

A Review on the Dashboard Characteristics for Manufacturing Organizations

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Abstract — The implementation of the Business Intelligence (BI) dashboard in the manufacturing organizations has shown an upward trend. As more and more manufacturing data is generated, there is a problem of the most important information that is needed by the organization is hidden and unseen. The dashboard has helped to overcome this problem where it is used to display the most important information that is needed by the organization in a single view. The dashboard used in those manufacturing organizations has its own characteristics to serve its purpose. This paper will review the previous literatures related to the implementation of dashboard in the manufacturing organizations and to find out the common characteristics that serve the manufacturing organizations' needs, as well as the type of dashboard that is commonly used. The review shows that the characteristics of dashboard needed by most of the manufacturing organizations have to be in real-time, include historical and future data (if possible) and include colorful graphs and charts for better visual. The operational dashboard is the most commonly used in the manufacturing industry. With the dashboard features discussed, hopefully it could built up confidence for future study on the characteristics to consider during the development of the dashboard for usage in a manufacturing organization.

Keywords – Manufacturing; Visualization Tool; BI Dashboard; Operational Dashboard

1. INTRODUCTION

Starting from the year 2000, a dashboard has become a BI technology in the organizations worldwide [11]. Its usage in the manufacturing organizations also shows a significant growth and provides benefits to the organizations [21]. For example, in Ansaldo STS Italy of Tito, an electronics manufacturing company, a performance dashboard was implemented across its production section [17]. The performance dashboard was used to show the Key Performance Indicators (KPI) for processes involved in the production site. This helped the decision makers to identify problems for doing the corrective action.

Another manufacturing organization that uses the performance dashboard is Foods (Bloomington, IL) [18]. Information from different units and locations is immediately available for their management without delay, with monthly and daily historical data. It helps the manufacturing company to change for a continuous improvement and increased productivity.

The EPE Corporation, Manchester NH, USA, an electronics manufacturing service provider has implemented a real-time dashboard [19]. Work in progress (WIP) history, active jobs, quality information, etc. is available collectively. The implementation of the dashboard has helped EPE corporation to grow while sustaining man power from either the IT or Engineering section. It has given them benefit in their sales and marketing, in the sense that the information from the production floor is available instantaneously through dashboards.

Much have been said about the implementation of the dashboard in the manufacturing organizations together with its characteristics and benefits. However, there is a question on what are the must-have key characteristics of a dashboard for the manufacturing organizations? Thus, this paper will study on the previous literatures on the problems faced by the manufacturing organizations that lead to the deployment of the dashboard, the types and characteristics of dashboard used. This research is hoped to give some guidance on the must-have characteristics in dashboard design for the manufacturing industry.

2. BI DASHBOARD IN MANUFACTURING

A BI dashboard or sometimes called a performance dashboard can be defined as a computer-based display that has a visual graphics like diagrams and charts of the organization's most relevant information [13]. It is a delivery system that contains visual and layered information that summarizes the performance metrics, in which with it; the users can achieve their strategic business objectives by measuring, monitoring and managing the effectiveness of their methods [14]. For Dr. Wolfgang Martin and Richard Nubdorfer, a dashboard is a visualization tool that compresses large volumes of information which comes from many different sources [15]. In this paper, a dashboard is defined as an information obtained to aid the decision making process of a business segment, through the transformation of the existing business data. The information is

represented visually to give the intended users a crystal clear guidance for a smooth decision making process and most importantly, an accurate and fast decision.

There are few types of performance dashboard. Table 1 shows the different types of performance dashboard [14].

TABLE 1: Pperformance dashboards types

	STRATEGIC	TACTICAL	OPERATIONAL
Focus	Execute strategy	Optimize process	Control operations
Use	Management	Analysis	Monitoring
Users	Executives	Managers	Staff
Scope	Enterprise	Departmental	Operational
Metrics	Outcome KPIs	Outcome and driver KPIs	Driver KPIs
Data	Summary	Detailed/summary	Detailed
Sources	Manual, external	Manual/core systems	Core systems
Refresh Cycle	Monthly/quarterly	Daily/weekly	Intraday
“Resembles a..”	Scorecard	Portal	Dashboard

In summary, the strategic dashboards help the executives to track their progress in accomplishing certain objectives, tactical dashboards let the managers track the progress of certain projects and activities in departmental level and the operational dashboards facilitate the front-line and operation employees to track down the processes in the production or operation side [16].

3. LITERATURE STUDIES

This study has opened up our mind to explore thoroughly the essence of dashboard and its characteristics in the manufacturing organizations. To come across this issue, we started our studies by observing all factors, criteria and definition of dashboard before we carried out the second phase of the study which is collecting the appropriate materials. In this study, our literature is based on the basic understanding of software and application development. We go back to the root idea before we channel our focus on dashboard. This is very important as it can guide us to have a very clear path on the whole idea of dashboard. Software and application development has broadened and deepened our understanding towards the dashboard and its characteristics. From the literature studies, we found all the important aspects that guide our understanding towards the dashboard, which is also an application to assist the manufacturing organizations, of the high or low volume to increase production, double up the profit and maintaining the quality. It does work to any industries as well but the interesting part of our finding is its name itself, that is the “dashboard”. We realized that for anybody who owns a car, they would consider the dashboard as one of the major components in their car. However, in this context, a dashboard has brought a very wide perception in our study. As we have stated in the first and second part of this article, a dashboard has become a BI technology in the organizations worldwide. This statement is quite challenging for us, especially in the process of exploring every patches and batches before coming out with it. Our effort towards finding out the essence of dashboard has taught us to be more focused on the dashboard.

There are three studies that guided us in order to increase our understanding towards the dashboard. Ahokas has reviewed a BI dashboard and designed guidelines for creating effective visual reporting interfaces [22]. He has explored the visual perception based on such characteristics; perception of organizations and perception of shapes, perceiving colour and visual attention and memory. From these characteristics, Ahokas has made a very good approach as it can scrutinize that the basic step for any studies is through learning the perception of elements that is related to particular issues. Then he continued reviewing his observation by looking at the principles of information visualization through seven characteristics which are maximizing the information content, colour coding, scaling, ordering data set, small multiples, interactive visual displays and evaluating the visual efficiency of statistical graphics. These are all important aspects that have been examined specifically by Ahokas. They are very important aspects as they can lead his observation towards the dashboard. All these principles have broadened and deepened his understanding, ultimately opened up his explanation to the discussion of decision support systems and business decision-making. Within this context, Ahokas has clarified the implementation of business intelligence and its performance management in Nordic countries. It has been noted that organizations, industries and even low volume companies need to have an application named a dashboard to assist their needs especially to increase production while maintaining the products quality. An explanation for that particular issue has made his work becomes more easily defined and clarified on all factors related to dashboard as a visual information interface. In order to strengthen his understanding, Ahokas has gone through all related aspects of dashboard such as graphical use of visualizing statistical data and some additional guidelines for designing dashboards. In short, his study is very crucial to us and it does open up our understanding towards the dashboard design and its implementation in business orientation.

Then we continued to look at the other resources that can assist us in understanding the BI, dashboard and its implementation towards the business solution. A study from Bai et. al. has made a great impact to our study [7]. In short, Bai et. al. have developed a prototype of dashboard to an auto motor manufacturer. They have proposed a viable and affordable real-time and online control technology named remote production dashboard (RPD) for discrete manufacturing process based on knowledge service. To conduct their study efficiently, Bai et. al. have strategized their effort through three variants of method. First, they construct the basic framework of RPD consisting of production environment layer, data process layer, knowledge service layer and man-machine interaction layer. Then they continued to the explanation of principles of two key technologies used in RPD including real-time manufacturing field data capture and knowledge service. Third, they explained on the mechanism of RPD through all the basic understanding of the whole idea and process of RPD. To summarize, the study from Bai et. al. have increased our understanding towards the dashboard and the important aspects related to it. The RPD system facilitates the visual management of the company's shop floor thus enhances the operational efficiency in a real-time manner, and is proven to be a promising next generation advanced manufacturing technology. It does really help our understanding to conduct our review processes more thoroughly.

Finally, our observation through the study from Romaniello et.al. has completed our target to design the methodology for this study [17]. Romaniello et.al. discussed the real case study application of the methodology in the manufacturing area of ANSALDO STS, a company that is based in Italy. This company has used the dashboard in their operation. Using four phases of approach namely the MAAR (Monitor, Analysis, Action and Review), Romaniello et.al. monitored all process in ANSALDO STS and its methodology to increase production through the use of a dashboard. Through this case study, Romaniello et.al. have discussed and presented the basic principles of management tools and techniques towards performance improvement in a manufacturing plant. Results from this case study have showed a very good impact to ANSALDO STS. The use of MAAR has really given a big impact especially in the production processes, subsequently added many advantages to the firm as well.

4. METHODOLOGY

We are very particular in choosing the right methodology for this study. After few discussion sessions, together with library studies and articles observation, we have agreed to conduct this study following three strategies as our methodology listed below;

(i) Collecting materials

Materials collection is not a big challenge to us. This study has given us the advantage and opportunity to see all resources related to the subject being discussed. There are four sources that have been collected as our materials in this study; books and thesis, articles, data papers and technical reports. Several books and thesis have been examined and chosen for this study. Specifically, there are three books and 3 thesis that really assist us in increasing our understanding towards dashboard and the elements related to it. Three books are from Pressman, Bartolo and Wang are our main resources while thesis from Ahokas, Krause and Dankó are thesis from their studies related to the dashboard in manufacturing [22-27]. About thirty articles, ten data papers and five technical reports were collected offline as well as online. Articles were gathered by downloading from the internet and the rest were borrowed from the library. Articles mostly come from high impact journals and indexed by ISI and Scopus such as Elsevier, ACM, IEEE, Scipub and Springer. Data paper is the easiest resource for this study. Our department has put up so much effort to assist us in our study. We obtained numbers of data papers but only ten are related to the discussion on the usage of dashboard in manufacturing topic. While for technical reports, they were downloaded from the internet. They were obtained from web site by organizations that are having good software development experience and performance such as IBM and Altosoft. Those technical reports also came from several journals such as ACM, IEEE and Elsevier.

(ii) Reviewing

The reviewing process of the collected resources was quite challenging to us. We had to be very specific in order to examine each and every material that we have. So to ease our reviewing process, we provide important four factors. This is our own effort and our literature review for this study really help us for this matter. The four factors that assist our reviewing process are listed as below;

- (a) Problems Faced – This factor has to be considered as some of the researchers did not state their problems in their research in detail. This could be due to the confidential status of some information related to the case study in certain organizations, or to cover weaknesses that could impact their reputation.
- (b) Types of Dashboard – There are few types of dashboard but we would select only one. To cater for this, we looked at the most commonly used one by the manufacturing organization.
- (c) Features of Dashboard – The features of the dashboard used were determined according to the nature of the dashboard, by means of facilitating the manufacturing processes through its usage.
- (d) Remarks – Our own remarks will be more specifically focused on the three factors outlined in this reviewing process. We commented based on our understanding, precisely and concisely. Remarks for the researchers'

studies are important as they will lead us to write our discussion in the conclusion section. At the same time, they can be used for potential future and continual studies to be conducted in this area.

(iii) Determination of Studies

Determination of studies is the final process for this study. We determined the selected study from researchers who captured our specifications based on the topic discussed. From all resources that we have, there are ten studies that really met our requirements to be presented in this article. The next section will sketch out the explanation for our findings.

5. TYPES AND CHARACTERISTICS OF DASHBOARDS USED IN MANUFACTURING ORGANIZATIONS

Table 2 consists of the problems faced by the manufacturing organizations that deployed dashboards in their premise, together with the types of dashboards and the characteristics of the dashboards used by them.

TABLE 2: Performance dashboards types

Author	Problems Faced	Types of Dashboard	Features of Dashboard	Remarks
Prakash Poobalan [1]	<ul style="list-style-type: none"> No tool to track equipment status and performance. Reduced production yield. 	<ul style="list-style-type: none"> Operational 	<ul style="list-style-type: none"> Real time Using charts (Pie and Stacked Bar) Clicking on certain part of graph will bring a pop-up page. 	<ul style="list-style-type: none"> Equipment utilization and states can be viewed, thus improving the performance of equipment. Eventually it helps to improve the production efficiency.
Paul Higgins, Jens Eschenbacher Jan Ola Strandhagen and Arne Horten [2].	Poor collaboration between decision makers, customers and suppliers due to information is not organized in efficient way.	<ul style="list-style-type: none"> Operational 	<ul style="list-style-type: none"> Include Real-time and historical data. Containing modules and interface of operation, management and KPI information. 	Achieving a strong, efficient and convenient delivery method for extended enterprise collaboration.
Purdy P. Ho [3].	<ul style="list-style-type: none"> Improve the engineering, Lean and Six Sigma, problem solving behavior and performance. Need to reduce cost, waste, cycle time, miscommunication and information hidden. 	<ul style="list-style-type: none"> Operational 	<ul style="list-style-type: none"> Real-time Contains graphical and table format. The graphs and tables are clickable. Having a “Drill-down” capability of a defect root cause. Displayed on flat screen panels stationed in the factory floor (exposed by everyone). 	<ul style="list-style-type: none"> Achieve six times Return on Investment (ROI). Save \$5 million in rework labor cost.
Neville G. McCaghren [4]	<ul style="list-style-type: none"> High Production cost. Late in information processing. 	<ul style="list-style-type: none"> Operational 	<ul style="list-style-type: none"> Interactive Having a function of detail “drill-down” to correct problems in the shop floor. Using color codes for intuitive purpose. Provides real-time and also historical data. 	<ul style="list-style-type: none"> Throughput increase of 50%. Throughput variation increase of 70 %. Save in cost of 600 hours per item.
Bhumika N. Hansoti	<ul style="list-style-type: none"> Long process to get an information from 	<ul style="list-style-type: none"> Operational 	<ul style="list-style-type: none"> Include graphs, charts and pictures. 	Reducing the decision making process time of the

[5]	huge amount of data, thus delaying in the decision making process.		<ul style="list-style-type: none"> • Include real-time and historical data. • Recommendations from workers of features to be added in the dashboard : Drag and drop, Drill-down function, Hide/Flag components, Frequently Asked Question, Hide/Delete data and easy navigation. 	organization
Charalambos J. Antoniou [6]	<ul style="list-style-type: none"> • Increase customer demand causing production ramp-up of double the output, thus there is a need to improve the overall production process. 	<ul style="list-style-type: none"> • Operational • Interactive 	<ul style="list-style-type: none"> • Contains tables, graphs and charts. • Contains instantaneous or real-time, past or historical and also future forecast data. • Having the drill-down capability. 	<ul style="list-style-type: none"> • Saving the working hours of stakeholders to 10%. • Organization achieved financial savings (figure is confidential). • Problems solving behavior is changed among the stakeholders, thus improving the team work between them.
Ao Bai, Ren-zhong Tang, Jing-xiang LV and Yu-xuan Zhu [7]	<ul style="list-style-type: none"> • Real-time manufacturing processes are difficult to monitor and control by the factory managers. 	<ul style="list-style-type: none"> • Operational 	<ul style="list-style-type: none"> • Real-time. • Using wireless technology. • Contains tables and indicators. 	<ul style="list-style-type: none"> • Reduced labor cost. • Reduced human errors.
M. Giriraj and Dr. S. Muthu [8]	<ul style="list-style-type: none"> • Production meeting takes long time due to information is outdated. 	<ul style="list-style-type: none"> • Executive • Operational 	<ul style="list-style-type: none"> • Real-time • Executive Dashboard contains tables and graphs. • Operational Dashboard contains drill-down capability that includes diagram and report generation. 	<ul style="list-style-type: none"> • Plant manufacturing activities can be monitored closely.
Anil B. Jambekar and Karol I. Pelc [9]	<ul style="list-style-type: none"> • New customer request challenges to redesign product and having an operational monitoring system. • Business processes need to prepare for high production output and new customers and markets. • There is a need for the managers to know the technical knowledge as well. 	Managerial	<ul style="list-style-type: none"> • Real time. • Having a drill-down functionality – hypertext link to the root cause of problems. • Having a knowledge interface, supplier interface and customer interface. 	<ul style="list-style-type: none"> • Knowledge gaining process becomes feasible as data is organized into an understandable manner.
Business Intelligence in Manufacturing (White Paper) [10]	<ul style="list-style-type: none"> • To improve orders fulfillment to the customers. • There is a need to track the in house operation for better service. 	<ul style="list-style-type: none"> • Operational 	<ul style="list-style-type: none"> • Real-time • Contains graphical representation of data. 	<ul style="list-style-type: none"> • Helps to reduce production cost, improve quality and increase customer satisfaction. • Improve decision making of organization management.

From the comparison table above, all the manufacturing organizations were having problems related to the information about the in-house operation or production floor. Many manufacturing organizations are facing with hidden information [3, 7, 9, 10], unorganized information [2] and lateness in getting the information [4, 5, 8]. All these consequently lead to trailing problems like decrease in the production yield [1, 3, 6, 9], poor customer service [2, 6, 9, 10], increase in the production cost [3, 4] and delay in decision making process [3, 5, 8-10].

To overcome these problems, all the manufacturing organizations chose the Operational Dashboard, except one which used the Managerial Dashboard [9]. Under the features of these dashboards, all of them are of real-time. Some of them also include historical data [2, 4-6]. There is also future forecast data [6]. Other than that, many of the organizations included graphs and charts in their dashboard [1, 3, 5-8, 10]. These graphical representations are clickable and include a drill-down capability for a more detail information or root cause for particular problems arouse. There is also color codes used for intuitive purpose [4]. A Managerial Dashboard designed by Anil B. Jambekar and Karol I. Pelc [9] is having a special feature whereby there are interfaces for knowledge, supplier and customer.

All the dashboards designed gave them remarkable advantages. Production efficiency was improved [1, 4, 8, 10], as well as the decision making process [5, 6, 10]. They also improved in the customer service [2, 10]. In terms of the operation cost, many also showed a significant reduction [3, 4, 6, 7, 10] and increase in the company revenue [3]. While in terms of knowledge, many gained from these dashboards, where the information now becomes available at the right time [1, 8, 9].

5. CONCLUSION

Many manufacturing organizations are facing with the problems of limited information to their employees that resulted in a delay in the decision making process, higher in production cost, low in production yield and poor customer service. From the analysis and discussion done on the features of dashboards used in those manufacturing companies, it can be concluded that in order to create a dashboard for a manufacturing company, it has to relate to the operational site of the organization, as that is where the core activities of the company run. It is the heart of the organization and information coming from it is crucial. Any problems related to it will cause a significant result that determines the success and failure of a manufacturing company.

The dashboard designed has to be in real-time, include historical and future data (if possible), include colorful graphs and charts for better visual. The graphs and charts must be clickable and have a drill-down capability in order to further finding the details of information or root cause of problems. A dashboard for managers (Managerial Dashboard) will have an interface for knowledge, supplier and customer. This is to aid the decision makers to make a wiser and quicker business decision. The dashboards implemented have helped them gaining a lot of benefits internally with their employees and externally with their customers.

Thus, the dashboard features discussed above has built up confidence for a study to develop a framework for dashboard to be used in a manufacturing organization. Depending on the problems faced by a manufacturing organization, the features can be added in, in order to improve the company to excel and be competitive in its field.

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