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Original Article

A Business Intelligence Solution for Improving the Higher Educational Learning Process

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***Abstract** - Higher Education Institutions (HEIs) today face many challenges such as the local and international expansion and the widespread utilization of Information and Communication Technologies (ICT) that facilitate global competition. To deal with these and with the changes in the labor market, HEIs administrators and planners need the information to improve their services, satisfy customers (students) and gain a competitive advantage. Learning is a process that includes interactions between students, educators, and courses under the umbrella of HEIs. It is the core and most important service provided by them and it is surrounded by many factors. Improving the learning process is multifaceted as there are numerous factors and stakeholders involved. This study aims to present a Business Intelligence (BI) solution and investigate its value in streamlining the learning process at HEIs. The proposed solution avails information and analytical capabilities to HEIs decision-makers. A mix of research methods was used to validate the solution, including content analysis to identify and categorize the factors involved in the learning process, along with a case study implementation of the proposed BI solution. Data was collected from different departments at the Sudan University of Science and Technology (SUST). The data analysis supports the research hypothesis that utilizing BI yields reliable information, knowledge-based decisions, and hence an improved learning process.*

***Keywords** - Learning process, higher education, decision-making, business intelligence, data warehouse, dimensional model.*

I. INTRODUCTION

Numerous research [1], [2] has shown that the core functions of HEIs are: education, research, and contributing to society. Moreover, HEIs play a vital role as a supplier to the labor market, as they provide highly qualified human resources. Learning is the most important process at HEIs, and it involves three main stakeholders, students, educators, and administrators [3]. The learning process is a system that consists of input, processing, and output. The inputs are students, educators, courses, and the environment. The processing in the system is the teaching process and the outputs are the graduate students, their quality, and their effect on the community and labor market [4], [5].

Advents in ICT have led to more and more data being generated and stored. Then organizations realized the potential value that resides in their data, and subsequently, they started to explore ways to utilize this valuable asset. Therefore, high demand arose for ICT methods and tools that can constructively transform data into information and knowledge. Decision-making plays a vital role within organizations and many times they are the reason behind their success or failure. Using systems to support the decision-making processes is significant since they help in data collection, organization, analysis, and transformation to information [6]. BI offers emerging solutions for improving data analysis, decision-making, and trend investigation. It plays a vital role since it improves the timeliness and quality of information, and enhances communication among departments while coordinating activities, and enabling quick responses to changes whether in financial conditions, customer preferences, or supply chain operations [7]. BI gives organizations a comprehensive and integrated view of their business operation and potential, and this facilitates the decision-making processes. Currently, it’s difficult to find successful organizations that do not yet use BI [8]. BI is used in different fields such as healthcare, communication, marketing, and finally it has entered the education field.

Many factors affect and interact with the learning process and its many stakeholders. To improve the learning at HEIs a deep study of the process and its influencers must be carried out. Recent research [4], [5], has shown that these factors can be grouped into SIX main groups or dimensions, namely: *environment*, *student*, *teaching*, *academic advising*, *HEI*, and *ICT*. This leads to this research’s question: how effectively create the data models toward an easy-to-implement scalable BI framework leading to improvements in the educational processes based on these learning process influences?

The objective of this research is to design a BI framework that analyzes the data collected toward new opportunities for managing and improving HE processes and to empirically investigate its effectiveness. The research contends that adopting BI increases the quality of information, reduces time, and increases efficiency.

This paper is organized into five sections beginning with this introduction. The following section presents background information about the learning process at HEIs, decision-making, BI, its component, and adoption at HEIs. The next section describes the research methodology that is organized into three phases. The first phase identifies and categorizes the factors involved in the learning process and BI components. While the second phase explores the development of a BI model that takes advantage of the identified learning process influences and the data collected. The third and final phase is the data analysis phase which discusses in detail the extraction of knowledge and validation of the model. Finally, the last section provides a summary of the paper and addresses the future direction of the research.

II. BACKGROUND

Globalization and the widespread use of ICT have led to increased worldwide competition between HEIs. Consequently, the need for competitive advantage has made many HEIs tend to use BI technologies in assisting with decision-making and solving problems. Many recent studies were published about BI utilization and applications at HEIs. For example, there are studies about using BI to assist in analytical activities regarding student affairs [9], and for analyzing students' performance [10], and enhancing the teaching-learning process [11]. Additionally, there is research on designing a BI framework for HEIs decision-makers [12], building an academic DW [13], [14], and aligning HEIs output with labor markets [15].

The learning process is vital and must always adapt to the labor market changes especially in this global knowledge economy. Improving the process is done by studying all the involved factors and identifying weaknesses and trying to resolve and improve them. As indicated earlier in the introduction, the list of factors influencing the process is not endless and is scalable, as the world around the learning process changes, the list can increase over time [5].

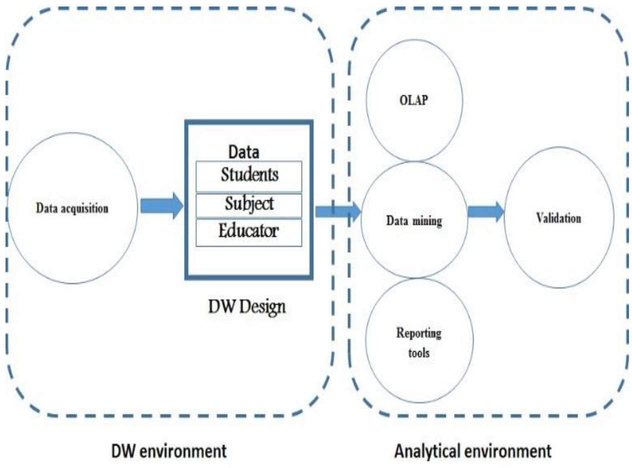

Fig. 1 Proposed BI solution

Fig. 1 illustrates the main components of the proposed BI framework that is comprised of two environments, DW and analytical. The DW environment contains the operational systems that supply the core data, the Extract, Transform, and Load (ETL) process, and the DW creation. The analytical environment is where the user creates reports and visual aids, queries the system for specific requests, and makes decisions based on information from the DW.

To gain a greater understanding of the components of the learning process and the factors affecting the success of the proposed BI model, the next section explores the creation of a case study implementation of the model at SUST together with the approach for its validation.

III. METHODOLOGY

This section describes the methodology used to realize the research objective by answering the research question. Content analysis, analytical research procedures, and exploratory interviews were used while performing an extensive review of the literature to identify the factors that affect the learning process, stakeholder, and data sources required for building the BI solution.

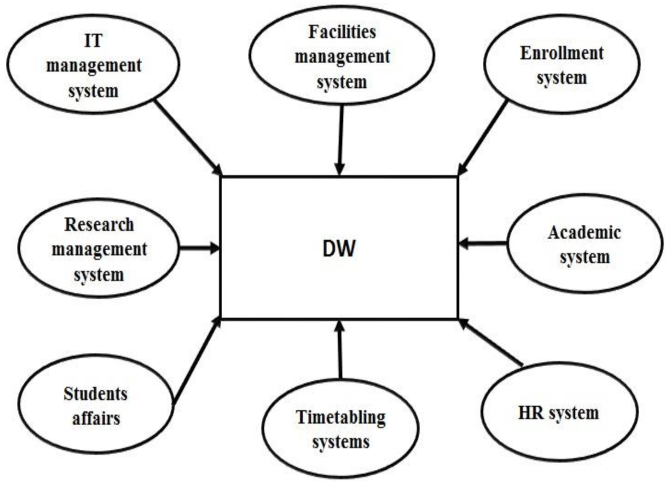

Fig. 2 Operational system

Based on the factors influencing the learning process outlined earlier in the introduction, the data for the proposed BI model comes from eight operational systems at SUST, as shown in Fig. 2. Interviews with key personnel at each data source department were conducted to clarify understanding of the data. First, is the facilities management system that encompasses data about all facilities including class and lecture rooms, laboratories, libraries, offices, cafeterias, etc. Second is the enrollment system that contains students' demographic information and registration data. Third is the academic system from which all data related to courses and students' performance is acquired. Fourth system is the human resource system that covers educators' data. The fifth is the timetable system which comprises the schedules of lectures, seminars, etc. The sixth system is students' affairs which has all the financial support data. Seventh is the research system that contains data about the many research projects at SUST. Finally, the last system is the ICT support system that includes data about computers, internet connectivity, applications including the Learning Management System (LMS), and all technology support-related data. The proposed BI framework integrates this carefully chosen data from all these sources into a central repository to be used by the appropriate stakeholders.

Table 1: Data Sources

Data about	Factor	Operational systems
Campus, class, and lecture rooms	Environment	Facilities management
Academic year, semester, student, college, department	Student Teaching Advising	Enrollment
Course, educator, course assignment, assessment method, references, mark, advisor, student GPA		Academic
Educator		HR
Timetable		Timetable
Financial support	HEI	Students affairs
Research		Research management
Computers, internet speed, WI-FI availability, LMS	ICT	IT management

Table 1 displays a mapping of the data sources' details to their corresponding learning process factors.

In the second phase of the methodology, a DW is composed of subject-oriented *data marts* using one or more schemas to represent specific business or processes. It is obvious that Kimball's data marts are more appropriate for this model [16], as their staggering approach satisfies the business requirements of the framework and is yet flexible and scalable, i.e., it grows with the availability of additional data.

The DW was modeled and designed by applying the dimension modeling approach. Content analysis methods resulted in the identification of many factors influencing BI implementations. To meet the objective of the research, this case study implementation targets three learning process subject areas, namely, Course-Progress, Class-Occupancy, and Students-Registration. These processes cover the Environment, Teaching, Student, and HEI factors. Exploratory interviews with key stakeholders from the earlier identified SUST departments helped in highlighting and prioritizing these recognized factors. As well, KPIs, possible queries, and information dashboards were created based on their feedback to study the possible correlation between the factors, their significance, and thus validate the framework. Each of the three target subject areas is represented with a data mart that is composed of

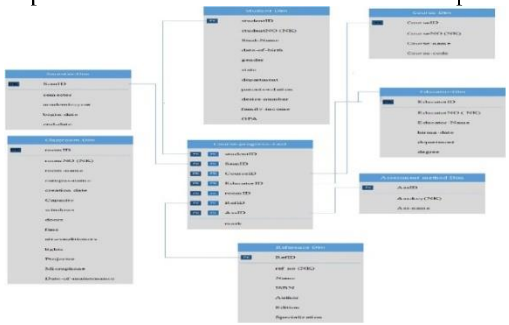

Fig. 3 Course-Progress data mart

one central table with a multipart key called the *Fact* Table and a set of smaller related tables called *Dimension* Tables. The data marts are:

A. Course-Progress

One of the most important key indicators of a successful learning process is students' academic performance. So, building a data mart to analyze data related to students' and their grades is extremely helpful in tracking the *Teaching* factor. The fact table for this data mart is called Course-Progress as shown in Fig.3.

The dimension tables are: *Semester* that is composed of semester id, academic year, semester begin and end dates, etc. The *Course* dimension table contains data about courses such as Course id, name, code, etc., while the *Educator* dimension includes educator id, name, qualifications, hiring date, department, etc. *Student* dimension includes student's information such as student id, name, gender, date of birth, etc. *Reference* dimension table includes reference id, ISBN, Name, etc. *The assessment method* dimension table contains data about which assessment method is used. The last dimension table is *Classroom* and it has all the information about the classroom environment including class or lecture room id, name, campus, capacity, windows, doors, light, fans, air conditioner, projector or not, and microphone or not, etc.

B. Class-Occupancy

Managing class and lecture rooms is one of the big challenges facing HEIs and has a huge impact on the learning process. It is quite helpful to examine which classrooms were used the most, and least, per academic year, and to explore which had the most, and least, equipment failures, etc. This information is vital for maintenance and load management as it relates to the *Environment* factor.

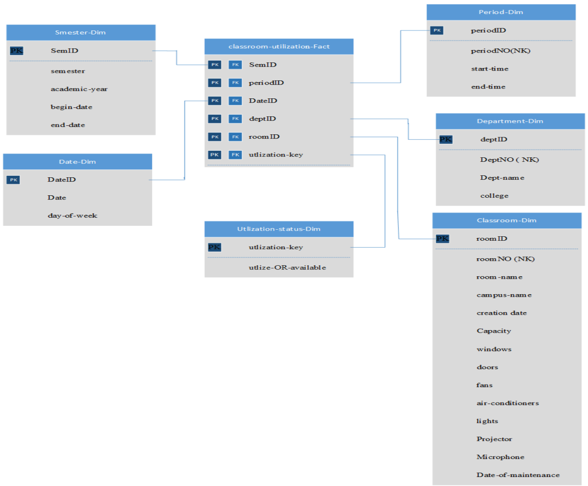

Fig. 4 Class-Occupancy

The fact table in this data mart, shown in Fig. 4, just views the relationship between all its dimensions. This type of table is called a *Factless* table, as it does not contain measures [16]. The dimension tables are *Semester* and *Classroom*, and they are similar to the ones with the same names described in the previous Course-Progress data mart shown Fig.3. The *Date* dimension contains information about important dates in each semester such as date id, date, day of the week such as Sunday, Monday, etc. The *Period* dimension table contains the time during the day, i.e., start and end times, for example, 8 to 10, etc. The *Department* dimension includes department id, name, college, etc. The *Occupancy* dimension contains data about occupancy status. The fact table for this data mart is *Classroom* and it consists of the keys of all the discussed dimension tables.

C. Students-Registration

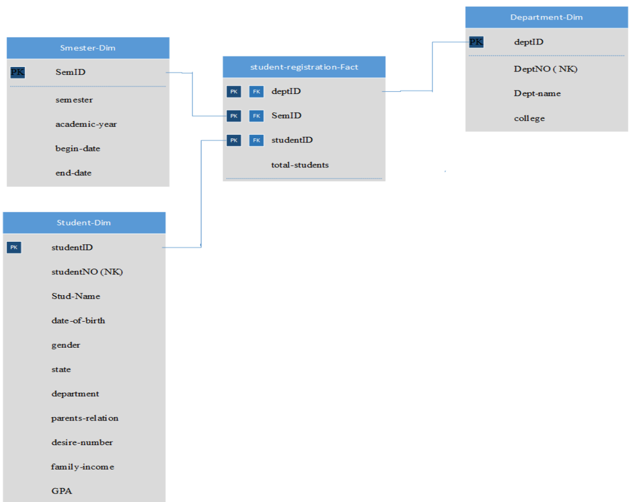

Fig. 5 Students-Registration

Trends of students' enrollment numbers at colleges and departments over time are a strong indicator of the HEIs' competitiveness and success. This information is captured with the *HEI* and *Student* learning process factors discussed earlier. Thus, the BI model tracks students' registration and enrollment information per department overtime to enable analyzing trends.

The fact table for this data mart is Student-Registration, shown in Fig. 5, and it contains keys of all dimension tables together with students' aggregates as measures. The dimension tables are *Semester*, *Department*, and *Student*. They are all identical to the dimension tables with the same names described in the two previous data marts.

After laying out the methodological steps of the research approach, the next section presents the implementation of the three data marts and discusses a selection of significant results. The purpose is to effectively expose the interrelationship between seminal factors and improvements in the learning process.

IV. DATA ANALYSIS

After completing the DW design, ETL procedures were carried, and the DW ready for the analytical phase. The open-source BI tool, SpagoBI [17], was utilized for the model implementation to explore the benefits achieved by stakeholders from adopting BI technologies and their impact on the learning process at HEIs.

Information dashboards and reports were created using SpagoBI that reflect key stakeholders' perspectives. The knowledge extracted from the three data marts is discussed in detail, and its impact on the study objective is outlined.

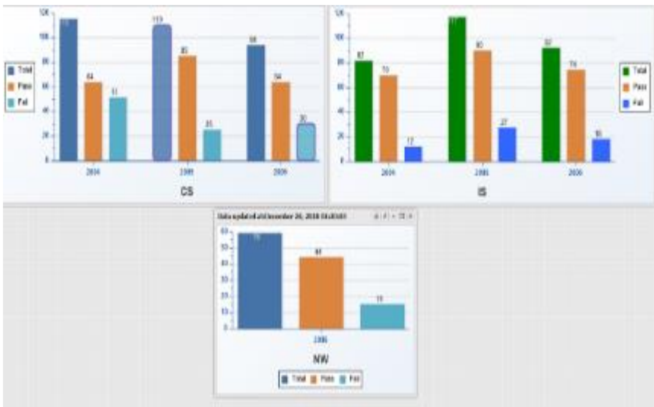

Fig. 6 Students' performance

First, the Course-Progress data mart avails students' performance data per course overtime to key stakeholders such as college deans, department heads, and educators. This academic performance information includes the total average, minimum, maximum, passing, and fail students.

The dashboard shown in Fig. 6 contains information about the *Data Structures* course taught at the College of Computer Science and Information Technology. The course was taught at the three departments in the college, namely, Computer Science (CS), Information System (IS), and Networks (NW) during 2004, 2005, and 2006 academic years in semester four. Enrollments in the NW department began in 2005, so there is data for the 2006 academic year only. The dashboard displays the total number of students registered for the course per department together with the number of passes and fails. The percentage of students who passed the course at the CS department was 77%, 55%, and 68% for the 2004, 2005, 2006 academic years respectively. Similarly, in the IS department, the results were 85%, 78%, and 80% for the same period, and 74% at the NW department in 2006. The number of students who passed the course in the IS department is greater than that of the two other departments. This information suggests that maybe there is a difference in the teaching environment, educator, assessment methods, students, etc., and that further investigation of this finding is warranted.

Additionally, from Fig. 6 we can see there was a high failure among the CS department, 51 students, during the 2004 academic year. These findings lead the Dean and department heads to explore what made performance differ in departments while the course content is the same. Correlating students' grades, educators, and assessment methods, and any other information related to the *Teaching* factor might lead to some answers. The BI model fully supports and empowers these kinds of investigations.

Fig. 7 Students' performance data

Fig. 7 shows a dashboard that was created from the Course-Progress data mart. It depicts the average, maximum, and minimum grade for each department during the 2004, 2005, and 2006 academic years. The dashboard clearly shows that the average grades at the CS department for this period were 40%, 49%, 42% respectively. While they were 51%, 50%, 48% in the IS department for the same period, and 49% in the NW department in 2006. The fact that the average grade was consistently less than 50% strongly indicates that the overall students' performance was not good enough, and there is a weakness in *one* or *more* factors that need improvement.

The third dashboard results, shown in Fig. 8, are from the Students-Registration data mart. It shows students' registration information for CS and IS departments between 1996 and 2008, and for the NW department from 2005 to 2008. These results show that in 1997 less than 20 students registered for both the CS and IS departments. Similarly, in 2002 the total number of students who registered for the CS department was about 200 and this is the largest number throughout the study period. The results also show that between the years 2005 to 2008 the total number of registered students in the IS department was consistently greater than the CS department. All of the information derived from this dashboard poses many questions that need answers. For example, why the number of CS and IS students in 1997 was so low? What is the reason behind the IS department accepting more students than the CS and NW departments during the 2005 to 2008 period? etc. The strength of the BI model is that it empowers such questions and inquiries while providing the tools and methods to analyze and find possible answers.

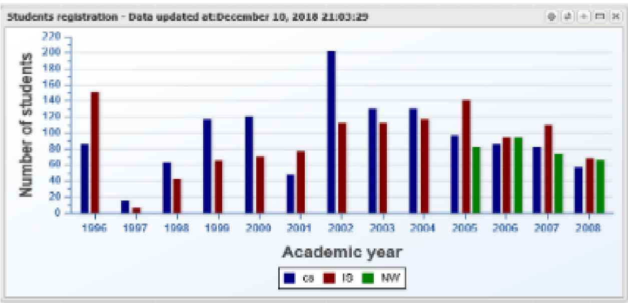

Fig. 8 First year students' registration

From the analysis above it is clear that using BI to investigate the many factors affecting the learning process, leads to information that can be used to determine weaknesses and to make improvement decisions.

V. CONCLUSION

This paper has investigated the adoption of BI technologies to enhance the learning process at HEIs. It has developed a basic BI implementation model, identified essential factors for its adoption, and empirically examined its efficiency. The case study implementation utilized as a part of the validation focused on four of the core factors identified; environment, teaching, student, and HEI.

The analysis of the results obtained from the model has demonstrated the efficiency and benefit of using BI tools to analyze data and obtain valuable decision-making information. The implemented model is very robust, and additional data will lead to more information about factors, and the relationship between factors and the learning process.

Furthermore, the study has laid out the foundation for improving the learning process while providing insight to HE planners, educators, and administrators to better realize the value of BI, the possible obstacles, and the existing leverage in its adoption. Future works involve extending the empirical study by involving additional data and factors as well as including HEIs in other regions.

REFERENCES

[1] Persson, Jacob, and Erik Sjöö. Business Intelligence–its Impact on the Decision-Making Process at Higher Rducation Institutions: A Case Study at Karlstad University. (2017).

[2] Khan, Rafi Ahmad, and S. M. K. Quadri. Business Intelligence: An Integrated Approach. Business Intelligence Journal 51) (2012): 64-70.

[3] Betoret, Fernando Doménech, and Adela Descals Tomás. Evaluation of the University Teaching/Learning Process for the Improvement of Quality in Higher Education. Assessment & Evaluation in Higher Education 28(2) (2003): 165-178.

[4] Pavione, Caroline Stéffani Santos Nério, Bruna Camargos Avelino, and José Roberto de Souza Francisco. Factors that

Influence the Teaching-Learning Process from the Perspective of Accountancy Students: Analysis at a Higher Education Institution in Minas Gerais.Revista de Educação e Pesquisa em Contabilidade 10(2) (2016).

[5] Wafa Ali Mohammed Investigating Factors Affecting the Learning Process in Higher Education - A Case Study International Journal of Computer Trends and Technology 68(6) (2020):10-17.

[6] Khan, Rafi Ahmad, and S. M. K. Quadri. Business Intelligence: An Integrated Approach. Business Intelligence Journal 5(1) (2012): 64-70. Power, Daniel J. A Brief History of Decision Support Systems."DSSResources. com 3 (2007).

[7] Ranjan, Jayanthi. Business Intelligence: Concepts, Components, Techniques, and Benefits. Journal of Theoretical and Applied Information Technology 9(1) (2009): 60-70.

[8] Chaudhuri, Surajit, Umeshwar Dayal, and Vivek Narasayya. An Overview of Business Intelligence Technology. Communications of the ACM 54(8) (2011): 88-98.

[9] Ta'a, Azman, Muhamad Shahbani Abu Bakar, and Abdul Razak Saleh. Academic Business Intelligence System Development Using SAS® Tools. In Workshop on Data Collection System for PHLI-MOHE, 13(1), (2006) 14.

[10] Kabakchieva, Dorina. Business Intelligence Systems for Analyzing University Students Data. Cybernetics and Information Technologies 15(1) (2015) 104-115.

[11] Piedade, Maria Beatriz, and Maribel Yasmina Santos. Business Intelligence in Higher Education: Enhancing the Teaching-Learning Process with an SRM System. In 5th Iberian Conference on Information Systems and Technologies, (2010)1-5. IEEE,

[12] Dell'Aquila, Carlo, Francesco Di Tria, Ezio Lefons, and Filippo Tangorra. "Business Intelligence Applications for University Decision Makers." WSEAS Transactions on Computers 7(7) (2008) 1010-1019.

[13] Aziz, Azwa Abdul, Julaily Aida Jusoh, Hasni Hassan, Wan Mohd Rizhan Wan Idris, Addy Putra MD Zulkifli, and Sharul Anuwar Mohamed Yusof. "A Framework for Educational Data Warehouse (EDW) Architecture Using Business Intelligence (BI) Technologies." Journal of Theoretical & Applied Information Technology 69(1) (2014).

[14] Aziz, Azwa Abdul, W. M. Rizhan, W. Idris, Hasni Hassan, and Julaily Aida Jusoh. Intelligent System for Personalizing Students' Academic Behaviors-A Conceptual Framework. International Journal on New Computer Architectures and Their Applications 2(1) (2012): 138-153.

[15] Izzeldin A. Elhassan Investigating the Success of Business Intelligence in Aligning Higher Education and Labor Market International Journal of Computer Trends and Technology 67.12 (2019) 62-70.

[16] Kimball, Ralph, and Margy Ross. The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling. John Wiley & Sons, 2011.

[17] Gioia, Andrea, Grazia Cazzin, and Ernesto Damiani. SpagoBI: A Distinctive Approach in Open Source Business Intelligence. In 2008 2nd IEEE International Conference on Digital Ecosystems and Technologies (2008) 592-595. IEEE.