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A business intelligence framework for Sultan Qaboos University: A case study in the Middle East

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ABSTRACT Higher education institutions generate big data, yet they are not exploited to obtain usable information. Making sense of data within organizations becomes the key factor for success in maintaining sustainability within the market and gaining competitive advantages. Business intelligence and analytics addresses the challenges of data visibility and data integrity that helps to shift the big data to provide deep insights into such data. This research aims to build a customized business intelligence (BI) framework for Sultan Qaboos University (SQU). The research starts with assessing the BI maturity of the educational institutions prior to implementation followed by developing a BI prototype to test BI capabilities of performance management in SQU. The prototype has been tested for the key business activity (KBA): teaching and learning at one college of the university. The results show that the aggregation of the different KBAs and KPIs will contribute to the overall SQU performance and will provide better visibility of how SQU as an organization is functioning, which is the key towards the successful implementation of BI within SQU in the future.

KEYWORDS Business intelligence, decision making, key business activity key performance indicator, maturity assessment, performance management

1. INTRODUCTION

The business environment is rapidly changing through different market transitions. These transitions introduce disrupting technologies and new ways of working. At the same time there is a massive growth of data within organizations. Making sense of data within organizations becomes the key factor for success in maintaining sustainability within the market and gaining competitive advantages. One of the major trends disrupting business is the evolution of business intelligence and analytics (BIA). However, business intelligence (BI) is not new as a concept, it has evolved over the past few years in terms of maturity and sophistication (Tapadinhas, 2014) (Sarma & Prasad, 2014). Organizations are facing double challenges when dealing with such trends. From one side, organizations have huge and diverse data sources, yet many of them are not doing much to capitalize on those data and convert them into useful and usable information. From another side, there is a lost opportunity on improving the data integrity and quality for providing better ways for decision makers/stakeholders to make the right decisions. BIA is one of the methods that could be used to address the challenges of data visibility and data integrity that will help to shift the existing data from different resources and hence provide deep insights into the data.

Information management and analytics enable innovation and transformation in how different organizations conduct business. The

importance of BIA is distilled from the fact that it is important to provide the right information and the right analysis to make the right decisions. The paradox that many organizations face today is how best to optimize their data, yet many of them often limit BI initiatives to focus on technology selection, neglecting the organizational approaches, processes and best practices necessary for success.

At first glance, one would think that educational institutions would be a prime area to utilize BI. The reason for such a belief is that educational institutions have a lot of data and often lack visibility to the importance of such an asset. There is often a struggle on how to use the data and how best the huge data coming from different sources could be utilized. If educational institutions want to get a competitive advantage from it, there is a need for these institutions to explore an efficient use of data. BI provides the ability to combine data sources in one place to analyze and improve the decision-making process. The success of the BI implementation journey can enhance productivity and improve efficiency. On the other hand, it creates the impression that every implementation will indeed be unique because no two institutions work in the same way. Though BI can be very important, it is still a developing process.

The major objective of this research is to develop a BI framework to be used for educational institutions. The study utilizes Sultan Qaboos University (SQU) as a case study to build this framework. Furthermore, in order to build the framework, there is a need to understand the maturity level of the university initially. Once the maturity level is understood, then the framework can be developed based on the maturity level assessment and the future direction of the university. Although this framework will use SQU as the main case study, it is assumed that this framework can later be used by other educational institutions within Oman (or even outside) to help implementing BI initiatives in their organizations. In addition, the study will also involve building a prototype of how BI can be used as a strategic initiative for SQU.

2. LITERATURE REVIEW

Looking at the evolution of business analytics, there are other areas where BI can be used. For example, it can be used to model business challenges and for using predictive analysis to generate a future prospective (Sherman, 2014). Depending on the business challenges and the business maturity, different organizations use BI in different ways. The main difference between the different methods is how efficient the use of data is. Since data is the main ingredient of any BI analysis, Sherman argues that in order for the BI to provide such benefits, the data has to meet five criteria; it has to be clean, consistent, conformed, current and comprehensive. However, the reality is that not all organizations will have all the above criteria for their data. Thus BI implementation within organizations becomes very challenging and prone to failure (ShaokunFana, Y.K.Laub, & LeonZhaob, 2015).

Traditional BI uses OLAP tools and reporting, which are currently in use today. If such reports exist today, what is so special about using BIA? The simple answer can be evolution. However, the initial enthusiasm about BI was generated from e-commerce by companies such as Amazon, where consumers' data is used to anticipate future purchases. In addition, there are other benefits anticipated from BI. One study (Ramanigopal, Palaniappan, & Mani, 2012) lists the number of key benefits that BI can provide; such as:

- BI can enhance the time to take action by making it shorter,
- BI is used to analyze market trends against the company capabilities and help in making informed decisions,
- BI enhances business agility by improving the communications among departments and enables the company to respond quickly to market changes.

BI provides comprehensive and flexible access to data (Fouche & Langit, 2008). In addition, it provides near real-time access to information, making it easier and faster for decision makers to make decisions. Although the authors (Fouche & Langit, 2008) were referring mostly to Microsoft BI tools, the same benefits can be achieved by other BI tools from other vendors.

At this point, it is important to mention that the value of BI can only be seen when the BI initiative is well integrated within the organization's decision making process (Ramanigopal, Palaniappan, & Mani, 2012). In addition, the choice of technology can also affect the speed of the decision making. The evolution of in-memory computing technologies gave birth to a new breed of what the industry

refers to as 'engineered systems'. These engineered systems provide faster access to the data in near-real time, hence, improving the speed of the decision making (Muntean & Surcel, 2013).

In addition, the importance of BI is very clear from trends in the industry. Gartner classified BI as a top priority for CIOs in the 2015 CIO Agenda. Furthermore, Gartner also classified BI as one of the top 4 technologies for CIOs in the higher education sector making this study very important and relevant to the university.

2.1 Business Intelligence Maturity Models

The benefits of BI that any organization would like to exploit are presented. Nevertheless, in order for organizations to embark on the BI journey, there is a need to assess its current maturity. A business intelligence maturity assessment is required to determine the organization's business needs, its capabilities, and the availability of the information sources (TDWI, 2015) (Chuah & Wong, 2012). The literature provides several maturity assessment models that can be used to assess an organization's readiness for implementing BI.

The Business Information Maturity Model is focused on assessing the BI importance within the organization. It assesses the organization's maturity based on three different criteria: alignment and governance, leverage, and delivery (Rajterič, 2010). The results of the assessment are then divided into 3 different levels with level 3 representing a mature organization. Although this model sounds interesting, it lacks full coverage of the usage of BI and its business value.

Gartner developed a maturity model for BI and performance management (PM). The model assesses an organization's maturity in five levels: unaware, tactical, focused, strategic, and pervasive (Rajterič, 2010). Gartner assesses the level of maturity based on three dimensions: people, processes, and metrics and technology.

Although the Gartner model has a good coverage of the different elements of BI within an organization, there is limited literature available on its reliability. Furthermore, only Gartner (or maybe a special consultancy firm) will be able to help in assessing the maturity level.

Advanced Market Research (AMR) developed a maturity model for BI (Rajterič, 2010). The model consists of 4 stages; reacting, anticipating, collaborating, and orchestrating. AMR was acquired by Gartner in 2009 although this acquisition doesn't necessarily mean that the maturity model can't be used. However, since Gartner has its own maturity model for BI, it is very likely this model will be made redundant.

Another business intelligence maturity model was developed by MIT Sloan Management. The model comprises of 3 maturity stages; aspiration, experienced and transformed and has 6 evaluation dimensions, namely: motive, functional proficiency, business challenges, key obstacles, data management and analytics in action (Gudfinnsson, Strand, & Brendtsson, 2015). This maturity model for BI was tested with 3000 executives from 108 countries and 30 industries mostly in manufacturing (Lavalle, Hopkins, Lesser, Schokely, & Kruschwitz, 2010). Although this model is well established and tested, it is mostly used to evaluate BI maturity in manufacturing. Since this research paper is focused in measuring the BI maturity in educational institutions, this model will not suffice.

The Data Warehouse Institute (TDWI) developed a maturity model for BI (TDWI, 2015). Although this model is primarily focused on the technical aspects of maturity, it is considered to be more practical in assessing any organization maturity for BI. The model has 5 different assessment dimensions: organization, infrastructure, data management, analytics, and governance. There are 5 stages which the organizations go through in their maturity journey namely: infant, child, teenager, adult, and sage (Rajterič, 2010). However, this model was modified later to have different names for the maturity levels. The new model stages are nascent, pre-adoption, early adoption, corporate adoption and mature or visionary (TDWI, 2015). In addition, the model also describes an interesting stage that exists between early adoption and corporate adoption called chasm. The TDWI model describes the chasm as the stage in which the organization must overcome certain obstacles for the transition to the corporate adoption stage. Furthermore, these struggles can be overcome through the use of proper funding, good governance, improved skill sets, and better management of change management.

Due to the TDWI maturity model simplicity, it was decided to use it in this research. Furthermore, the TDWI maturity model has developed 35 questions to help organizations assess their maturity level. Although the questions are general, there is a need to customize them to suite the educational institutions.

2.2 BI in Educational Institutions

Although there are not many articles found in the literature that cover the implementation of BI in educational institution, there are a few that are critically analyzed that have some insight on the use of BI within higher education sectors. One study (Guster & Brown, 2012) discusses the BI system structure that can assist a strategy map for higher education whether achieved or not achieved. This also focused on the linkage between a strategy map and MOLAP system, which reads from different databases and its article makes use of the strategy map to measure how well the performance is done. In addition, there are some challenges regarding how the information got extracted from different data sources such as in the use of the metrics and fine-tuning the data warehouse to calculate the performance. Furthermore, the data modelling took a lot of time and suffered in assessing the data quality.

Aziz & Sarsam (2013) investigate on how a BI system called GLIS influences the decision making process in Uppsala University. The author concludes that GLIS has a big positive impact on the decision making process in Uppsala University. León-Barranco et al. (2014) use an analytical model for analyzing decision making in educational institutions. Although the study covered only two semesters and the authors have selected specific careers, the developed model seems to help in analyzing the data required for making decisions. Randy (2014) carried out a survey on implementing BI in educational institutions and concluded that key performance indicators (KPI) are important for successful implementation of BI in educational institutions.

Zilli (2014) discusses the self-service usage of BI for students. The author developed dimensional modelling utilizing the Excel PowerPivot modelling tool. Although the impact of BI on relative technical efficiency of higher institutions was not assessed in this research, it provided some evidence that PowerPivot can be used as a BI method. The second part of the research focused on undergraduate retention and detection of obstacles to successful graduation. While a self-serving portal will help students, the implementation of the BI and how best to ensure its success could be better covered. Rajterič (2010) proposes an overview of BI maturity models detailing the pros and cons of six maturity models.

2.3 BI Frameworks

The purpose of BI initiatives within many organizations is to create value out of existing data that will provide either improved decision making or give a competitive advantage. Hence, BI frameworks are supposed to provide the basic elements of how organizations should identify direction, standards and best practices required to ensure that BI meets organizational requirements. In addition, the framework will guide the development of the implementation roadmap (Washer, 2007).

In order to develop a BI framework for SQU, it is important to understand the different frameworks available for BI in the literature. Most of the frameworks available in the literature are either technical (Chu, 2013) or specific to develop a BI solution (Ortega, Avila, & Gomez, 2011). Therefore, for the purpose of this research it has been decided to shift our review to the available framework in the industry. Hence, focus has been on two main frameworks that are widely used Gartner's Business Analytics Framework and the Business Intelligence Framework 2020.

Gartner's Business Analytics Framework: This is based on an approach to integrate people, processes and platforms to create an approach to BIA and PM initiatives (Tapadinhas, 2014). The framework was established as early as 2006 but gained more momentum recently due to the organization's increased appetite to invest in BI and analytics.

The center of the framework focuses on three main pillars: people, processes and platform. The ‘people’ element refers to the human element for producing, consuming or enabling the activities required for successful business analytics. The ‘processes’ element addresses the different processes used within the business. These processes vary to include decision making processes, analytics processes and information governance processes. The final pillar is the platform which is the technology part of BI. There are three capabilities that the technology needs to provide. Firstly, decision capabilities that will

enable organizations to build applications that help to learn and understand the business. Secondly, analytic capabilities, that will develop applications which have predefined data and process workflows, and models for the analysis capabilities. The third capability has to do with information. As organizations create more and more data, the search for such information can be tedious. The solution is to develop an information infrastructure that will unify all these technologies, services and schemas under one umbrella to be used as a source for other capabilities as well.

The bottom of the framework represents information which is the most important ingredient in the BI implementation. Metadata, program management, and business models, strategy and metrics form different layers of how the center is integrating with the rest of what's going on inside the organization. Above all, the true measure of how successful the BI framework is, is the performance it generates for the organization. In other words, BI success should be measured on how well it helps the business achieve its strategic goals.

BI Framework 2020: It is one of the recent approaches to try to create an ecosystem for implementing BI solutions. In this framework, multiple reporting and analysis systems can be used and they are designed to help business people use information to make smarter decisions. The BI team in this framework needs to disseminate standards that govern the use of data. This framework defines four domains of intelligence and maps them to end-user tools, design environments and architectures.

3. RESEARCH METHODOLOGY

3.1 Research Background

There are two schools of thought when educational institutions are embarking on business intelligence initiatives. The first school of thought questions the real need for BI within educational institutions based on the fact that BI initiatives tend to be expensive, time consuming and they don't deliver the anticipated business results. This school of thought argues that most universities around the world are traditional education institutions and therefore their prime focus should be in providing quality education rather than investing time and resources in BI tools. The second school of thought is the opposite of the first one. It supports the idea of BI and positions it as the main stream to enhance the university both academically and professionally. This school of thought has an assumption that BI brings value to educational institutions in terms of visibility of the university data and increases productivity.

The basis of our research is to support the second school of thought primarily due to the fact that educational institutions need to evolve and innovate. The more insight such educational institutions have into their dark data, the more capable they become to face future challenges. This was evident from the journey that the University of Minnesota and the University of Indiana took to invest in BI tools. Furthermore, BI, if used properly, can provide a competitive advantage for the university over other educational institutions. Although SQU is a government funded university, any improvement made within the university will derive value.

SQU has a huge volume of data. The processing of such data quickly and accurately can improve the decision making process, by making the use of such data more effective and efficient. For example, modeling the student's grades and subjects can provide the university an advantage in responding quickly to changes in the industry, making the university more agile.

3.2 Research Questions

Based on the above, this research aims to provide answers to the following main research questions:

1. What are the future cases in SQU that use BI?

It is important during the maturity assessment to understand how BI is used currently and how BI will be used in the future. The first part describes the as-is situation while the second part describes the future aspirations of SQU.

2. If an educational institutions want to implement a BI solution, what is the best approach?

From the maturity assessment, it will be clear what the current situation and BI status of SQU is. Educational institutions are different in nature than commercial organizations and therefore it is important to develop the best approach for implementing BI. This will be clear during the development of the BI framework. Once SQU begins to implement the BI framework, it will improve the success rate of the BI implementation.

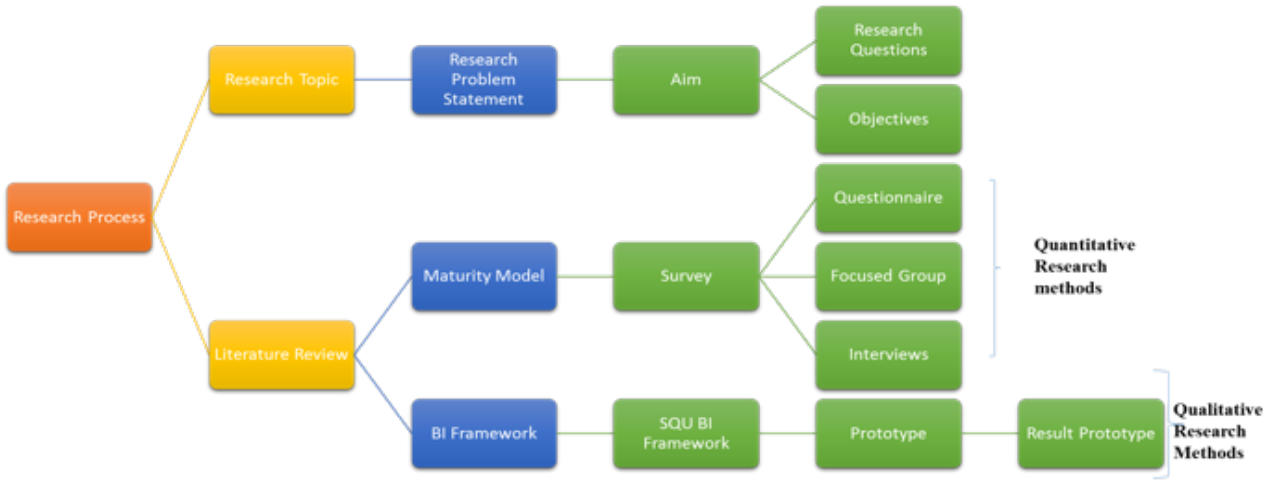

Figure 1 Research methodology.

3. How can BI be used in SQU to address strategic decision making challenges?

As stated in the literature review, the field of BI is wide. Furthermore, BI tools can be used as descriptive, diagnostic, predictive or prescriptive tools. In order to know what's best suited for SQU, a prototype will be developed to demonstrate the value of BI in addressing the strategic decision making challenges.

3.3 Proposed Methodology

The objective of this research is to develop a BI framework to be used for educational institutions. Furthermore, the research will use SQU as a case study to build this framework. In this research, both qualitative and quantitative research methods have been utilized. As can be seen from Figure 1, the research process uses two important approaches. The first approach is the selection of the research topic that followed certain steps starting from identifying the problem statement to identifying the aim and research objectives. The aim is divided into two-sub sections which are the research questions and objectives of the research. From a literature review, the maturity model and BI framework have been selected. Finally ending up with using both the quantitative approach (through questionnaire and interviews) and the qualitative approach (through the development of framework and using that framework to develop a prototype).

3.4 Data Analysis

The data analysis method followed two main approaches. The first approach was to use secondary data analysis such as literature reviews and case studies to identify the different BI maturity models and BI framework available in the industry. Two main frameworks were evaluated, namely, Gartner and BI 2020. In addition, five maturity models, namely, TDWI (TDWI, 2015) (Chuah & Wong, 2012), the business information maturity model (Rajterič, 2010) , Gartner's maturity model, advanced market research (AMR) (Rajterič, 2010) and MIT Sloan (Lavalle, Hopkins, Lesser, Schokely, & Kruschwitz, 2010) were evaluated. Once a maturity model was identified, we started using the primary data to create a custom questionnaire that suits SQU requirements. A number of interviews with the executive board of SQU were conducted to provide strategic direction and business priority for the BI implementation in SQU. Figure 2 shows a graphical overview of the data analysis approach.

4. BI FRAMEWORK DESIGN FOR SQU

The objective of the BI framework is to provide a formal structure to be adopted by the organization (in this case: SQU) when implementing BI. In addition, another objective of the BI framework is to provide a practical guide to help SQU understand the different considerations it needs to include when embarking on the BI journey. It is important to note that frameworks might be implemented in different ways depending on the maturity level and the type of industry. Nevertheless, BI frameworks are mostly used within business organizations and rarely used within educational institutions. Although general frameworks are commonly used in educational institutions to describe structures

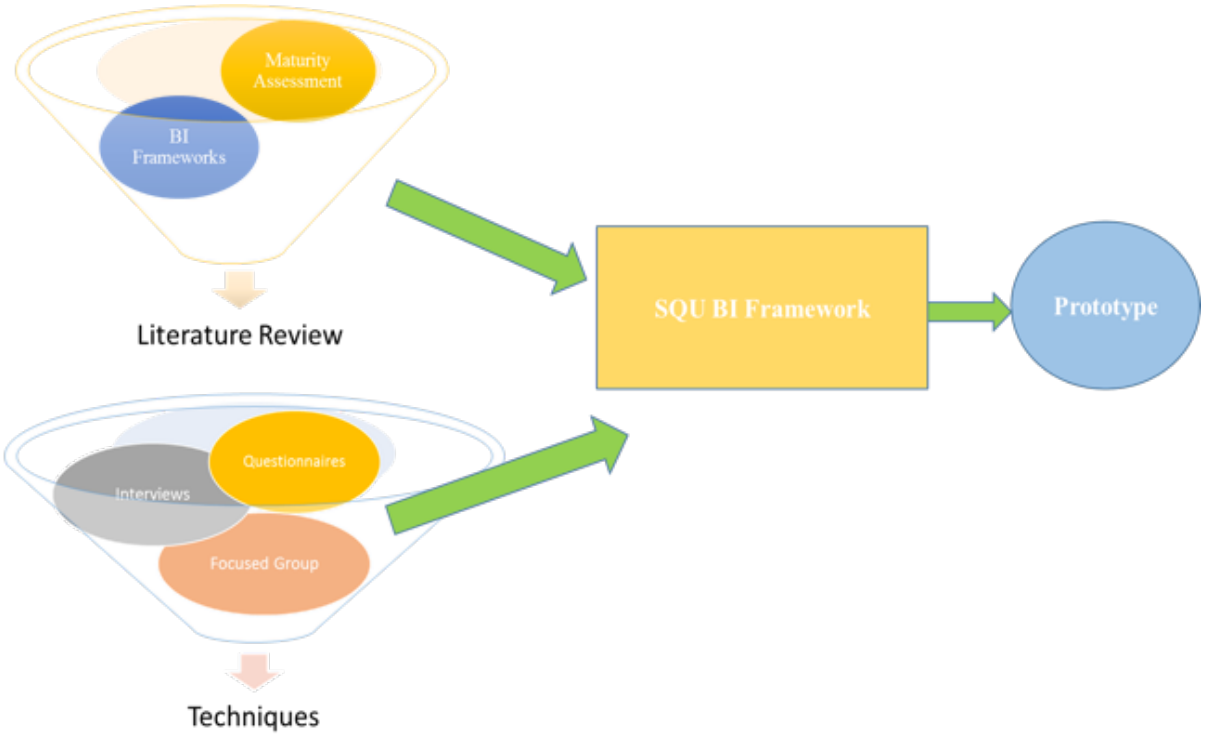

Figure 2 Data analysis approach.

and hierarchy (QAA, 2014), the literature provided little evidence on the use of BI frameworks in educational institutions. This prompted the development of a BI framework to be used specifically for SQU.

4.1 Basis of the Framework

In order to select which framework is suitable for SQU from Gartner and BI 2020, the following criteria were developed:

1. Framework should cover people, process and technology elements.
2. Framework should be flexible to include elements from the maturity assessment without affecting its structure.
3. Framework can be easily fragmented into different layers where accountabilities and responsibilities can be defined for each layer.
4. Framework should be simple and easy to understand.

Comparing the two frameworks, Gartner's framework met the above criteria. Therefore, the basis for our BI framework was Gartner's business analytics framework. Figure 3 shows the proposed BI framework adopted from Gartner.

4.2 BI Framework Components

As depicted in Figure 3, the framework is divided into five main components:

1. People:

This component will describe the main user groups within the university. It is important to identify the main users of BI within SQU in order to develop the different applications that each group will use. Three main user groups were defined for SQU; student, administration and faculty. Each user group has a different set of requirements. Furthermore, this component also covers the skills required by each user group to utilize and benefit from the BI implementation within SQU. In addition, this component addresses the organizational structure required for having successful BI implementation.

It is important to note that in Gartner's Framework, the definition of people is different from the one used in this research. In Gartner's Framework, people are divided into producer (mainly IT), consumers (mainly business) and enablers (mainly information managers who facilitate analytics). Due to the maturity level of SQU, the three groups will be mainly consuming BI. This is due to the fact that in order for SQU to start producing analytics, it needs to be mature. This can be achieved in

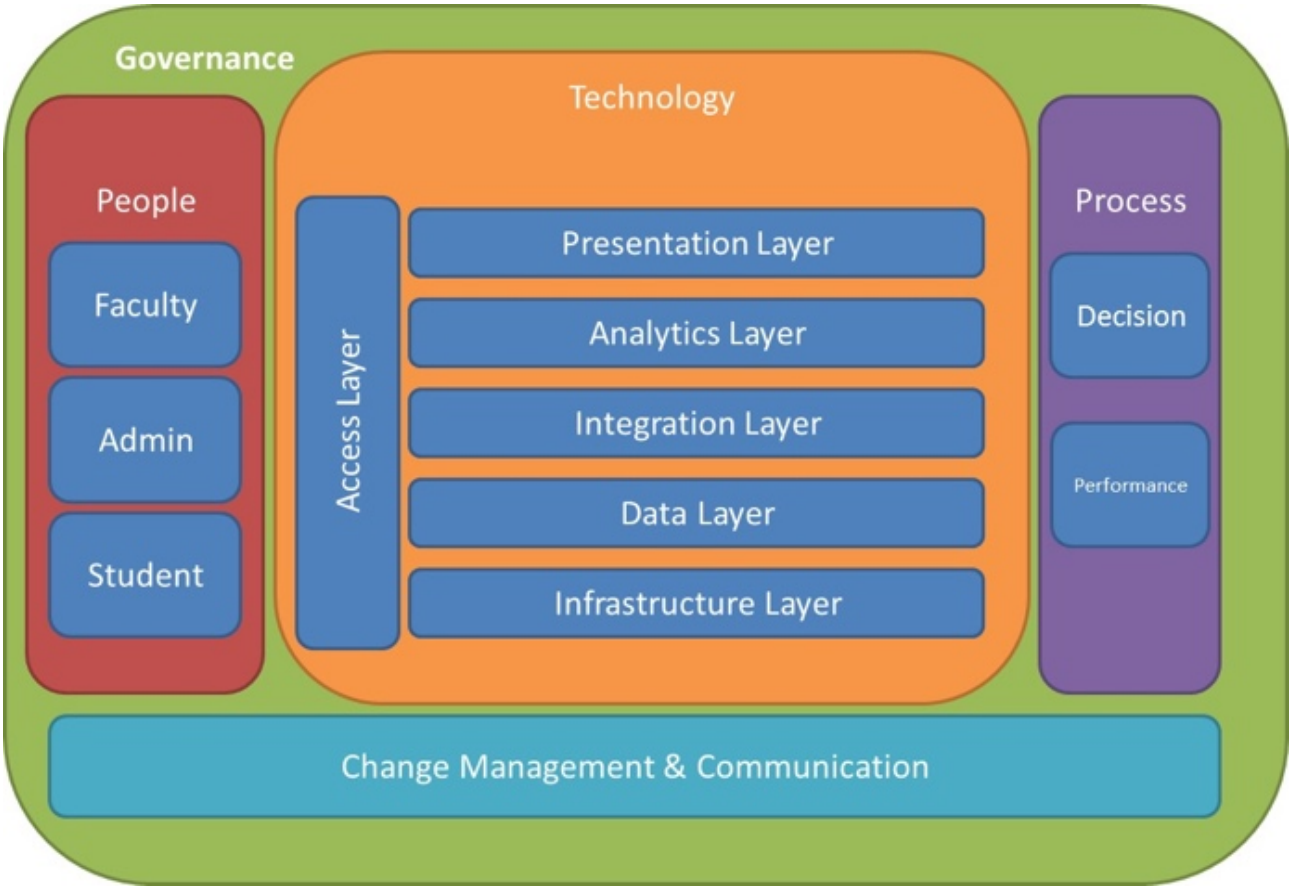

Figure 3 Proposed BI framework.

phases and not necessarily from initial BI implementation.

2. Technology:

In Gartner's framework, this section is referred to as the platform. Gartner classifies the platform into capabilities such as decision capabilities, analytics capabilities and information capabilities. Since SQU BI maturity is low, the classification is done based on different technology layers. This was clear from the maturity assessment since the respondents were more interested to see the BI framework covering different layers such as access, infrastructure, data, integration, analytics and presentation. The description of each layer is as follows:

- Infrastructure Layer: describes the different components of servers, network, storage, etc.
- Data Layer: describes the different databases and data warehouse used to store data.
- Integration Layer: describes the different tools used to extract and load data.
- Analytics Layer: smart analysis takes place. It represents the different BI applications that are used for decision analysis or even performance management.
- Presentation Layer: covers the different dashboards that are used for representing analyzed or processed data.
- Access Layer: During the maturity assessment, many respondents complained about data accessibility. This layer is to ensure that the different user groups are able to access data they are authorized to access.

3. Process:

During the maturity assessment, there are two main use cases for BI within SQU: decision making and performance management. Since these two are the main use cases for BI in SQU, it is essential to develop processes for using BI tools to help in performing the above two use cases. For example, in order to perform performance management, there is a process, which will define the different stages that performance management undertakes. At each

stage of the process, there is a need to define where BI plays a role. This will become clear during the prototype stage.

4. Change Management & Communication:

It was evident from the maturity assessment that there are gaps identified in communication. Apart from the fact that SQU has a low BI maturity, the survey questions revealed a need to address the communication gap between the different levels within the university. Therefore, as part of the framework, communication is included. Furthermore, any introduction of new technology has to be accompanied with change management. This is required in general for any change in technology environment and it is essential for SQU to have one due to the low level of maturity and high expectation for BI success. Therefore, it is important to allow for a better management of change when introducing BI.

5. Governance

The assessment of BI governance during the maturity assessment proved that SQU has a low level of governance. The policies are still maturing and there is a need to develop a better governance model around data that will help in improving the data integrity. In addition, there is a lack of clarity in the roles and responsibilities of who is supposed to do what in a business intelligence environment. It is essential that a governance structure has to be in place to address these gaps.

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4.3.1 Start with Business Demand

Three main user groups will be the main users of BI within SQU. The initial judgment based on the maturity assessment and structured interviews provided the current demand for performance management and decision-making. Although this might sound like a complete demand, it is not. Therefore, it is important when using the framework to capture specific needs related to performance and decision making requirements. This can be in the form of different capabilities (i.e. the tool should be capable of doing so and so) or a particular feature (i.e. the tool needs to be colorful). Regardless of the type of requirements, once all the requirements are captured, an overall synergy needs to be done to arrive at the different user groups' expectations.

During the maturity assessment and the structured interviews, few requirements were captured from the administration and faculty. Respondents to the survey expect easy access to the BI tools. They expect training to be an integral part of any solution. They also expect that there is a need to centralize the BI support and to have a single ownership for the solution. While these expectations will drive some of the design principles of the technical solution, this is only the initial assessment and doesn't cover the full BI requirements of SQU.

4.3.2 Technology is an iterative process

Once the demand is identified, the technology can be determined. During the maturity assessment and the structured interviews, it was clear that the university needs to revamp its technical capabilities to address BI requirements. Under the technology element, there are different layers that need to be addressed. It is important to note that when designing a BI solution for the university, the solution will need to undergo several iterations before determining the best fit. For example, it is clear from the maturity assessment that the university doesn't have a data warehouse and doesn't have the tools for extracting and loading the data. In order to address this gap, the data layer (in the framework) needs to be designed to include a data warehouse. The infrastructure layer needs to have all the different components (servers, storage and databases) to enable the development of the data warehouse. The integration layer will have all the ETL tools required to extract and load the data while the analytics layer will be responsible for executing different algorithms to help data analysis. It was also clear from the maturity assessment that the user groups demand easy access and good representation of data. The presentation layer is responsible for

presenting the analyzed data in a format that is understood by the user groups.

It is clear from the above that when designing the solutions there are interdependencies between the different layers. Thus, it is important to do the first iteration rather than correct any misalignment in the following iterations.

4.3.3 Agree the target process

Technology will not solve defects in the process or the organization. It is important when capturing the user demands to develop the target process. For example, one of the SQU target processes is performance management. This process needs to be clarified prior to implementing the technology element to understand how the different users will use performance management to address their needs and how the technical infrastructure can help. Therefore, it is important that once the technology solutions are finalized (as an initial or detailed design), the two main processes (i.e. decision making and performance management) are designed to work in harmony with the technical solution and people's expectations.

4.3.4 Plan the change

The BI solution is new to the university and it is going to change the way they carry out decision making and performance management. The university has a style of doing things at present that will need to evolve once BI tools are introduced. Managing the transition between the old and new way of making decisions and managing performance will be one of the key success criteria for BI project. Therefore, it is important to plan for the change and to develop a comprehensive communication plan.

Since the awareness level of BI is low in SQU, the first step will be to increase the level of awareness. It is important at this stage to plan how the change will be managed and communicated. Once decided, communication can be done through a series of presentations, posters, circulars, etc. The different communication channels will be determined by the current policies within SQU for communicating project information or changes to the status quo.

Table 1 Main differences between the Gartner and SQU BI frameworks.

Dimension	Gartner BI Framework	SQU BI Framework
Components	Gartner model has 3 core components: people, processes, and platform and 4 non-core components: program management, performance, metadata and information.	SQU Framework has 5 core components: people, processes, technology, change & communication and governance.
Framework Focus	This framework is focused to ensure the BI strategy in place before organizations start to implement BI	The focus is on BI implementation. There is an assumption that a BI strategy already exists within SQU.
People	Focuses mainly on people as produce, consume and enable.	People are users of BI but they also support BI and thus there is a need to include training & development as part of this dimension.
Technology or Platform	Process driven and focuses mainly on 3 main capabilities; Decision, Analytics and Information.	Technically driven and focuses on how the access, infrastructure, integration elements will work together.
Processes	Very general and focuses on 3 processes: decision, analytics and information processes.	Specific to educational institutions needs and focuses on processes related to SQU and what is important for the BI framework to deliver.
Change & Communication	Not clear in the framework.	The importance of managing change and communication is clearly visible as an important part of the framework.
Governance	Focused mainly on information governance.	Focused on how to govern the overall implementation of BI within SQU.

4.3.5 Govern and Improve

Governance is important to make sure that things are implemented in the right order. Currently, the university has no policies for data management. These policies need to be created and implemented. There is a need to have a body within the university to oversee BI implementation and steer the direction of the implementation. In addition, any improvement initiatives need to be captured and fed back to the framework to ensure that the different layers are working together to deliver the maximum value to the university.

The result from the above five steps is an implementation plan for BI within the university. This plan can be used by the system integrators to implement the BI solution for the university.

4.4 BI Framework Features

Although the BI framework in Figure 3 is adopted from Gartner's BI framework, there are a few differences between the proposed framework and Gartner's framework. Table 1 illustrates the main differences.

5. THE IMPLEMENTATION OF BI

5.1 Introduction

As discussed previously, SQU's interest in BI is driven towards performance management. In order to demonstrate how BI analytics can help the university, it is important to develop a prototype of the BI system. The objective of developing a BI prototype is to provide a closer insight into the design of the BI solution and highlight issues and risks associated with the implementation. Furthermore, the prototype will highlight challenges that the university might face during the implementation of the performance management part.

In order for the prototype to reflect reality, the prototype design will be aligned to the industry's best practices. There are many vendors who have developed BI solutions for different organizations and it will be very useful to utilize their architecture as a reference for this prototyping exercise. In addition, the prototype will use available tools for academic use. These tools (such as Microsoft SQL and Microsoft Visual Studio) might not necessarily provide the best of breed scenario, but they are mainly used to demonstrate the concept. Although the prototype is based on simple tools, the university might have to use a more sophisticated BI solution from BI companies such as Microsoft or Oracle in the future.

5.2 BI Architecture

In order to develop a prototype, there is a need to examine the real life setup of a typical BI implementation. Since the university doesn't have a BI solution in place, it was difficult to find a company in Oman that would allow access to its BI solution setup. Therefore, it was important to search for the top providers for BI solution and see if there is a way to examine their BI solutions. Two main vendors were identified, Microsoft and Oracle, who have a local presence in Oman. Since Microsoft Office tools are widely used, Microsoft Business Intelligence Solution was selected. In addition, it was easier to get support from Microsoft, due to their strong local presence in Oman.

Microsoft BI Architecture is divided into three tiers:

1. Data Tier: This tier is based on the Microsoft database server (SQL Server) and has four main elements:
    - SQL Analytics Tools: mainly analytics.
    - SQL Reporting Tool: creating dashboards.
    - SQL Integration Tool: main ETL tool for loading and extracting data from other non-Microsoft sources.
    - SQL DBMS: where the database tables are located.
2. Microsoft SharePoint provides the main content management and search. This is where all the delivery aspects of BI will happen.
3. End User Reporting Tools such as Microsoft Excel and Performance Point Dashboard.

In addition, Microsoft introduced Power view BI as part of their BI solutions to aid organizations to get a better view of their data. There are a number of options for Power BI, the desktop, mobile and cloud options. When trying the cloud option, SQU IT department blocked the use of any Power BI usage in the cloud. Since SQU already has Office 2013 and Excel

2013, Power BI is integrated as part of that option so as to utilize the existing tool.

5.3 Prototype Design

It was decided when building the prototype that one key business activity (KBA) (Teaching and Learning) will be used among 1. Teaching and Learning 2. Research and Consultancy 3. Community Service and 4. Resources and Facilities. Under this KBA, there are 15 different KPIs with different algorithms to calculate, as follows:

1 -Percentage of course section with 30 or less students
2 -Percentage of reviewed programs during the past 4 years
3 -Percentage of courses assessed and evaluated
4 -Growth in the total number of student enrolled
5 -Percentage of undergraduate students achieving CGPA ≥ 2.7
6 -Percentage of undergraduate students on probation
7 -Percentage of postgraduate students on probation
8 -Percentage of international undergraduate students
9 -Percentage of international postgraduate students
10 -Percentage of undergraduate student withdrawn
11 -Percentage of postgraduate student withdrawn
12 -Percentage of student transferring into the college
13 -Percentage of students transferring out of the college
14 -Full time equivalent (FTE) student-staff ratio
15 -Percentage of students graduated within expected period of graduation of concerned cohort

Furthermore, since the university has nine colleges, it was difficult to demonstrate this using a prototype. Therefore, it was decided to focus the prototype in one college initially. The initial prototype design was based on the three tier model:

- Data layer: MS Access.
- BI layer: MS Excel using Power BI.
- User interface layer: Excel or Web page integration.

Figure 4 Architecture of the prototype solution showing the user interface.

However, during the development work, Power BI in Excel didn't provide the right level of analytics required by the university. Therefore, it was decided to use a new prototype design that reflects in close proximity with the Microsoft BI solution. The final prototype design was based on the three tier model as well:

- Data layer: All tables were created in Microsoft SQL Server 2008 R2.
- BI layer: The algorithm for calculating and analyzing the performance data was scripted using Visual Basic (VB) coding in Microsoft Visual Studio 2013. The reason for selecting visual basic is due to its simplicity and wide adoption in SQU.
- User interface: Login page distinguishes between different user profiles. There are two user profiles created. The interface for the whole solution was developed in SQL reporting.

Figure 4 shows the architecture of the prototype solution showing the user interface: SQU dashboard.

When designing the different layers for the prototype, the following were the main considerations:

1. Simple user interface. Although we focused our efforts on one KBA and one college, there are 15 different KPIs to be represented. The initial interface design had multiple web pages to show the different KPIs in different years. However, after a number of iterations, it was decided to simplify the interface with one page that represents the 15 KPIs.

2. Use of real data. The College of Science was selected to be the first college to run their KPIs using the prototype. In order to make the prototype more realistic, it was decided to use real data from the college.

3. Segregation of users. Two types of users were identified during the prototype design. One user that has access to the final performance dashboard. Another user that has access to the data entry and performance dashboard. The roles of each should be segregated.

4. Availability for staff to test the prototype. In order to ensure that the BI prototype meets the university expectations, two users were identified; one user from the college of science and another from the planning and statistics department. Their role is simply to ensure the prototype meets the expected requirements. Since agile methodology is utilized for the development of this prototype, it was important to have someone to own the requirements as they change during the different iterations.

5.4 User Acceptance Testing Results

The current performance calculation for the university is done by the Planning and Statistics Department in SQU. There is no dashboard currently to show the status of different KBAs for the different colleges. The following is the feedback from the acceptance test:

- The overall performance result for College of Science in Teaching and Learning KBA is shown as low in this dashboard. This reflects reality while we didn't have this visibility of the college performance before. We thought they are doing fine.
- It is easier using this dashboard to track the changes of the different KPIs in different years. It provides solid evidence of which KPI needs more attention and which KPI doesn't change over the years.
- It would have been nice if each KPI has a traffic light showing if it is above or under target. This can be added as part of the interface improvements.
- The thing I like most about this dashboard is its simplicity. I assume that the real life dashboard will have all four KBAs aggregated to the SQU level and the overall college performance will be represented in a similar fashion.

5.5 Research Analysis and Discussion

The maturity assessment questionnaire was sent to key staff in SQU including staff working in technical, faculty and administrative positions. The total number of key staff was 200 but only 68 responded. This means that the response rate was 34% which is considered to be a good rate. Table 2 shows the main findings of the maturity assessment questionnaire.

As discussed previously, the SQU BI framework consists of a number of elements.

Table 2 Main findings (maturity assessment questionnaire).

Maturity Assessment Questionnaire Main Findings
The breakdown of the survey respondents are; 47.1% technical staff, 30.9% administrative staff and 22% faculty.
The overall maturity of BI within SQU based on TDWI Model is 1.4, which is considered low.
Majority of respondents do understand BI although the initial assumption when this research commenced was the opposite.
Majority of the people who understand BI think that BI is mostly used to predict and not necessarily to describe or analyze.
Majority of staff within SQU don't understand how BI can be used in SQU.
Majority of staff in SQU (91.2%) expect the BI initiative to be more than 60% successful.
There is a need for a better communication strategy for BI initiatives within SQU.
80% of respondents stated that SQU doesn't have any mechanism to ensure data quality while 20% believe it exists somehow.
All the interviewed executives agreed that the university should invest on BI solution.
Improved strategic performance management is the first priority for SQU management.
Majority of executives agreed that BI should be owned by the Planning and Statistics Department.
Executives believed that BI will help in improving the decision making process.

The prototype reflects the technical element of the framework only. This is due to the fact that the main focus of the prototype is to demonstrate the applicability of BI to the performance management within SQU. Table 3 shows the main findings from the SQU BI framework and prototype.

Table 3 . Main findings (SQU BI framework & prototype).

Main Findings (SQU BI Framework & Prototype)
The framework has a wide coverage on the main elements that will contribute to a successful BI implementation.
Prototype covered one college and one KBA, yet provided overall feasibility on the college KPI.
The data sources for the prototype are manually entered but in real implementation integration points need to be in place to extract the data. Thus, use of a data warehouse is recommended.
The use of agile methodology provided a faster feedback cycle to correct and optimize the prototype design.
The real value of the prototype was to give the college the aggregated performance of that particular KBA in addition to visibility on all KPIs as related to benchmark.

6. CONCLUSION AND FUTURE WORK

This research was carried out to develop a framework to implement BI solutions for higher education institutions with SQU as the case study. In order to develop a customized BI framework, the study utilized Gartner's Business Analytics Framework and the results from the BI maturity assessment. Although the results of the BI maturity assessment came as no surprise, the effort needed to ensure that SQU implemented BI successfully, was dramatically increased due to its low maturity level. This was challenging initially and changed management needs which played a major role in ensuring successful implementation.

In addition, the research developed a BI prototype to test the concept of performance management utilizing the BIA capabilities. It was clear from the maturity assessment and the stakeholder engagements that BI is positioned as a performance management improvement tool. This encouraged the development of the prototype using the KBA and KPI that the university had. Furthermore, the prototype has to be based on a real life scenario to increase its success and its reality check. Microsoft BI Architecture was used as the main reference for the BI prototype. Thus, the prototype consists of 3 main elements, namely a database where performance data are stored, an analytics tool using Excel Power BI, and a web interface representing the visualization of the dashboards. Although the focus of the prototype was limited to one KBA in one college (College of Science), it provided critical insight into how the College of Science has been performing during the last three years. Such insight into this information is a critical part of the value proposition the BI is recommending.

To our knowledge, this research is the first of its kind to build a BI implementation framework for educational institutions, especially in the Middle East sector. It is important to note that while SQU scored low in the BI maturity assessment, other educational institutions might not have the same maturity level. Therefore, it is recommended that the BI framework is tested against different maturity levels to see how it works.

As discussed previously, the prototype developed during this research was limited to one KBA and one college. There are 4 KBAs within SQU and 9 colleges that need to be examined with this prototype. By building such a prototype, the credibility of BI will be established and tested in real life. Moreover, the aggregation of the different KBAs and KPIs will contribute to the overall SQU performance and will provide better visibility of how SQU as an organization is functioning. This is the key towards the successful implementation of BI within SQU in the future.

Future researchers can use this framework to test how BI should be implemented in educational institutions. They can focus on testing the SQU BI framework through using comparative analysis of two organizations with and without using the BI framework. Also, the future research will expand the prototype to include all SQU colleges and all four business KBAs.

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