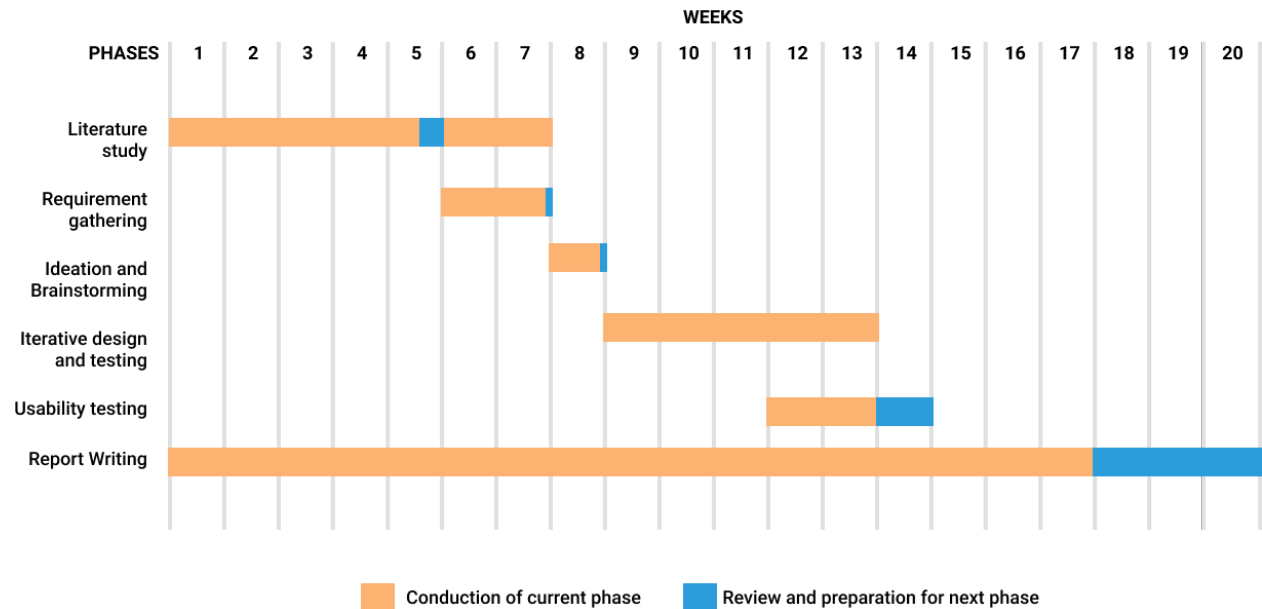


Figure 5.1 Project time plan Gantt chart

Detailed plan:

Week 1-2 (Jan 15- 26)

Literature study

Task

Find literature in information design, visual perception, dashboard design guidelines, design methodology and Interface design.

Make literature summaries

Week 3 (Jan 29- Feb 3)

Literature study and getting to know the tool

Task

Make a list of things to improve within the tool with respect to the styling framework

Finish literature summaries

Start time plan for 20 weeks

Week 4 (Feb 5-9)

Literature study continued and start working with examples in the tool

Task

KJ analysis to categorize literature topics

Make a list of dashboard design Do's and Don'ts based on the literature

Finish the Theory section of report

Decide on the methodology

Finalise time plan (Report)

Week 5 (Feb 12-16)

Study existing dashboard design examples made on the tool

Task

Make a list of common mistakes made in the examples on the tool

Plan questions for expert interviews

Submit planning report

Continue learning the tool through examples

Recruit participants for expert interviews

Start literature section (Report)

Week 6 (Feb 19-23)

Requirements gathering (Expert Interviews)

Task

Conduct expert interviews to understand user scenarios

Start execution section (Report)

Plan for design workshop

Week 7 (Feb 26- Mar 2)

Requirements gathering (Expert Interviews)

Task

Conduct design workshop

Transcribe observations from design workshop

Create user scenarios based on the persona

Finalise a list of requirements

Week 8 (Mar 5-9)

Ideation and brainstorming session with the UX team

Task

Start the first iteration of Lo-fi paper prototype

Week 9 (Mar 12-16)

Iterative design and testing

Task

Prototype hierarchies and layouts- Balsamiq

Usability Test and feedback

First draft of test results (Report)

Week 10 (Mar 19-23)

Iterative design and testing

Task

Finalise layout

Prototype interaction flow-Figma/ Invision

Usability test and feedback

Recruit participants for evaluation and usability testing at chalmers

Complete second draft of test results (Report)

Week 11 (Mar 26- 30)

Iterative design and testing

Task

Finalise interaction

Prototype visual look and feel- Figma/ Invision

Plan evaluation workshop

Finish the execution section other till testing (Report)

Week 12 (Apr 2-6)

Report writing

Task

Finalise design guidelines

Week 13-14 (Apr 9-20)

Testing at Chalmers + TIBCO

Task

Conduct evaluation workshop

Finalise testing section (Report)

Week 15 (Apr 23-27)

Report writing

Task

Finish results, discussion, conclusion, appendix (Report)

Finish report first draft

Week 16 (Apr 30 - May 4)

Submit first draft of finished report to supervisor

Task

Finalise report

Week 17 (May 7-11)

Submit thesis report to opponents

Task

Read opponents thesis report

Week 18 (May 14-18)

Presentation

Appendix B

Interview questions for head of product and the managers:

1. Could you please describe your role?
2. How often do you interact with customers?
3. How often do customers bring up concerns about general look and feel of the analyses as opposed to other concerns?
4. What are their main concerns regarding good looking analyses?
5. Do you give advice in these situations? Do you refer to certain dashboard design guidelines? (Could be overall dashboard design recommendations or specific to look and feel.)
6. Could you share examples of situations where customers have had issues with overall look and feel?(Could be good and bad examples)
7. Do you have examples of situations where The Company have suffered with lost deals(with profits/ general progress) because of lack of a good looking analyses?
8. Based on customer feedback, what features would you like to include in the The Company's tool that can help make good looking analyses?
9. Would you like to change existing The Company's tool's styling features? What features would you change and why?
10. What level of flexibility do customers prefer with styling their analyses? Would they prefer the tool to do most of the styling for them or do they like to have more control of how things look?
11. Based on the current level of flexibility, do you have any ideas of how the experience can be improved?
12. If anything was possible, how would you create good looking analyses?

Interview questions for Data Scientists:

1. Could you please describe your role?
2. How often do you interact with customers?
3. How often do customers bring up concerns about general look and feel of the analyses as opposed to other concerns?
4. What are their main concerns regarding good looking analyses?
5. Do you give advice in these situations? Do you refer to certain dashboard design guidelines? (Could be overall dashboard design recommendations or specific to look and feel.)
6. Could you share examples of situations where customers have had issues with overall look and feel?(Could be good and bad examples)
7. Do you have examples of situations where The Company have suffered with lost deals(with profits/ general progress) because of lack of a good looking analyses?
8. Based on customer feedback, what features would you like to include in the The Company's tool that can help make good looking analyses?
9. What is the most important styling feature that needs to be fixed and what has the least priority that you notice but others don't?
10. What level of flexibility do customers prefer with styling their analyses? Would they prefer the tool to do most of the styling for them or do they like to have more control of how things look?
11. Based on the current level of flexibility, do you have any ideas of how the experience can be improved?
12. If anything was possible, how would you create good looking analyses?
13. When companies ask to have a certain way for a dashboard look, do they refer to resources or examples? What comparisons do they make?

Interview questions for the Visual designer

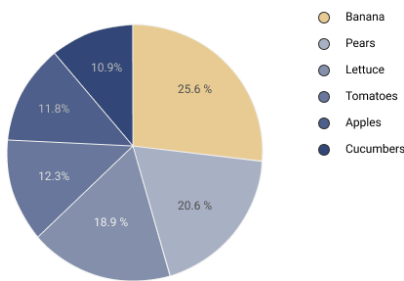
1. Describe your role.
2. What are the most important aspects of visual design when focussing on end result?
3. What were the main features or details you targeted when you designed the light and dark themes?
4. If you were to make a custom theme, what main aspects would you focus on while making custom themes?
5. Do you refer to resources for colour and colour palette design? Could be literature or online generators?
6. Do you recommend different colour scheme for continuous variables and categorical variables?
7. What guidelines or best practices do you follow for general look and feel?
8. *What best practices do you follow for information design? How would you arrange information on a screen?*
9. Does this change when interactivity is involved?
10. What best practices do you follow for colour balance on a dashboard? (Same colours for every graph or different colours for graphs with different information?)
11. How would you change existing styling features? What would you like to add to existing styling features?
12. What is the most important to manipulate for the overall impression of the analysis?
13. If anything was possible, how would you create good looking analyses?

Appendix C

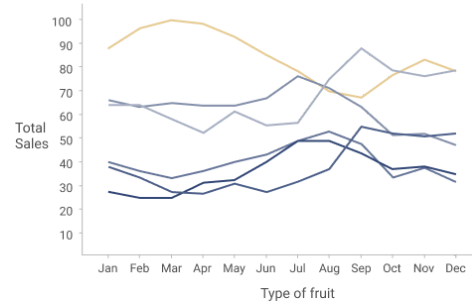
Different elements provided to populate the dashboard

Visualizations: (Provided in three different colour schemes)

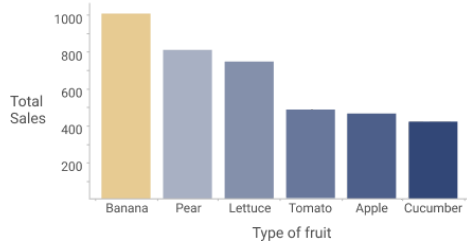
Percentage sales per fruit



Sales per month for each fruit



Total sales per fruit



Total sales of all fruits per month



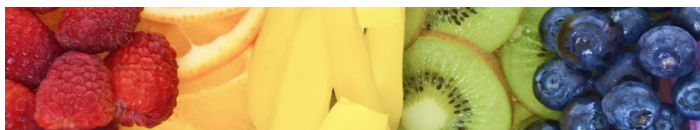
Other contents provided: Filters, logo and images

Filter: Years

- 2011
- 2012
- 2013

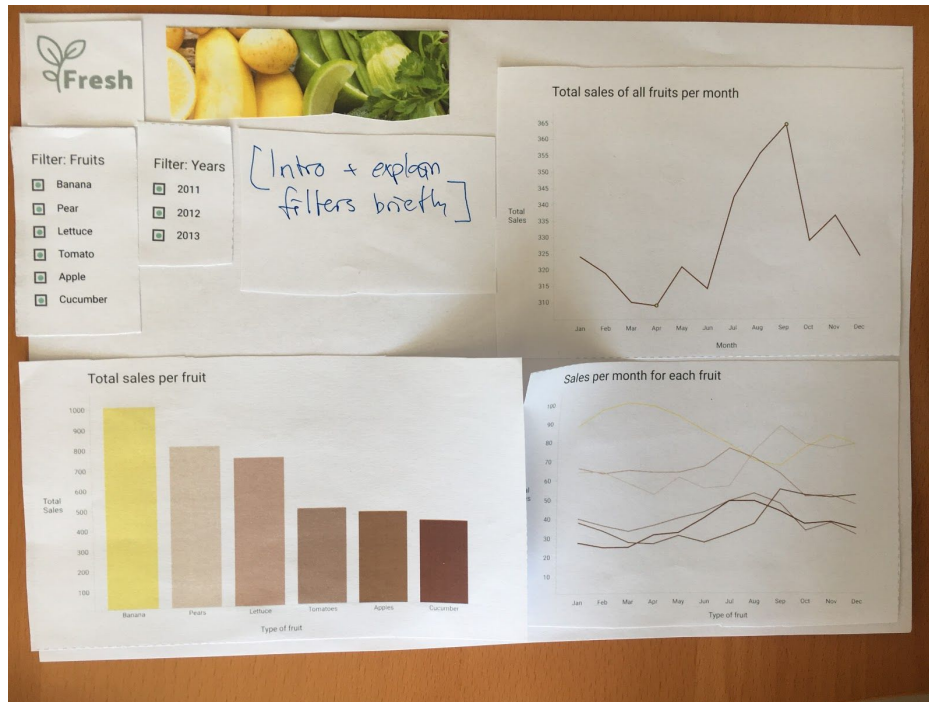
Filter: Fruits

- Banana
- Pear
- Lettuce
- Tomato
- Apple
- Cucumber



Dashboards created by the participants

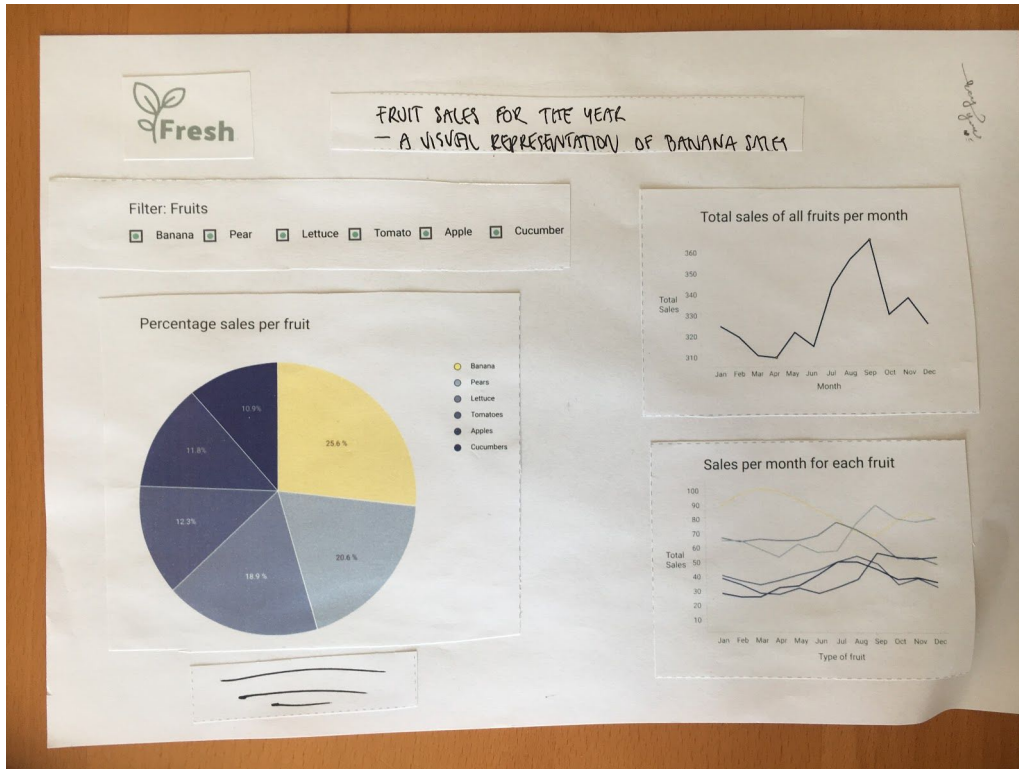
A. Dashboard created by the members of the UX team at The Company



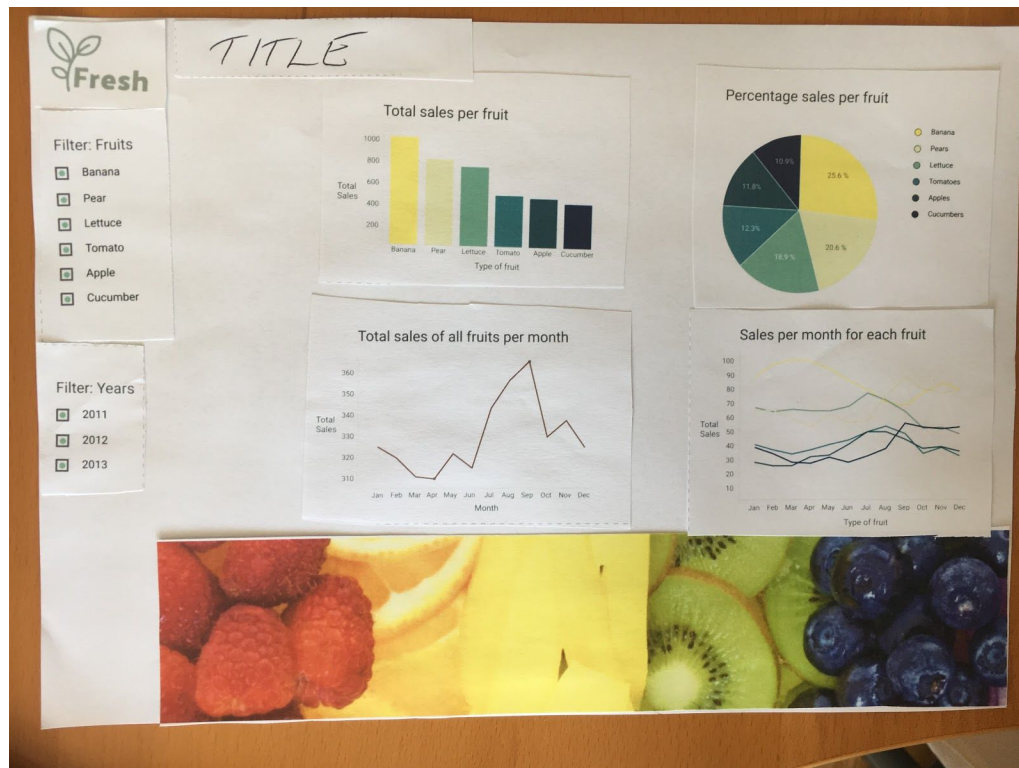
Participant 1



Participant 2



Participant 3: Visual designer's dashboard with no redundancy, right balance of colours and information

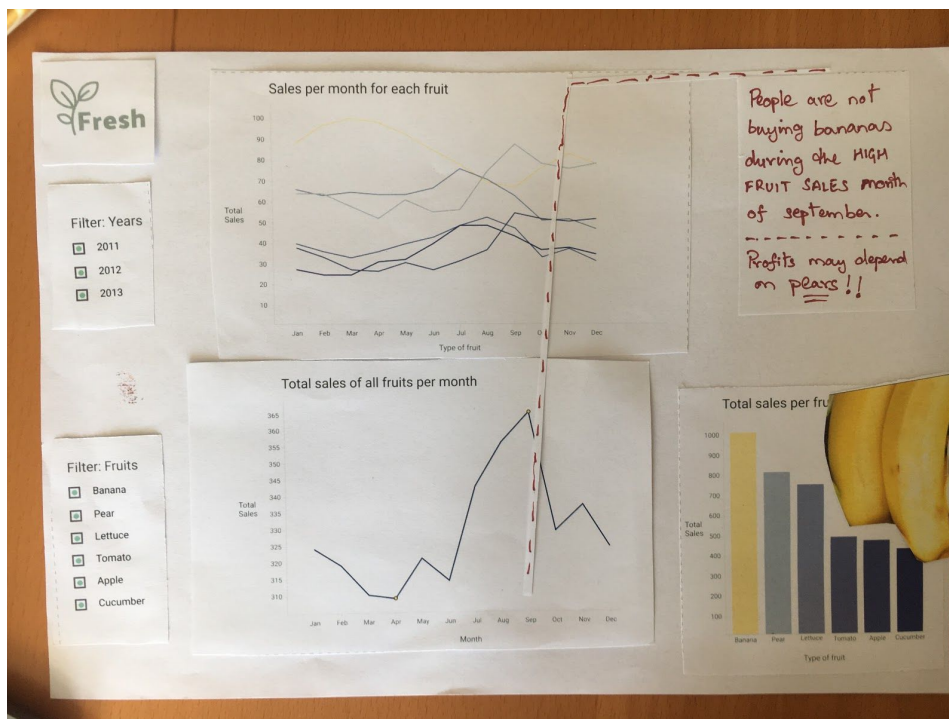


Participant 4

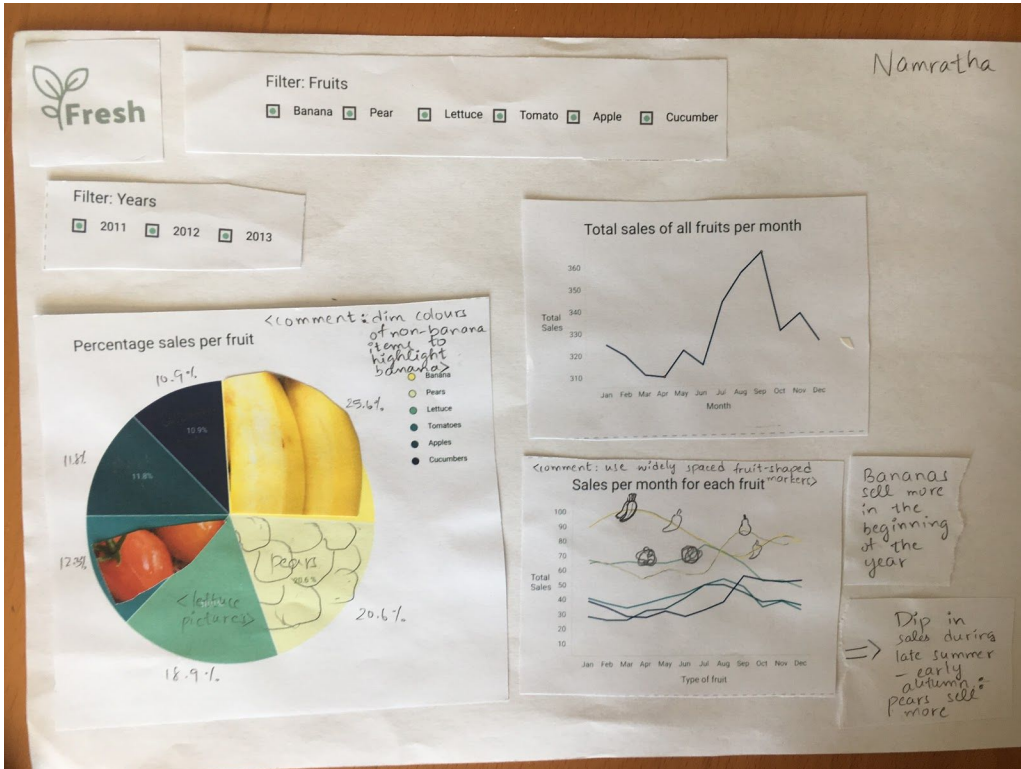


Participant 5

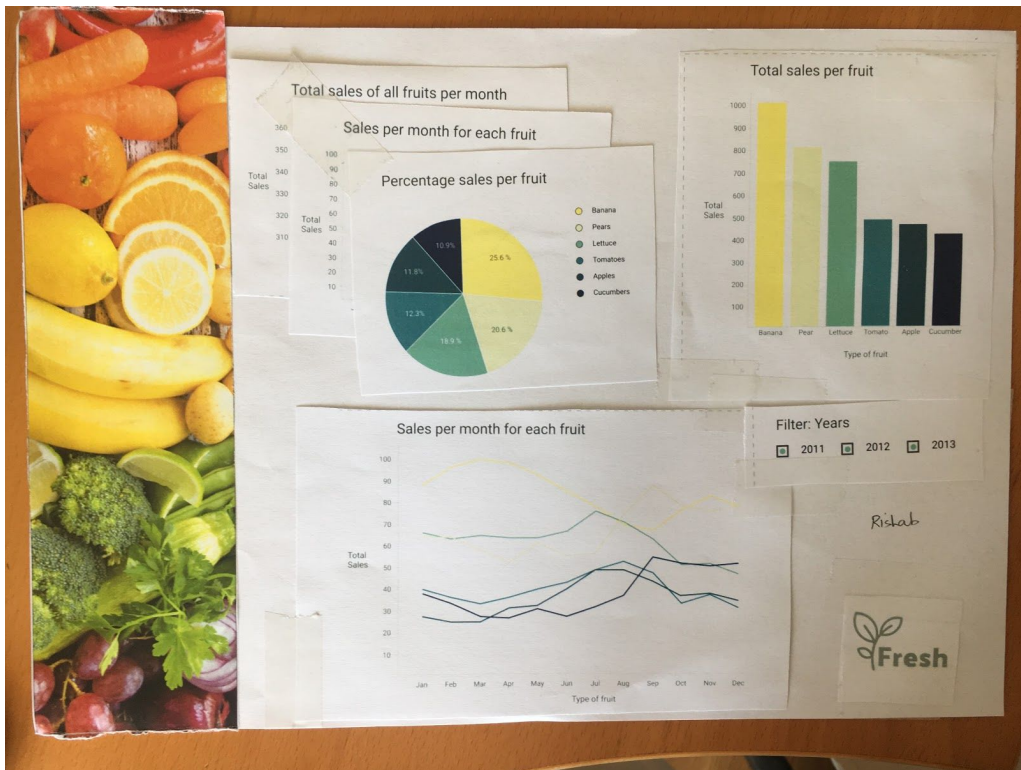
B. Dashboards created by the students at Chalmers University



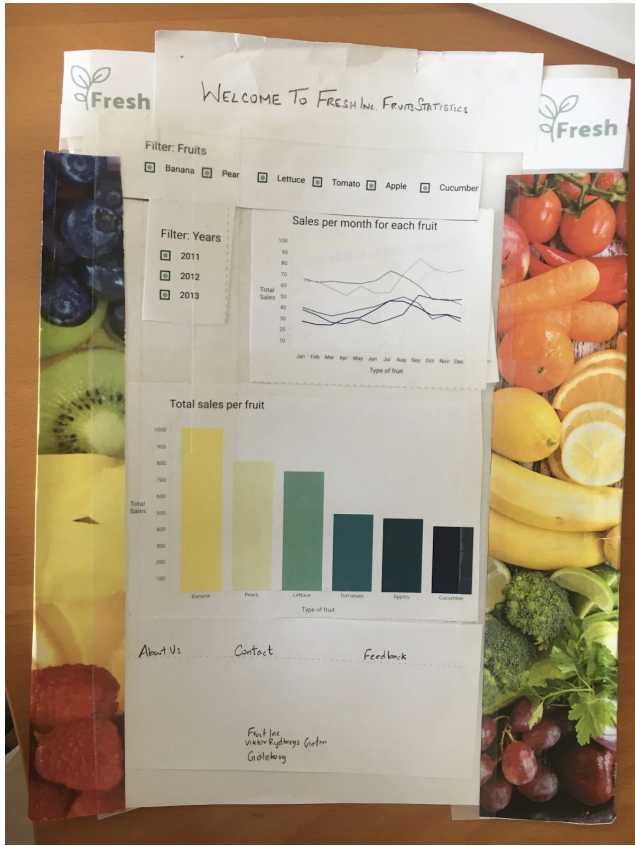
Participant 5



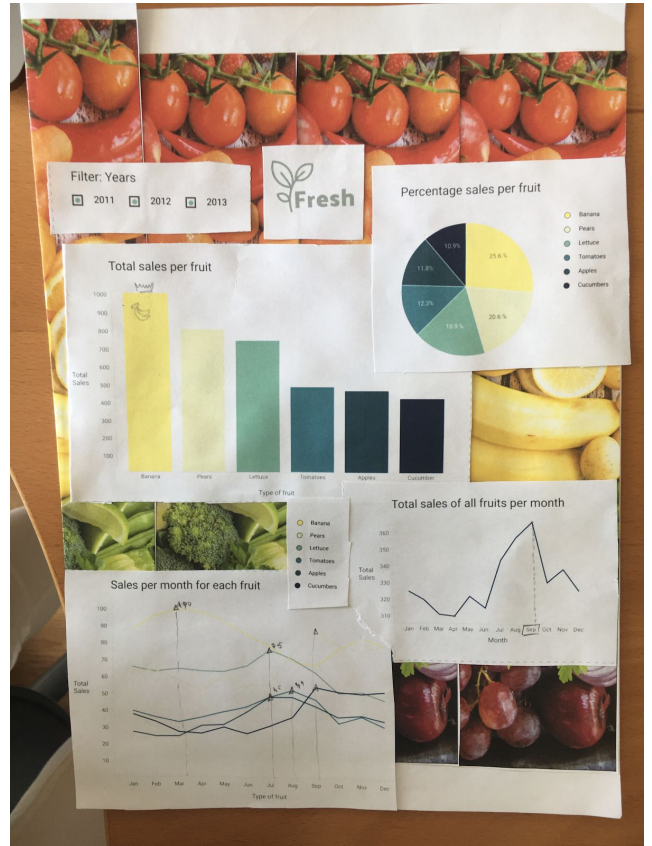
Participant 7



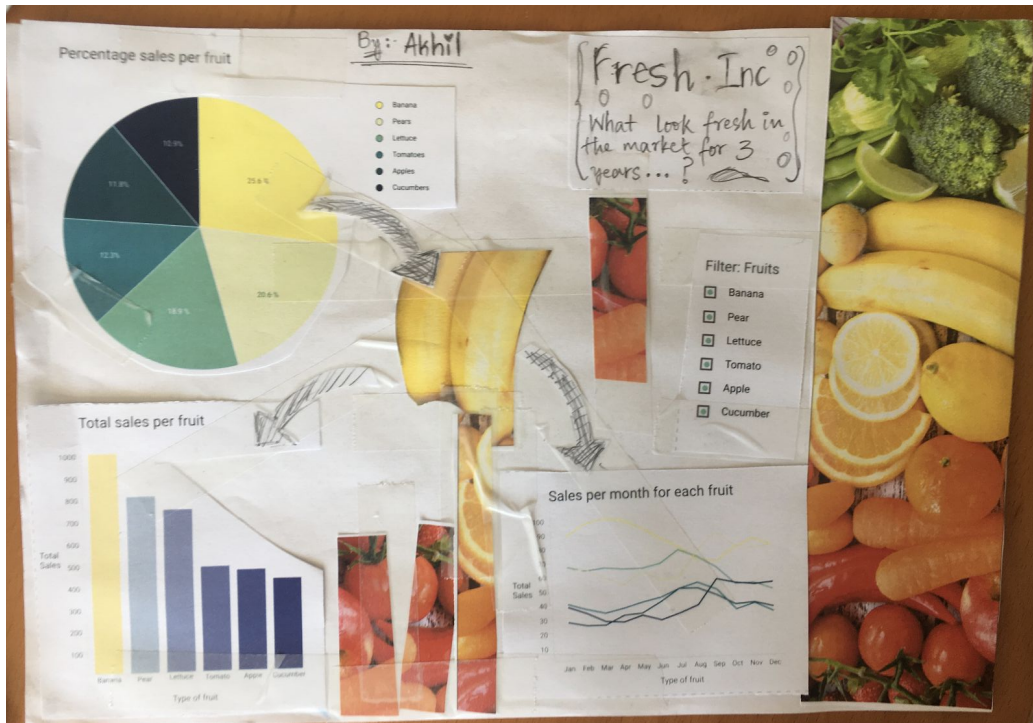
Participant 8



Participant 9



Participant 10



Participant 11

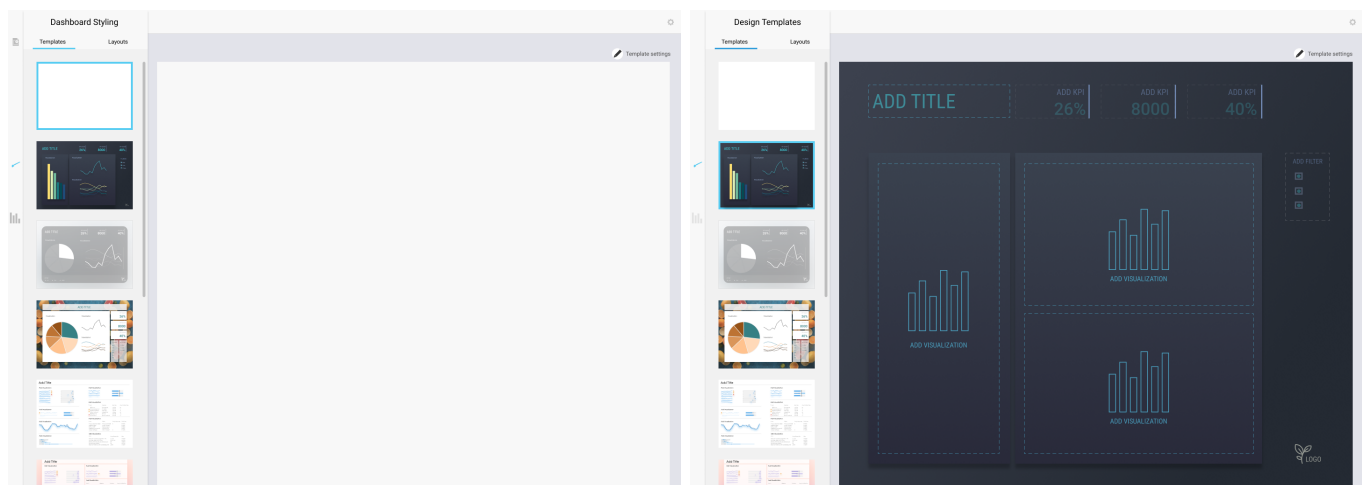
Appendix D

Usability Testing

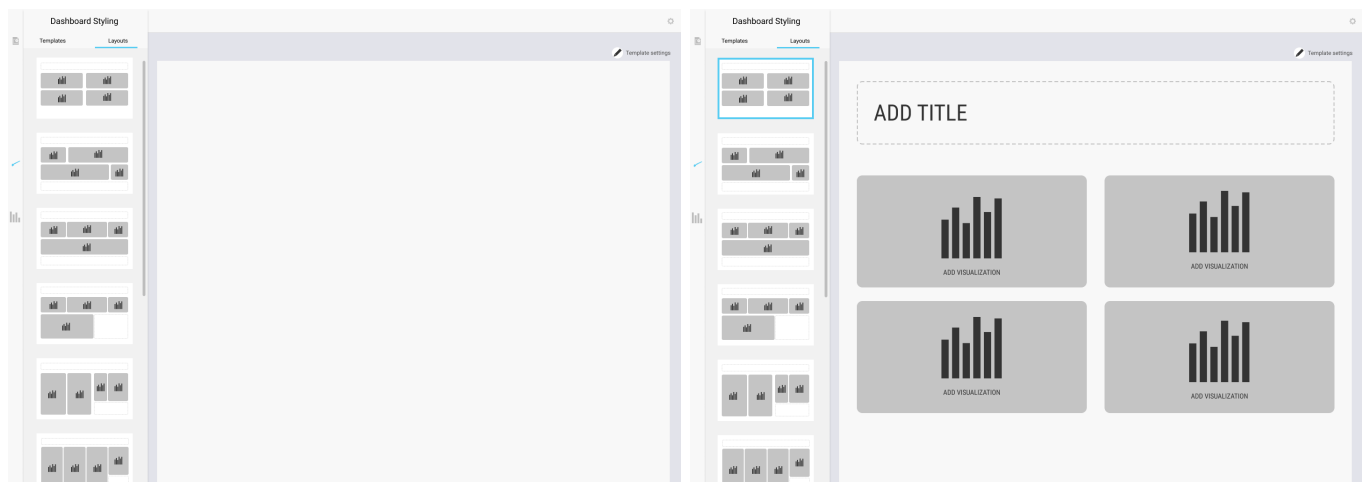
Test prototype:

The prototype tested consisted of the following interaction flow:

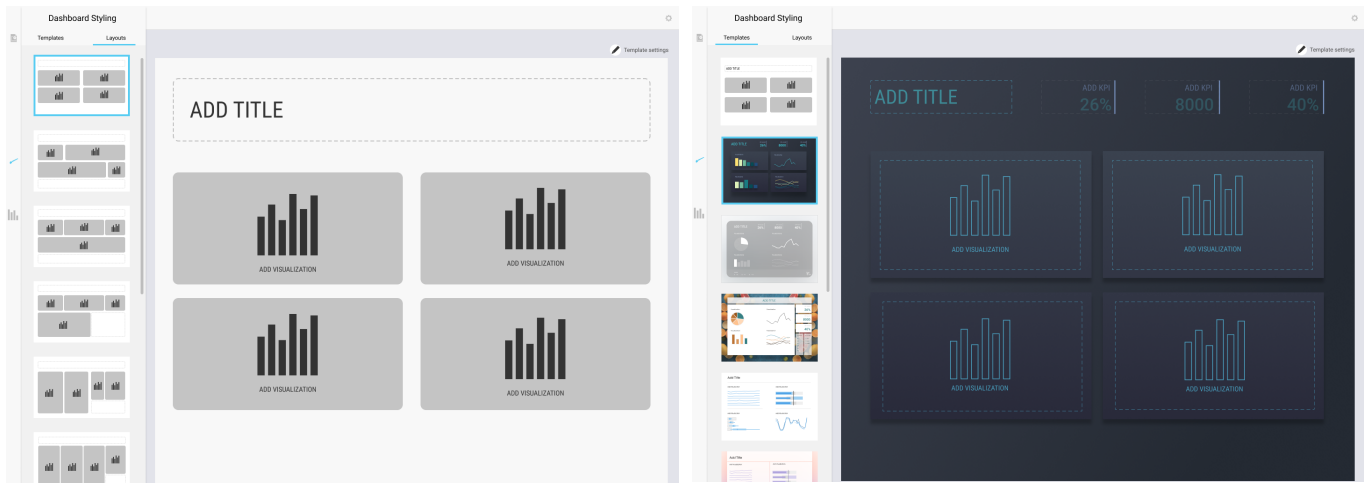
Task 1: Switch between the blank and dark template



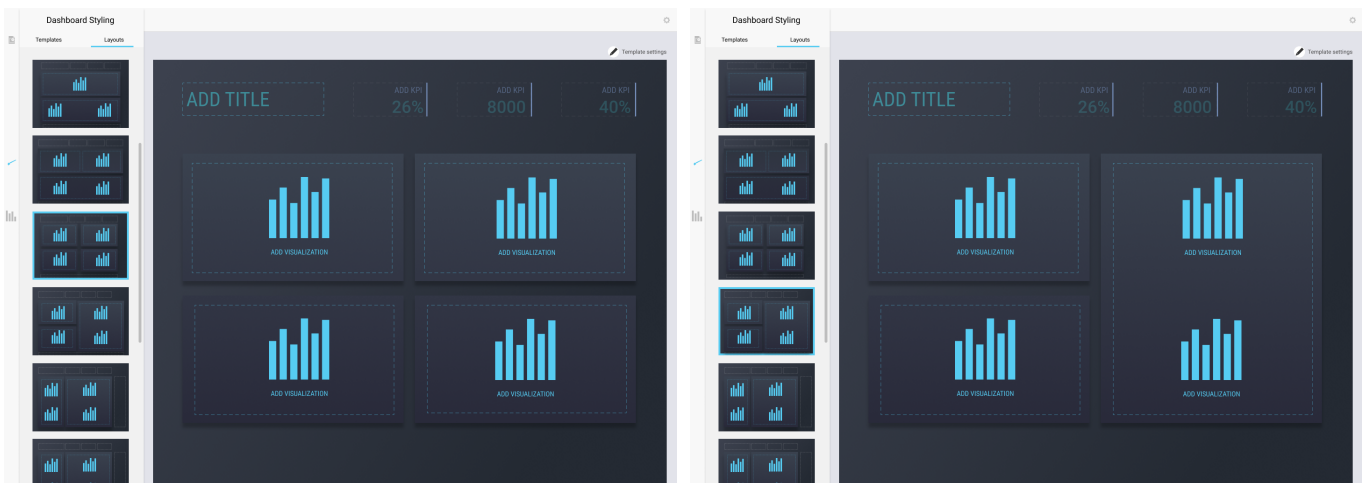
Task 2: Apply the topmost layout



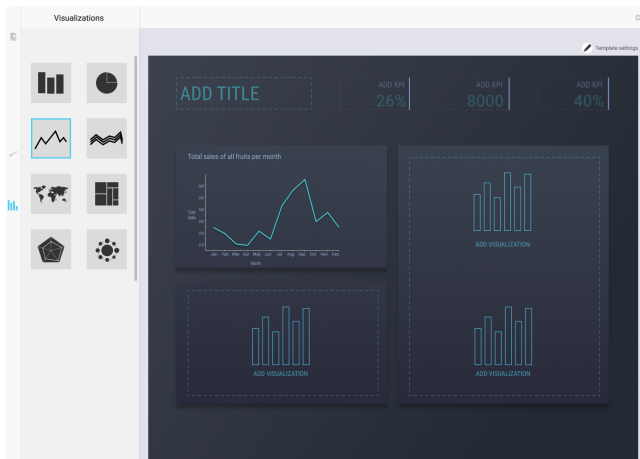
Task 3: Apply the dark template after applying layout



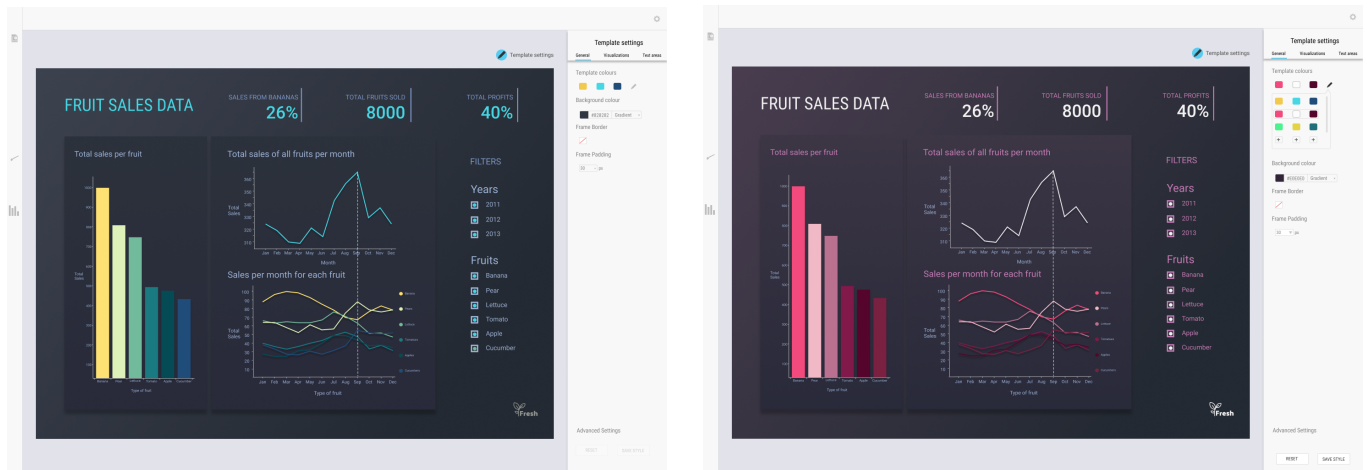
Task 4: Group the right most visualizations in the layouts tab



Task 5: Add a line graph from the visualization flyout



Task 6,7 and 8: Explore the custom styling



Testing Script

1. Empty state:

Explain where the template/layout flyout and the visualization flyouts are.

Task 1: Switch between the blank template and the dark template

- Before: What do you expect would happen?
- After: Is this what you expected?

Task 2: Go to the layouts and apply the topmost Layout

- Before: What do you expect would happen?
- After: Is this what you expected?

Task 3: Apply dark Template after applying layout

- Before: What do you expect would happen?
- After: Is this what you expected?

Task 4: Group the right most visualizations in the layouts tab

- Before: Do you notice any difference in the layout flyout from the last time you saw it? Were you expecting the template to be incorporated into the layouts section?
- After: What are your thoughts on a grouped visualization like this?

Task 5: Add a line graph from the visualization flyout.

- Is this an expected interaction? If no, how else would you like to interact with it?

2. Custom styling

Task 6: Explore the dashboard styling. Edit the template settings

- Where would you find this “editing” option?
- What is the general tab?- what does it affect
- What is the Visualizations tab- What does it affect
- What is the text areas tab?- What does it affect- can you point them out

Task 7: Change the Dashboard style

- How would you change the background colour of the dashboard frame?
- If you changed the template style, what would you expect to change?
- How would you change the template colours of the dashboard?

Task 9: Advanced settings

- What do you think the reset button does?
- What do you think the Save style button does?