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The Role of Business Intelligence and Analytics in Higher Education Quality: A Proposed Architecture

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***Abstract*— This paper aims to show how Business Intelligence is utilized in Higher Education Institutions for the purpose of monitoring Quality Assurance activities. This paper discusses Quality Assurance in Higher Education and investigates the challenging issues that institutions are facing. In addition, the paper discusses the role of Business Intelligence and Analytics in supporting decision making in the context of Higher Education. The paper outlines the link between Quality Assurance core elements and Business Intelligence systems. The paper outlines a proposed Business Intelligence solution for application to Higher Education in Saudi Arabia to address the main concerns for performance evaluation and monitoring in relation to Quality Assurance.**

Keywords*— *business intelligence, educational institutions, higher education, performance evaluation, monitoring, Saudi Arabia

I. INTRODUCTION

Business Intelligence (BI) is currently being utilized in the context of Higher Education Institutions (HEIs) to support decision making processes [1], [2]. Business Intelligence can be used in HEIs to provide real-time information to assist HEI top management in keeping track of performance [2], [3]. BI is defined as the set of tools that includes the concept, strategies, processes, applications, data, products, technologies and technical architectures used to support the collection, analysis, presentation and dissemination of business information to different stakeholders to support decision making [4]–[8]

BI plays an important role in supporting decision making especially in areas concerned with teaching performance and financial aspects [1], [3], [9]. Sinaga and Girsang 2017 [10] discuss the development of a data warehouse to support university accreditation. There are many pressures on HEI management in terms of accountability and the large amounts of data that an HEI now handles. Business Intelligence can assist financial monitoring and operational performance and the identification of areas of concern that need management attention [11]. Business Intelligence applications identified for HEIs include Student Relationship Management (SRM), and the adoption of Online Analytical Processing (OLAP) techniques for obtaining information about student achievements and conducting descriptive analysis [11] and the use of BI to support decision making [12]. Scholtz et al 2018 [3] proposed a BI framework for sustainability information management in HE and suggested that dashboards can assist management in determining whether strategic goals have been achieved. Schultheis 2016 [13] suggested that adopting BI in the context of HEI can have a positive effect on strategic decision making. Additionally, [14] discuss the development of a university financial data warehouse and visualisation tool. The UK Higher Education Statistics Agency (HESA) introduced in 2017 a business intelligence service for UK Higher Education *Heidi Plus Service*. Heidi Plus allows HEIs in the UK to view live data for benchmarking and monitoring purposes through visualized dashboards [15], [16].

This study aims to explore the role of BI and analytics in monitoring Quality Assurance (QA) in HEIs. Additionally, the paper proposes a BI architecture for HEIs that aims to demonstrate several issues that HEIs must consider while benefiting from BI analytics for the purpose of monitoring performance in HE.

II. QUALITY ASSURANCE IN HIGHER EDUCATION

The nature of HE systems encompasses different internal and external stakeholders, as well as the large amount of funds allocated by governments in support of HEIs operations. This has led to stakeholder requirements for assurance that resources are used in the most efficient way. Consequently, QA plays an essential role in demonstrating that an organizational mission and objectives are aligned to meet the expectations of stakeholders [17], [18].

Governments which support HEIs are mainly concerned with efficiency, cost-effectiveness, community satisfaction and accountability [19]. Consequently, institutions are more interested in the assurance and improvement of the quality of courses, learning processes and outcomes, management and staffing, while the main concerns for students are focused on costs and career opportunities [20]. This range of stakeholder needs and perspectives means that HEIs are under pressure to demonstrate that they are in

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conformance with these requirements. HEIs have also realized that the quality of their services and the degree of customer satisfaction can set them apart from other universities as well as achieving long-term survival [20].

Mokhtar et al 2012 [21] suggested that QA in the context of HE is not limited to quality improvement and sustainability, but that the implementation of an effective quality management system in HE provides a dynamic process of monitoring, continuous improvement, and change. However, QA should also help in determining the extent of improvements made, ensuring compliance with specifications, requirements and standards. In addition, Quality Assurance should also include the identification of monitoring performance indicators against those standards [22]. Therefore, Key Performance Indicators (KPIs) are set by HEIs in order to be able to monitor QA activities in HE. The issues related to KPIs and monitoring in HE is discussed as follows:

A. *Key Performance Indicators for Higher Education Quality Assurance*

KPIs are used by HEIs to benchmark performance in certain areas. The actual performance is measured and compared to referencing KPI in order to determine the level of satisfaction or compliance with the target. As KPIs are directly related to the organizational mission, the achievement level can predict whether or not the HEI is aligned to its mission and strategic objectives. Furthermore, [23] suggested that, for the purpose of decision-making, good decisions require good information and datasets. Metrics and KPIs can be relevant to learning and teaching as well as research. which can include time-series on achievement and attrition, student evaluations, and electronic assessment of submissions and reporting. The results from these data sets may be aggregated on an individual, school, discipline, faculty, university, or system-wide basis. Schindler et al 2015 [24] reviewed the literature on quality indicators in HE and found that HE quality indicators can be categorized into four main categories; (1) Administrative Indicators, (2) Student Support Indicators, (3) Instructional Indicators, and (4) Student Performance Indicators.

B. *Challenges of Quality Assurance in Higher Education*

Research has shown that most faculty members are not enthusiastic about the accreditation process and the data collection requirements, document and form preparation, data aggregation, data analysis, evidence collection, and the development of corrective actions [25]. A significant part of QA measures in HEIs is in the form of procedures followed in planning, implementation, evaluation, and the development of education and teaching [26]. Almurshidee 2017 [27] suggested that optimal use of feedback and speedy delivery of information are required by decision makers in a timely manner and could help in saving time, effort, and money. Hamdatu et al 2013 [22] suggested that HEIs must have an assessment mechanism for quality as an evidence-based performance indicator with high external standards.

III. ROLE OF BI IN HE QA

QA requires the collection of large amounts of information related to the institution's activities and the documentation of each activity associated with QA in the HEIs. Information, Communication, and Technology (ICT) can play a significant role during this process [28].

Although HEIs have demonstrated that great importance is attached to quality assurance, the ambiguity related to QA concepts and requirements constitute important challenges when implementing an information system [26]. The objective of an effective QA system is to assist a company in satisfying customers' needs and expectations while helping in protecting the organization's interests [29]. However, planning for quality control should recognize the need to provide a network of information for all decision makers at all levels. In the context of HE, the success of a QA system is dependent upon the support of management. In addition, the QA system should cover strategic management, process management, and measuring-monitoring; these systems interact with each other in order to enable improvement in the processes of the institutions [30]. Some levels in the organizational hierarchy have a need for real-time information for detection and correction of nonconformance to goal activities. At other levels, the emphasis is on summaries that provide control over vital areas [31]. Kahveci 2012 [30] suggested that QA information provided to higher management may include sensitive and important information for decision makers and real-time access may be required in order to take corrective actions, if any are needed, to ensure that the HEI remains on track.

Business Intelligence can support QA by providing real-time information to assist HEI top management in keeping track of performance as BI can provide effective capabilities for the generation and delivery of different kinds of reports [32]. Colbran and Al-Ghreimil 2013 [23] suggested that BI systems and QA go 'hand in hand' as BI reporting allows the provision of summarized dashboards and reports for teaching and learning quality indicators. These reports can be generated easily by the utilization of BI tools and Colbran and Al-Ghreimil 2013 [23] suggest that this can improve teaching and learning outcomes while the reports themselves can be aggregated to provide individual and sector-wide benchmarks. Furthermore, their study suggested that Saudi Arabian universities have some data sets that can be used as a backbone of BI system such as student evaluation and attrition, but there is no evidence so far for the application of BI reporting systems by Saudi Arabian universities.

IV. BUSINESS INTELLIGENCE ARCHITECTURE IN HIGHER EDUCATION

There are several studies that have discussed BI architecture in HEIs, and this normally encompasses three main layers; 1) Data source layer, 2) Extract, Transform, and load (ETL) layer, and 3) Data presentation layer that

contains dashboard for monitoring learning process [1], [9], [11], [33]. Fig. 1 depicts these layers and shows that the data is being collected from different databases representing different data sources. The ETL process collects the data needed for analysis and transforms it into the Data Warehouse (DW) which is responsible for storing data for further analysis. Dashboards are used to present these analytics in summary form with drill down capability to assist decision makers in reviewing learning objectives and monitoring the performance of learning Key Performance Indicators (KPIs) [33], [34].

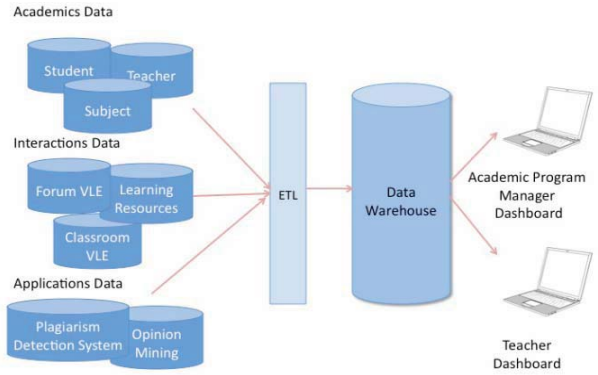

Fig. 1. Business Intelligence Architecture in Higher Education [35]

Data warehouses were originally developed to store transactional data [36] but there is recognition of the need to extend the data to include feedback and opinions obtained through social media channels [37]–[40]. Sentiment analysis may also be used to analyse data from social media and clean it to prepare it for use in the system [41]. Additionally, the emergence of cloud services like Microsoft Azure, Amazon AWS, Google Cloud, and other cloud services allowed some Business Intelligence providers like Tableau and Microsoft Power Business Intelligence to allow users to connect to cloud services. This allows users to get the benefits of real-time update of data from Cloud systems and avoid the costs of implementing local servers. The data and analytics are then represented to decision makers in terms of reports and graphical representation that is known now as Dashboards [3], [9], [42].

Pinheiro 2014 [9] identified the key components of Business Intelligence systems, as shown in Fig. 2. However, the diagram does not show the linkage between components in the system and how they interact with each other.

Fig. 2. Business Intelligence Components [9]

The components shown in Fig. 2 represent the main elements of a data warehouse based on Business Intelligence systems. In this approach, ETL plays an important role in the acquisition of data, as the ETL stage ensures that data is transformed into compatible formats before it is loaded into the DW [43] or other data storage mechanism. The information contained in the Data Warehouse can be retrieved as required by the system. The data in the data warehouse can then be processed in a number of ways, for example by the use of OLAP (Online Analytical Processing). OLAP data cubes are used to support OLAP operations such as roll-up, drill-down, slice and dice, and pivot [44]. The data in the data warehouse can be further analysed through the use of data mining algorithms which support data exploration and the finding of patterns in the data [9], [42].

Zulkefli et al 2015 [32] suggested that HEIs are required to consider some components on its Business Intelligence system in order to achieve their strategic vision and mission (such as people, processes, and KPIs). A BI system utilizes technologies and information infrastructure in addressing the KPIs that are designed to measure the performance of the HEI under the umbrella of institutional mission/vision.

Bentley 2017 [38] suggested that successful implementation needs senior management commitment, a business need for the Business Intelligence implementation, and satisfactory quality of available data. Additionally, [12] also suggested that BI systems in HEI share a number of characteristics. The BI system should be aligned to the institution's strategy in order to give assurance that the strategic objectives have been met [12]. The human aspect is considered one of the key components of successful BI implementation in HEIs as the stakeholders and decision makers are the intended users of the system [12], [32].

Social media is increasingly important as a source of data for HE as it provides feedback on the quality of services provided by HEIs [37], [45]. There are challenges in working with social media data in BI [46]. Hajli and Laroche [46] suggest that there is a need to explore how the data coming from social media can be utilized to capture consumer thoughts and insights from social media platforms.

V. Proposed BI Architecture in Higher Education

Based on the previous discussion, we can see that in order to benefit from BI analytics in HE for monitoring QA, there is a need to depict the architecture of BI in HE. The first phase of developing a proposed architecture was to make a link between the main elements of the QA system and the BI system. This linkage is shown in Fig. 3. As stakeholders and management are the main users of BI, and given that they play a key role in crafting the HEI strategy, the organizational mission is determined according to their monitoring needs Quality Assurance KPIs are determined under the influence of the organizational mission according to the expected performance of the HEI, for the purpose of

monitoring. The BI system should support decision making for HEI management by providing real-time performance measurements and analytics. Additionally, the BI system can provide performance monitoring information for stakeholders interested in these measurements.

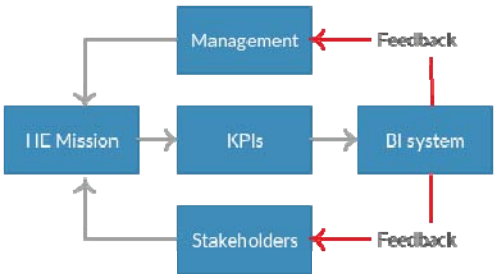

Fig. 3. Quality Assurance and Business Intelligence Linkage

The BI system shown in Fig.3 is intended to be fed by several sources of data. These sources include external sources, internally stored data in the databases, social media, and data stored in the cloud. The traditional data warehouse-based Business Intelligence architecture has three main layers: data source layer; data movement, storage, and processing layer; and data visualization and reporting layer as shown in Fig. 4. The data source layer includes all the data sources used by the system. The ETL (Extract Transform Load) layer handles the data extraction of data from the data sources, cleansing and loading this data, usually into a staging area and then loading the data into the data warehouse. In the presentation layer, data is presented to the decision maker using a range of formats to support data understanding and decision making.

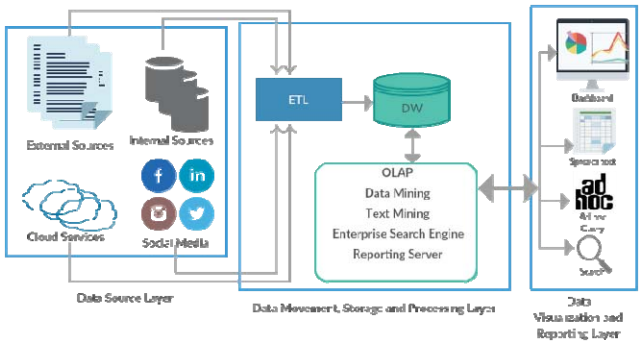

Fig. 4. Traditional DW based Business Intelligence Architecture

VI. Discussion

This paper shows that the proposed BI architecture can assist decision makers to benefit from the monitoring of QA activities in the HE. The architecture identifies several input sources for data that feeds the system. It takes into consideration the important role of social media in getting feedback on service quality provided by the HEI. Additionally, it takes into consideration different data storage mechanisms like cloud services and internal databases. The ETL process transforms data into the DW for the purpose of processing data into information to be presented to decision makers. While data is stored in the DW, several operations may be conducted on data for further analysis to support the decision-making process. Data presentation and visualization layer displays the analysed data to the decision makers in several forms (such as dashboards, reports, spreadsheets, and adhoc queries). Stakeholders are able to display dashboards with the data that concerns them. However, as HEIs differs in their capabilities, size, and expertise of practitioners working in IT departments, the conventional BI architecture may not be the best solution for HEIs to enable them to benefit from BI capabilities. There are other solutions (such as Service-oriented Business Intelligence and Self-Service Business Intelligence) that can be applied by Small and Medium-sized Enterprises (SMEs) which enables them to benefit from BI [47]–[49]. Currently there is limited research on different alternatives for adopting BI architecture in Higher Education (HE).

VII. Conclusion and Future Work

Business Intelligence can play an important role in HE for monitoring QA processes. Decision makers in the HEIs can benefit from BI and analytics by obtaining real-time feedback to support the monitoring of QA activities. While this paper discusses the provision of BI architecture in the context of the HEIs, this architecture is not limited to the implementation of QA monitoring system but can be utilized for monitoring additional institution wide KPIs.

As the emerging technologies like cloud computing and social media have a role in HEI, the proposed BI architecture includes these technologies for obtaining data for supporting decision making. In addition, a comparison with other state-of-art architectures of BI should be addressed and compared to traditional DW BI architecture. BI architecture in HEI context should be implemented and tested for validation purposes, and this is the subject of future work by the authors.

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