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Abstract

Purpose – The purpose of this paper is to explore the complexities in dashboard design process.

Design/methodology/approach – The authors chose case study research, following Benbasat *et al.* (2002) who argued that it is suitable for information system research, as researchers could perform the study in the organisation as a natural setting. As a result, the authors could learn and generate insights from practice. Another reason was mainly as the phenomenon being studied cannot be taken away from its context (Yin, 2003). In addition, through case study, the authors aim to achieve a deeper understanding and richer descriptions on the subject of research in a "real-world context" (Yin, 2012). In addition, it aims to understand the intricacy of the processes going on in the organisation by focusing more towards organisational rather than the technological issues (Benbasat *et al.*, 1987).

Findings – Through research, the authors highlighted that it is important to align the dashboard design with the organisation's visions and goals. This creates a more persuasive rationale for adoption amongst the users, as they could use the dashboard as a means to assist them in achieving the vision and goals of the organisation. More importantly, the analysis clearly indicates the need to consider the creation of a dashboard as a holistic exercise. The intricate processes of designing a dashboard are often underestimated. Instead of focusing into a specific aspect (such as user interface or functionality) of designing dashboards, the authors should look into the multi-faceted aspects in designing an effective dashboard.

Research limitations/implications – This paper articulates the findings from a single case study. However, arguably, the results of this study are transferable to other entities responsible for designing business intelligence (BI) and business analytics dashboards. Research on dashboard design and the use of design thinking across different type organisations is currently ongoing to allow for cross-case analyses.

Practical implications – The study has determined that interdisciplinary and cross-functional group communications play a significant role in designing a dashboard. The ability to collaborate with "data owners", would be dashboard users, managers of the technical infrastructure, and process owners leads to a workable and effective dashboard. In this sense, design thinking could be used and/or regarded as a holistic, creative and solutions-oriented framework.

Originality/value – With an increasing interest on BI and business analytics, dashboards have an increasingly pivotal role in providing a summary of data for business users. The literature review shows in designing a dashboard; there is much emphasis on the graphical user interface and in providing features and functionalities for the dashboards. This paper presents a case study outlining the key considerations of a team in charge of business analytics and dashboard creations for a university. Through the case study analysis, the authors explore the key aspects that influence a dashboard design and analyse the design processes using the concept of design thinking as the theoretical framework.

Keywords Business intelligence, Design thinking, Business analytics, Dashboard, Design process

Paper type Research paper

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Introduction

Contemporary organisations (particularly medium to large organisations) need something to help managers to monitor organisational performance simply and in a more efficient way (Few, 2006). A dashboard is one of the outcomes of business intelligence (BI) that could be used to facilitate the key management tasks of monitoring, examining and controlling (Eckerson, 2006, Su and Chiong, 2011). Not all dashboards are necessarily built on top of BI infrastructure (Eckerson, 2011), as there are dashboards that come as a component of enterprise systems (Microsoft, 2012, SAP, 2011). Generally, dashboards are created through a series of analyses of the data and used to represent key metrics that matter for the decision makers (Howson, 2008). These key metrics may be influential in the decision-making activities of the organisation; hence, arguably, an appropriate design of the dashboard is pivotal.

Our paper is focused on the issue of dashboard design. In an organisational context, managers use dashboards to support their daily tasks in their organisations (Rasmussen *et al.*, 2009; Resnick, 2003). According to Rasmussen *et al.* (2009), a well-designed dashboard displaying key information can help managers spot problems and, hence, take proper actions to improve the situations. It seems clear, therefore, that having efficient tools to access information related to the key performance indicators (KPIs) would be valuable to decision-makers in the organisation (Dyczkowski *et al.*, 2014).

Arguably, the creation of a dashboard is a design issue and activity. Fundamentally, design occurs in most of the things we do (Papanek, 1984), as it is a basic human activity (Papanek, 1984, Lawson and Dorst, 2009). Everything around us is a product of design and everyone is capable of designing (Cross, 2011). We start designing when we want to create something new (Cross, 2011) or when we want a current situation to change into a more desired one (Simon, 1996). The design process starts when we initiate the preparation of actions towards a desired and expected result (Papanek, 1984).

Research has been conducted in the past into the importance of dashboard design, development and implementation (Clark *et al.*, 2006; Pauwels *et al.*, 2009; Yigitbasioglu and Velcu, 2012). Pauwels *et al.* (2009) conducted a study on the literature focusing on the development stages and the effectiveness of marketing dashboards, measured by the benefits generated for the organisation. Elsewhere, Clark *et al.* (2006) performed two surveys which had shown a relation between using a dashboard and a better return of investment.

Later, Yigitbasioglu and Velcu (2012) reviewed the literature on dashboard visualisation, appearance and user characteristics. Generally, while the graphical user interface (GUI) and visual features were essential, they found that functionality was also an important feature that needs to be taken into consideration when implementing a dashboard. They argued that as users continue to utilised information to support their decision making, designers need to be mindful of the effect of information overload. It is important not to make poor design decisions by putting anything on the dashboard which distracts the users' focus on the key information in the dashboard (Yigitbasioglu and Velcu, 2012).

Similarly, practitioner-oriented publications discuss how information should be visualised in dashboards (Few, 2006); how to monitor, manage and measure businesses with dashboards (Eckerson, 2011); and how dashboards should be designed through a number of steps in the dashboard design process (Rasmussen *et al.*, 2009, p. 93).

Generally, they tend to treat the dashboard as a final product of design, without looking at the detailed design process. This might send an inaccurate indication to managers as potential users, that designing a dashboard is a straight forward task. Therefore, managers might not be expecting to encounter such potential issues as data availability and reliability. Indeed, it is not uncommon that some process change or improvement would be needed as part of the dashboard design initiative.

In essence, research studies and publications in the area of dashboards to date have been focused on the GUI, on functionalities and on technological aspects. We argue that there is wider range of issues and elements need to be taken into consideration. So, our research objective is to explore key elements or aspects that influence a dashboard design and to analyse the design process using the concept of design thinking as our theoretical framework. Design thinking is a way of thinking, strategising and approaching problems the way designers would (Martin, 2009; Dunne and Martin, 2006 cited in Rylander, 2009; Poulsen and Thøgersen, 2011). Essentially, it is a holistic approach that aims for innovation (Boland *et al.*, 2007, Brown, 2008) and using a designer's sensibility to satisfy user requirements, based on technological feasibility with a possibility of making a practical business strategy, creating a prospective market and adding value to customers (Brown, 2008). Through our research, we hope to provide insights and contribute to better understanding on what goes into the intricate process of designing a dashboard that often underestimated.

We structure our paper as follows: firstly, we discuss our literature review and present the concept of design thinking as our theoretical framework. Secondly, we describe the research method used in this research, outline the details of our case study and present our results based on analysis of the data we gathered from the case study. We conclude with a discussion of the research implications and our future research.

Literature review and theoretical framework

Dashboards

The history of dashboards dates back to the 1980s and the era of executive information systems. However, these were only used by a few people in each organisation and were expensive to maintain and modify due to their mainframe infrastructures (Eckerson, 2011). Later, BI flourished and became an "umbrella term" for systems that support business decision making by using factual data from the organisations (Power, 2007), including dashboards as one of the components (Watson, 2011). However, it is worth noting that the tendency now has shifted to analytics as the "umbrella term" rather than BI (Watson, 2011).

Dashboards aggregate all the information throughout an organisation and assemble it into a single display (Pauwels *et al.*, 2009; Clark *et al.*, 2006; Few, 2006). Dashboard enables all users in an organisation, regardless of their roles, to have the same view of its performance metrics and the underlying "drivers", as according to Clark *et al.* (2006), the dashboard users were in the same "ship" moving towards the same goals. As a result, a successful dashboard must be aligned with an organisation's core business goals and processes.

However, not all dashboards are necessarily built on top of BI infrastructures (Eckerson, 2011). There are dashboards that come as a component of enterprise resource planning systems like SAP (SAP, 2011) or of customer relationship management software like Microsoft Dynamics (Microsoft, 2012). These are normally referred to as

analytics. The main differences are in the types of infrastructure and the database management systems that feed the data into the dashboards. We could even connect a dashboard into various data sources, ranging from a relational database to a mere delimited text file (Dundas, 2013).

In general, we could simply break down a dashboard into a few components. For instance, data being displayed, features, graphs and metrics, the technologies built upon, the users and the organisation the users belong to. We argue that in the process of designing a dashboard, these dashboard components need to be well-understood. Based on the literature review, there are a number of elements associated with each component that need to be considered (Table I).

Dashboard components	Design elements	Reference
Data	Data warehouse, database systems and data quality	Nagy *et al.* (2008), Olsha-Yehiav *et al.* (2006), Wadsworth *et al.* (2009), Hranac and Petty (2007), Devillers *et al.* (2007) and Pauwels *et al.* (2009)
Technologies	Platform, system architecture, software and information systems	Nagy *et al.* (2008), Olsha-Yehiav *et al.* (2006) and Wadsworth *et al.* (2009)
User	Characteristics (profile, background, experience and preference)	Malik (2005), Yigitbasioglu and Velcu (2012), Hennen (2009) and Pauwels *et al.* (2009)
Organisation	User roles, culture, requirements, policy, goals, decision-making style and business rules definition	Hennen (2009), Yigitbasioglu and Velcu (2012), Clark *et al.* (2006), Eckerson (2006), Hranac and Petty (2007), Rasmussen *et al.* (2009), Pauwels *et al.* (2009) and Devillers *et al.* (2007)
Features	Functionality, drill-down and slice-dice features	Malik (2005), Hennen (2009), Sloane *et al.* (2006), Wadsworth *et al.* (2009), Few (2006), Hranac and Petty (2007) and Pauwels *et al.* (2009)
Graphs and metrics	User interface and metrics selections	Malik (2005), Nagy *et al.* (2008), Olsha-Yehiav *et al.* (2006), Wadsworth *et al.* (2009), Yigitbasioglu and Velcu (2012), Few (2006), Hranac and Petty (2007) and Pauwels *et al.* (2009)

Table I.
Design elements of a dashboard mapped to the dashboard components

Furthermore, we want to look into the design process that takes place before the dashboard design comes into reality. In most cases, the process begins with design problems; for instance, this could be an instruction from an executive to create a dashboard to display KPIs in "external engagements". Understanding these components and the associated elements is arguably critical to the creation of a dashboard. Having knowledge of what data is available, the expectations from key users, the decision making culture, the technological platform of the organisation and the processes that generates the data required could become the contributing factors when making a design decision leading to the creation of a dashboard.

Next, we further discuss design thinking as our worldview to approaching dashboard design issues.

Design thinking

Design thinking refers to "the cognitive processes that are manifested in design action" (Cross *et al.*, 1992). Similarly Boland and Collopy (2004) observe that thinking is not something that happens solely inside our head, but is generally done with interactions with other people and with the help of tools.

Idea generation. Design problems are generally ill-defined or wicked (Cross, 2006). As such, the options may not be clearly articulated nor obvious. In this situation, we should diverge ourselves by creating many choices of solutions (Brown, 2009). Applying design thinking in this situation means we are building the solutions by thinking, not the other way around. Also, in design thinking, we are learning by making, something which can be achieved through creating prototypes as early as possible (Brown, 2009) or models as tools for thinking instead of merely as ways to represent ideas (Boland *et al.*, 2007, Boland and Collopy, 2004). In the context of dashboard design, we argue that design thinking would serve well as a fundamental approach to work with the design problems in creating a dashboard.

Balancing analysis and intuition. Martin (2009) suggested that design thinking could be achieved by balancing analytical and intuitive thinking. On the one hand, analytical thinking involves past-and-proven or tried-and-tested data, rigour and quantitative analysis that potentially gain such advantages as repeatability and scalability. On the other hand, intuitive thinking involves creativity and innovation which Martin (2009) referred to as "the art of knowing without reasoning". Essentially, according to Lawson and Dorst (2009), designers need to make a conscious effort to reach their targeted goal.

At the same time, designers have also paid attention to their intuition. Intuition has been described as notions and contemplations designers unintentionally compose "on a subconscious, unconscious, or preconscious level" (Papanek, 1984). In addition, Cross (2011) stated that intuitive thinking might be something that designers possess naturally or even derive from their experience, prior learning and familiar situations. In the context of dashboard design, designers might possibly make design decisions intuitively based on familiar situations, such as previous projects, but at the same, time they would analyse the situation based on what they had done in the past.

Human-centred: empathy and collaboration. Design thinking is human-centred and is achievable through empathy and collaboration (Brown, 2009). Essentially, Brown (2009) argues that we should think ahead about what users need or might need and give them more than good ergonomics, by understanding the cultural context and environment. Furthermore, he argues that the role of users in design has shifted from consumption to

participation. Hence, design is too significant to be left in the hands of the designer alone. Instead, we should involve users as part of the collaboration team. In the context of dashboard design, arguably, this is going to involve interaction and collaboration between the design team and users. This includes the need to understand the concerns and requirements from the users. As a result, design thinking enables the design of dashboards that could potentially be useful for the users.

Creating innovations. While designing, Boland and Collopy (2004) suggest we start anew on each design task and always strive for creating something new and significant. Also, we should respect any special conditions or constraints, but should not feel being limited by them. In applying design thinking, we should have the ability to exploit contrasting ideas and constraints to create new solutions (Brown, 2009). That way we move towards changing things for the better. This can be achieved through balancing the "liquid and crystal" states while designing. That is to avoid fixating ourselves into a certain idea too soon, and at the same time, we keep new ideas flowing (Boland *et al.*, 2007, Boland and Collopy, 2004).

Another way to assess the opposing constraints on design is to balance between desirability, viability and feasibility (Brown, 2009). Especially, in the context of dashboard design, there could be some intricacy behind the design process. Based on the design elements listed earlier in Table I, we foresee a discourse and the involvement of different parties such as designers, business users and/or information technology (IT)/ information system (IS) personnel. Apart from that, there would be users and organisational aspects immersed in the design process that we simply could not ignore. Also, it is beneficial to be mindful of the impact of the design process on the current technologies and processes in the organisation. Designers need to make sure each and every design element is taken into consideration so that the end result, the dashboard itself, could eventually deliver an innovation for both the users and the organisation.

Design thinking strategy

To summarise the notion of design thinking, we checked the design strategy model developed by Cross (2011, p. 78), created based on his interviews with renowned designers (Figure 1). The main idea was to understand how designers think, and three main characteristics were identified. The first characteristic was to take a comprehensive and holistic approach to the problem as a whole rather than accepting narrow problem criteria. The second one was to frame the problem in a unique and rather subjective way. The third characteristic was to utilise first principles to bridge the gap between the problem frame and the solution concept. (Cross, 2011). Essentially, it seems that innovative design matures when designers encounter conflicts between their ideal problem goals and users' basic criteria. This means that they were challenged to explore the problem frame in a very personal way and, at the same time, develop a solution concept that matched the solution criteria set by users (Cross, 2011).

Overall, we find Cross' (2011) design thinking strategy model relevant to our research, as we could make use of it to address our research objective. Hence, we will put forward a theoretical framework (Figure 2) for our research based on this model (Figure 1). Taking the recollections of designers during the dashboard design process, we need to investigate if there are elements in the design process that indicate the features of design thinking. The extensive discussion on design thinking in this section,

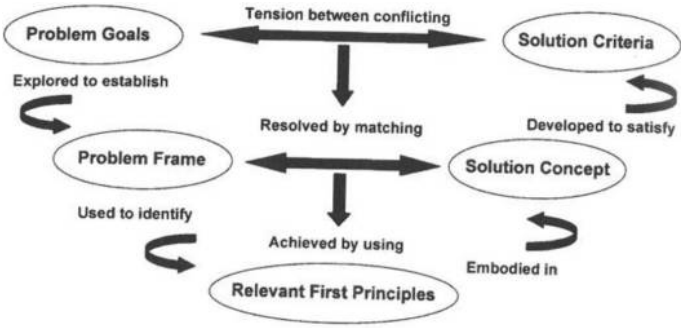

Figure 1.
The design thinking strategy model developed by

Note: 4.1 A model of the design strategy followed by creative designers
Source: Cross (2011, p. 78)

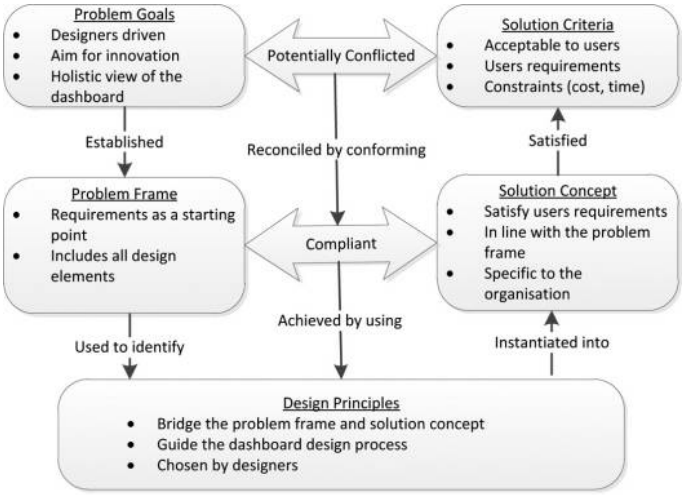

Figure 2.
Design thinking dashboard development framework adapted from

Source: Cross (2011)

especially on definition and the characteristics would later be useful in the development of codes to analyse our research data.

While the original model placed more emphasis on the designer's point of view, we would include the participation of users and stakeholders in the dashboard design process. We also make a slight modification by replacing the "first principles" in the original model with the term "design principles", as they both denote the same meaning (Cross and Cross, 1996).

The design process starts with a discourse involving users and stakeholders and led by designers. This is when users state their expectations and need, and stakeholders express their concerns related to the design initiative. All of these will later be identified as criteria for the solution. Then designers would obtain information from various data

sources (internal and external) in the organisation before outlining their problem goals. There is a likely gap between the problem goals and the solution criteria. The problem goals in this context signify the designers' entire innovative idea for how the dashboard will be designed. The solution criteria suggest what is required by and acceptable to the users, including some potential constraints. As designers seek to reconcile the gap, they will start by exploring the problem area and framing the problem.

Furthermore, the problem frame would inform designers when choosing the design principles. The principles would help designers to instantiate and to make a conjecture of the solution concepts. At this stage, the solution concepts have to be in line with the problem frame. Additionally, it is possible for designers to work back and forth between the problem frame and solution concepts to finally to create a dashboard that satisfy the solution criteria within acceptable time constraints.

In subsequent sections, we describe the research method used in this research, outline the details of our case study and present our results based on analysis of the data we gathered from the case study.

Research methods – case study research

We chose to use case study research because it is recognised as being suitable for investigations in natural organisational settings (Benbasat *et al.*, 2002). As a result, we were able to learn and generate insights from practice. Another reason for choosing the case method was based on the argument that the phenomenon being studied cannot be taken away from its context (Yin, 2003). Through case study, we aim to achieve a deeper understanding and richer descriptions of the subject of research in a "real-world context" (Yin, 2012) and to understand the intricacy of the processes going on in the organisation by focusing more on organisational than technological issues (Benbasat *et al.*, 1987).

Methods

This was a qualitative research project where data were gathered through semi-structured interviews with key personnel in the design team, including managers, analysts and a business user at the executive level. Each interview took about an hour and was recorded using a digital audio recorder and later transcribed to help with analysis. The interview questions covered areas of the design process, considerations, collaboration, conflicts or discourses which were relevant to the process of creating a dashboard. Also, we discussed with the participants some key aspects that influenced the process of designing a dashboard in the organisation.

To analyse the data, we used qualitative content analysis, a method which is commonly used to analyse an extensive range of textual data, including interview transcripts and notes on observations. It could be used regardless of our research methods and design (Julien, 2008), as it focuses on the content and the contextual meaning of a text (Hsieh and Shannon, 2005). In particular, it examines the text in depth for the purpose of categorising parts of the text with similar meaning into a number of categories (Weber, 1990). Furthermore, qualitative content analysis involves close reading of the textual data, assignment of codes onto clusters of text which later would be transformed into themes (Julien, 2008) and grouping "similarly coded data" into categories (Saldaña, 2013, p. 8).

We started our initial data analysis or as Miles *et al.* (2014) put it, first cycle of coding, with a deductive approach by preparing a list of initial codes. We prepared these initial codes based on our theoretical framework as discussed earlier and on the literature on dashboards and design thinking. Meanwhile, our theoretical framework and literature review informed us when developing interview questions for use during data collection. At a later stage, following Forman and Damschroder (2008), we combined this initial approach with an inductive approach. Hence, we used the a priori or initial codes to start coding the data, while at the same time we identified new codes inductively and also to improve our initial codes.

Our list of initial codes was greatly informed by and derived from the literature review, such as in Table I, where we listed key design elements to be considered when designing dashboards, and in Figure 2, where we described the Design Thinking Dashboard Development Framework adapted from Cross (2011). While reading each interview transcript, we applied our initial codes and added new codes if we encountered interesting ideas that had not been covered on our list. Subsequently, we categorised our codes and continued our data analysis by assigning themes based on our interpretation of the meanings of data. Although themes normally are "derived from codes" (Firmin, 2008, p. 868), Saldaña (2013) argues that themes are not merely a translation of codes, but are the results of coding, categorisation, analysis and reflection.

Case background

Our case study was done in UniOne's finance department. UniOne is one of public universities located in Melbourne, Australia, that has been around for more than 20 years. As of 2014, it employs more than 2,500 staff and has more than 30,000 students enrolled across its campuses in Melbourne and overseas. The University has committed to dedicate itself in providing high-quality teaching and research by combining in-class study with industry engagement. In the long term, it has planned to be one of the most prominent universities in terms of innovation, learning and technology in Australia.

At the time of interview, on the first half of year 2014, the University was undergoing a structural change due to various reasons, mainly in line with the government funding regulation changes. Previously, the organisation structured by faculty. Each faculty would have its own functional departments to support daily operations in running courses and programs for students. Subsequently, the University changed the structure of the faculties and incorporated the functional departments into a centralised area to support all faculties. By doing so, they hoped to create a much more efficient way of running the business and to be in line with the University's long-term strategic plans.

We performed our interviews on a particular team that handles financial planning and performance monitoring for all departments in UniOne. They work with users in the University from different levels (executive, managerial and operational) to provide necessary information in reports or dashboards formats. Prior to that, the team needed to consolidate data from various sources throughout the University and from external sources. Those data would then be prepared, cleaned and transformed before the team could use them to create and design the reports and dashboards for the users.

For the past two to three years prior to our interviews, the team has been using Tableau application as a tool to design the dashboards. In the past, they served the

users with statistical data analysis and delivered the results in Excel files. With Tableau, they could provide their users with more capabilities than Excel in terms of data presentation and visualisation. It is worth noting that the emphasis was on presenting numbers and statistical analysis. Although they were not specifically trained in IT/IS or design field, they were able to utilise Tableau application to deliver useful information for their users.

In Figure 3, we describe a simplified organisational structure of UniOne's finance department. We have also circled the area of interest where we performed the interviews with the dashboard design team. In Table II, we summarise some relevant information (using pseudo-synonyms) about the research participants and their job roles in relation to the dashboard design process.

Next, we present our interpretation of data followed by results discussions.

Interpretation and results

From the data analysis, we present our interpretation and results of this research. Firstly, we discuss the dashboard's importance and visions based on the accounts of UniOne's design team. Secondly, we describe key aspects in dashboard design according to the design team, including some of the design elements mentioned earlier in Table I. Lastly, we present the arguments resulting from our analysis and based on our theoretical framework of design thinking.

Dashboard visions and importance

In UniOne, when designing a dashboard, it is important that the purpose is in line with the University's strategic plans, visions and missions. Those strategic plans were strongly influenced by employees' job descriptions and responsibilities across different divisions and hierarchies at UniOne. Aligning the dashboard design with UniOne's strategic plans makes it easier to reach out to different levels of users in the University, as everyone could relate to their day-to-day tasks. Practically, information on the

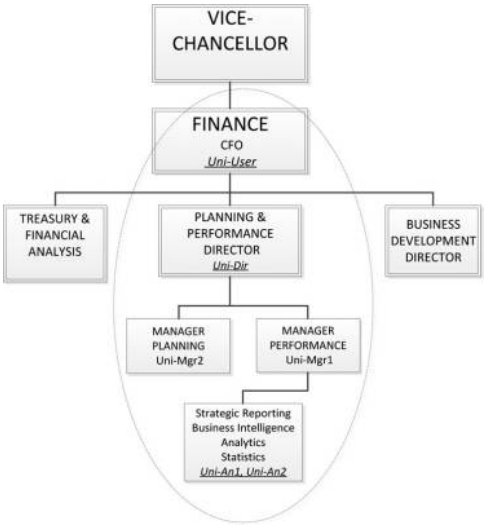

Figure 3.
Structure of dashboard design team under UniOne's finance department

Participant	Job title	Role description
Uni-Dir	Director	He is the head of the team. The main responsibilities of his team are to manage data from internal and external resources, and to support users from different levels in the University in making sure that they get the information they need
Uni-Mgr1	Manager, performance report team	Although his current job title is as a manager, he performs various roles as an analyst, and designer as well as a team leader His department is responsible for several tasks, such as reports preparation and development, statistical and trend analysis, metrics and dashboard design and delivery, data cleansing and integration and many more
Uni-An1	Analyst	Uni-An1 is one of Uni-Mgr1's team members. Her role mainly has been as a reports/dashboards analyst. Prior to publishing reports or dashboards, she collects the necessary data from different sources in the University. Subsequently, she uses Tableau to design and develop the dashboards for her users
Uni-An2	Analyst	Uni-An2 is also one of Uni-Mgr1's team members. Her role is similar to Uni-An1. She and Uni-An1 handle different types of data and information
Uni-Mgr2	Manager, planning team	Uni-Mgr2 is a manager in a University's finance planning department in UniOne. She works with the reporting team, Uni-Mgr1 and his team in developing metrics and measures and aligning those metrics with the University's strategic goals. She is not only part of the design team but also a dashboard user
Uni-User	CFO	Uni-User does not only function as the head of the finance department; he is also a dashboard user. He actively utilised information on the current systems in UniOne to support his decision-making activities in daily basis

Table II. Summary of interview participants in UniOne

dashboard could be presented with a different level of detail according to the users' needs. Executive users would see summarised information while managers and users at the operational level would see more detailed information:

> And a very convenient way to do that is through a hierarchy of dashboards. So that at a very high level you'll have a high level dashboard that might be aligned to the major strategic plans of the organisation but you've got to be able to drill down from that all the way down to a much lower levels of data for people that need data at a much more detailed level (Uni-Dir).

This idea resonates with the views of Clark *et al.* (2006); a dashboard enables an organisation to have the same view of its performance metrics and the underlying "drivers". Clark *et al.* (2006) also argue that regardless of the user roles in the

organisation, the dashboard users were in the same "ship" moving towards the same goals. That is why a successful dashboard must be aligned with core organisational business goals and processes.

Apart from this, the design team concurred that the dashboard helped them make the most of the data that have been collected over the years. They hoped this information could be useful in helping people in the University to assess their work performances and to use evidences to base their decisions on. Essentially, the design team wanted to encourage users to use dashboards by creating awareness on the extent of information they had access to and by showing the users what the dashboards could do:

> [W]e try to engage the end users, if they're at senior level then we try to let them aware actually this application we can combine sources that from like you can get anywhere not just within UniOne. So it makes them aware the capability that you can actually do more analysis (Uni-An2).

Last, their ultimate goal of delivering information through dashboards for users in UniOne is to provide a self-service access to dashboards so that users can perform their own analysis and queries, and subsequently enable them to make decisions based on the information that they obtain from the dashboards. They also like the idea of designing dashboards for the University as a source of information in which users trust and will go to every time they needed information. As what Uni-Mgr1 and Uni-An1 referred to as "one source of truth":

> [It] will be sort of our one source of truth and one source of one stop of platform that people know of okay if I need report I'd go there (Uni-An1).

Key aspects in dashboard design

Earlier on the literature review, we gathered a number of elements associated with key components that need to be considered when designing dashboards (Table I). We now discuss these key aspects or elements based on the interviews with the design team at UniOne. We also summarise these key aspects into three main categories (users, technologies and contents) which are presented in Figure 4.

One of the key aspects of the dashboard design process mentioned by the design team at UniOne is organisational culture. According to Uni-Mgr1, his team has been actively encouraging, giving advice and promoting the use of various sorts of reports and predictive models, as well as dashboards. Users were not going to get a maximum amount of information nor being able to see the value of the data unless the culture in the University was changed. Uni-An2 also pointed out a need to change the organisational culture of users in the University, such that they would not work in an *isolated way* or in silos. She also noticed that some groups of users had produced their own reports. By designing dashboards for them, the users could see information from a wider perspective, as the design team would have access to various data sources across the University. Meanwhile, Uni-Dir noted the culture of some cohort of users in UniOne that liked to make decisions based on gut feelings indicating a "slow" adoption of dashboards:

> But getting people within the University at a very senior level to pay attention to the data it's not as much as part of the organisational culture as I'd like it to be. So a lot of what occurs in a place still I think is more a little bit too much gut feel and based on a lot of things and not enough looking at the hard numbers of about something [Uni-Dir].

Apart from the organisational culture, users were also considered key in the dashboard design process. Every user would have unique requirements depending on which area in

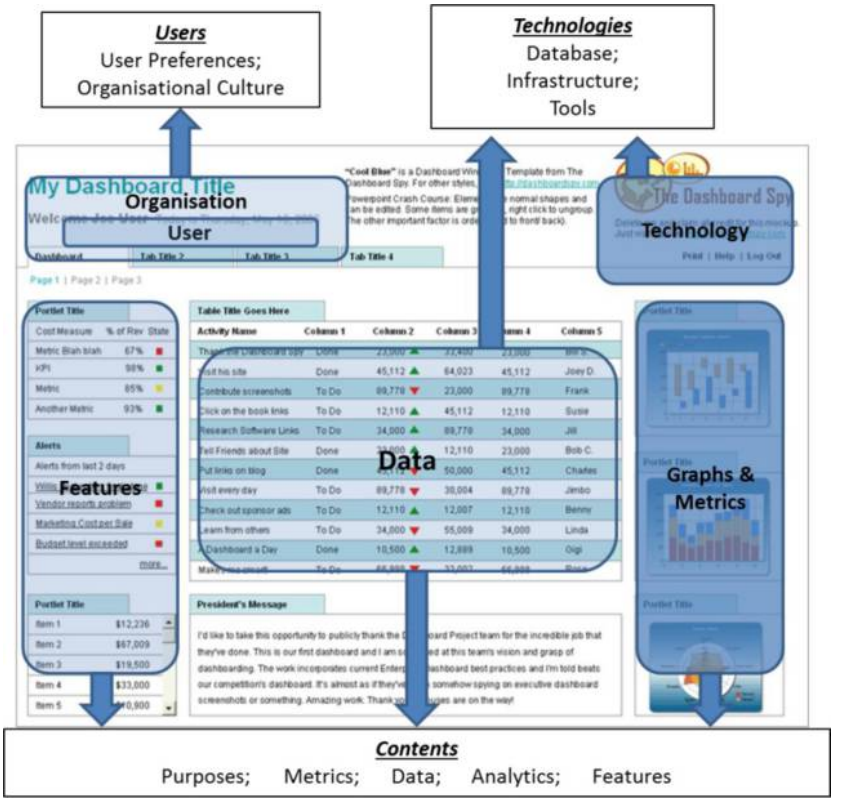

Figure 4.
Key aspects of dashboard design in UniOne[1]

the University the user works in. Also, different levels of users (executive, managerial and operational) would determine the granularity or how detailed the information to be presented:

> So we need to be careful in how we present them and what sort of level of user we're expecting […]. Because there's a different level of users. Someone a lot of details […]. Whilst some are just more interested in seeing the overall trend (Uni-An1).

Therefore, dashboards need a drill-down feature so that they can show different granularities of data for users at different levels. With easy access to information on the dashboards, Uni-Mgr1 suggested that people could manage their own work performance, encouraging them to work more productively and independently. Thus, managers could spend less time managing people and subsequently could make use of the time to *mentor* them and focus on the main jobs. Also, the facility to display how people perform at work through the metrics on the dashboards promotes good morale and increases satisfaction among staff, according to Uni-Mgr1.

Not only that, Uni-Dir mentioned that the drill-down feature helped finding a root cause when users were investigating a phenomenon. Furthermore, Uni-An2 argued that the drill-down feature enabled users to work interactively with dashboards:

> So if your employment rates are down, or the student satisfaction rates are down, and they'll try to drill down further into the data and try work out just what it is. Why students are unhappy with the subject or, and then develop the improvement plans (Uni-Dir).

Choosing the metrics is also crucial when designing dashboards. There is a need to identify the business drivers to be able to evaluate the efficiency of all areas in the University. When it comes to identifying the important metrics, Uni-Mgr1 thought that we have got to understand the purposes of the metrics and their relevance to the users. Apart from that, we need to bear in mind the indirect effects on the University's reputation in the long term. In a way, a metric might not only represent the performance of a specific area in the University, but holistically it also has impacts on the University one way or another. Additionally, according to Uni-Mgr2, the metrics should be developed strategically in alignment to UniOne's visions and missions.

Despite the users' eagerness to get more reports and dashboards, getting access to reliable and clean data was a bit of a struggle for the design team. They needed to make sure that data from various sources in the University were pooled, integrated and standardised before they linked them to the dashboards. Uni-An1 argued that the design team needs to work with data owners to ensure they are accountable. So, in the end, the dashboards could display consistent and accurate information.

In relation to that, another aspect in delivering dashboards to the user was the technology of the database and infrastructures in the University, areas in which there was still room for improvement at UniOne. At the moment, they had to source data from disparate and decentralised databases and the legacy systems. Having a *good infrastructure* or a data warehouse system, Uni-An2 and Uni-An1 concurred, would help in delivering dashboards to the users:

> I Guess at the background you have to have that good infrastructure to fit in this purpose (Uni-An2).

To make dashboards more advanced, Uni-An2 and Uni-Mgr1 thought they should provide an analytics capability to the dashboards. Uni-Mgr1 argued that the heart of the dashboards is in the analytic models. In particular, a predictive analytic could be a vital feature in the future, as it helps predict growth and gives the University an edge to compete in the industry. But most importantly, we need to get *the concept right* and to keep in mind the purpose of the analytics and the dashboards as a whole:

> We have a feel of what we need to identify analytics within University to identify performance and quality. […] The most important part of developing models is giving the concept right and always keeping the best of your head the purpose of what we're trying to do with this particular model (Uni-Mgr1).

Having discussed all the key aspects above, there was an insight from Uni-Mgr2 that has not been mentioned by others. According to her, the most important aspect when designing dashboards for users in UniOne is the *usefulness* of the dashboards. She argued that it is essential to make sure the design team understand the purpose of the dashboards. Hence, that they knew that they were doing it right and looking at the right focus, rather than directly starting with a dashboard project without thinking about or looking at the big picture:

> So with anything, it's that usefulness from the perspective of the business user and the relevance to that, to operational and strategic goal. And knowing how or why it's useful, that's

> for me is primary. Yep, it has to be useful. […] Well if we're providing a lot of data that people looking at and, "well that's interesting that's great but it's not useful". It's not really the key objective of the dashboards from my perspective (Uni-Mgr2).

Reflections on design thinking

When we analysed our data, we were informed by our theoretical framework of design thinking illustrated earlier in Figure 2. As a result of our interpretation, four main arguments emerged from our case study which is presented in the following sub-sections. For each argument, we discuss the relationship with the key aspects or elements mentioned earlier in Table I.

Communication as a key to user-centred dashboard design

Our discussion in this section is related mainly to the users as one of the key aspects when designing dashboards. Based on the middle part of our theoretical framework in Figure 2, we stated that as the design team tried to reconcile the gap between the problem goals and the solution criteria, they would start exploring the problem area and framing the problem. At this stage, the solution concepts have to be in line with the problem frame. We also mentioned that it is possible for designers to work back and forth between the problem frame and solution concepts to finally come out with a dashboard that satisfies the solution criteria within an acceptable time constraint.

Therefore, we argue that communication becomes an important skill for members of a design team, as they need to collaborate with and understand what users really need to have on the dashboards. The analysts and other members of the design team in UniOne may not be formally trained as designers or software designers. However, through empathy and collaboration as characteristics of design thinking, they were able to assume a designer role. They developed "hybrid skills" (Keen, 1981, p. 31) that enabled them to be more flexible and to have interdisciplinary communication skills that help them move forward with the project of designing dashboards for their users in UniOne:

> [B]y not only after we communicate with them and see what help in their daily life, and their work, then we probably won't aware that what sort of report they focus that are more important to them (Uni-An2).

> And knowing how or why it's useful, that's for me is primary. […] And now I understand why it's important to be looking at this data in a molecular basis because they are key indicators (Uni-Mgr2).

The "hybrid skills" which included mainly communication were needed because in organisations we cannot ignore organisational and political issues (Keen (1981). Uni-An2 discussed the issue of politics while gathering requirements and during collecting data from different divisions at UniOne. It became an issue with data ownership and accountability at the end of the day. The design team needed to collaborate with data owners across the University and to negotiate with them to share their data as well. More importantly, they needed to explain the big picture, with data integration as part of their effort in designing a dashboard for users in UniOne:

> [D]ifficult in a way that I think political reason. Because each of the area they have their also they have their data reporting people. And they also have some sort of data set that have been somewhere. […] But sometimes I guess it involved whether people are happy to share or yeah.

> Because I […]. You don't want to feel like you're taking over someone else's job […]. if they don't tell me what kind of data they're having, I won't be able to know (Uni-An2)

Gaps in realising ideal dashboard design

In this section, we discuss the data and organisational aspects when designing dashboards. Based on the top part of our theoretical framework in Figure 2, we stated that as there is a likely gap between the problem goals and the solution criteria. In terms of UniOne, they are yet to deliver the ideal dashboard that they have planned for. If we reflect on some characteristics of design thinking, they have started with early prototyping and have tried to gather feedback from users. They also have tapped into their past experience, on what they were good at in terms of providing reports and information, and have combined this with using Tableau as a new tool/technology. In a way, they have figured out their ideal problem goals. But they are still on their way to realise those problem goals and match them with the users' solution criteria.

In other words, there were gaps between the plans and the reality or between the problem goals and the solution criteria. We thought that "social inertia" could be a plausible explanation for this (Keen, 1981, p. 24). Keen's ideas on "social inertia" are related to information systems and changes in organisations. In general, it refers to a situation where we have tried the best we could to discover how things could improve, the necessary changes have not happened yet. According to Keen (1981), this could be due to many reasons such as information being only a small part of the decision-making equation, with the complexity of organisations and activities such as data being used as political assets also playing a part.

Uni-User as a chief financial officer (CFO) of UniOne believed that information is important for him when making decisions. This may not be true for all users in the University, as it was confirmed by Uni-Mgr2 that some senior users in UniOne had been able to make decisions based on gut feelings and what had worked before. This is a part of the organisational culture on decision making for some of the users. Therefore, she concurred it is challenging to get "buy-in" from them and to send a message across that information on the dashboards is going to be useful in supporting their decision making:

> [W]ell I'm not doing things by guesswork. […] So, by holding an appropriate trend data we can see, how we are going in relation to the past, how we are going against our plans (Uni-User).

> We've been able to get away in kind of planning […] and measurement […] based on intuition for a really long time. Like people in senior management have been working […] for a long time, this always works for students. We're just do that, oh if they doing this its because of this (Uni-Mgr2).

Apart from that, following Keen (1981), due to the complexity of organisations, changes were normally done incrementally and gradually over a long period of time. This might be an explanation for a big organisation like UniOne. They have various stakeholders to convince when making changes, especially the University council. Nonetheless, the design team were fully aware and have acknowledged the level of difficulties of this task. With a top-down approach, Uni-Mgr1 hoped to change the old culture of decision making into a fact-based decision-making process by getting endorsement from users at the executive level. Ideally, when executive level users are convinced of the value of the dashboard, they might encourage others to use the dashboard as well:

> So I'm hoping in the future that we can draft up, or put in a business plan, pass it through the CFO through executive group, that gets endorsed, then pass that into the business areas and Deans; that later at least see something in writing and endorsed by the higher level (Uni-Mgr1).

Last, Keen (1981) also mentioned that in some organisations, data are viewed as political assets. We discussed this issue in the previous section when we talked about communication and collaboration with users and data owners across UniOne. Uni-An2 clearly pointed out that there were other reporting people in other divisions. The decision to share the data with the dashboard design team was entirely up to the data owners. This undoubtedly adds to the explanation for why the gaps in realising the ideal dashboard design still persisted.

Roadmap to innovations

In this section, we discuss infrastructural and technological aspects when designing dashboards. We argue that the infrastructure and technology seemed to be less of a concern when an organisation decided to implement dashboards. In UniOne, they used Tableau as their BI dashboards tool. According to Uni-An1, the implementation was easily done with the help of an IT team in deploying or upgrading the server. As implementation becomes more straightforward, presumably we need less lead time for users to start using the dashboard:

> [W]ith Tableau that's the beauty of it. Is actually minimum fuss I'd say. […] we set up the server to hook on to it and it can take in multiple sources. […] It doesn't require a lot of setup or a lot of infrastructure to support it (Uni-An1).

Therefore, from a design thinking perspective, an organisation is able to focus their resources on the desirability aspect when the feasibility and the viability aspects have been sorted out. In UniOne's case, they were supported by the University in terms of budget and resources, and its feasibility and viability are not considered as problems:

> [W]ith modern tools, the feasibility and viability becoming less of an issue, so to me the main thing to be clear on is where you wanna get to (Uni-User).

So, the design team can focus on designing the dashboards for users that displayed the most significant metrics aligned with the organisation's visions and goals. They can also concentrate on creating innovation through dashboard design. In reference to our theoretical framework in Figure 2, the design team should always aim for innovation while defining the problem goals early in the design process. In UniOne, they have started making an effort to create innovation by changing users' mindsets about data, educating users on the benefits of data integration, giving users self-service dashboards and by involving people with different skillsets on the design team:

> There's something there about diversity of opinions probably needs to be reflected somehow. Innovation would come from difference. So to me, if we're doing things the same way, we're definitely not going to get innovations. […] people coming in from different disciplines or different skillsets that help with innovations. So if you only have IT people working on the project like this […]. And if you only have accountants working on it, you won't get the right outcomes. There has to be a bit of a mixture to bring innovations (Uni-User).

Assessment on wants versus needs

Lastly, we discuss another important aspect when designing dashboards, which is the metrics and features for users. This is considered as part of user requirements, and in Figure 2, user requirements are shown under the solution criteria. In UniOne, the design team would start approaching users by creating a prototype of a dashboard with some features and metrics that they thought would be useful for users.

We argue that through envisioning the end result of the dashboard, we balance the time we spend in analysing user requirements, in the problems space, with the time we spend in the solution space. This helps the design team to assess the usefulness of the dashboard early before the dashboard is completely done:

> We are at this stage where we are saying to the […] give us any sort of comments you have. Let us know, be it the design or information or how the layout. So we do have a couple that does giving us those information now. Which is good, it helps us because sometimes what we see is not what they expect. So it's important to have that conversation to know what is required out there for the user (Uni-An1).

Also, gathering feedback from users as they build the prototype and later incorporate it onto subsequent iterations could increase the likelihood of the future use of the dashboard. Compared to designing a dashboard based on merely a list of requirements, in the end, the dashboard may not be fully used. As what users "want" on the requirement might change or might not necessarily what they "need" or may not be well-aligned with the organisation's strategic goals.

Contributions and future research

Through our research, we highlighted that it is important to align the dashboard design with the organisation's visions and goals. This creates a more persuasive rationale for adoption amongst the users, as they could use the dashboard as a means to assist them in achieving the vision and goals of the organisation. More importantly, the analysis clearly indicates the need to consider the creation of a dashboard as being a holistic exercise. The intricate processes of designing a dashboard are often underestimated. Instead of focusing into a specific aspect (such as user interface or functionality) of designing dashboards, we should look into the multi-faceted aspects in designing an effective dashboard.

Our study has determined that interdisciplinary and cross-functional group communications play a significant role in designing a dashboard. The ability to collaborate with "data owners", would be dashboard users, managers of the technical infrastructure and process owners, leads to a workable and effective dashboard. In this sense, design thinking could be used and/or regarded as a holistic, creative and solutions-oriented framework.

This paper articulates the findings from a single case study. However, arguably, the results of this study are transferable to other entities responsible for designing BI and business analytics dashboards. Research on dashboard design and the use of design thinking across different type organisations is currently ongoing to allow for cross-case analyses.

Note

1. The background picture of a dashboard was taken from http://dashboardspy.com/dashboard-screenshot-wireframe-coolblue-template.html

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