Application of business intelligence in the quality management of higher education institutions

Y M Pérez-Pérez¹, A A Rosado-Gómez¹ and A M Puentes-Velásquez¹
¹ Grupo de Investigación en Tecnología y Desarrollo en ingenierías, Universidad Francisco de Paula Santander, Ocaña, Colombia

E-mail: ymperezp@ufpsocol.co, aarosadog@ufpsocol.co

Abstract: Business Intelligence (BI) combines tools, that supported by technology, allow to use the data generated by an organization in order to extract information that supports decision making. This paper exposes the application of BI in Higher Education Institutions focusing on administrative and academic management processes. The review links BI with its tools balanced scorecard (BSC), data mining (DM) and data warehouse (DW). Among the results, we found a relationship between the used tool and the type of process, identifying three categories: administrative management, educational quality assurance and academic performance.

1. Introduction
Making right decisions is a daily activity. As defined at [1], is a broad process that can include the evaluation of alternatives, the judgement, and the choice of one of them, obtaining consequences or results produced by each choice. Within the context of companies, the decision-making permeates the administrative functions of planning, organizing, executing and controlling; because of this reason, there are different degrees of consequences depending on the hierarchical level where they are located [2].

The educational accreditation, and in particular, higher education accreditation, is a generalized trend [3-4], with the objective that the institution obtains global recognition of the quality of its educational work [5,6].

Higher education institutions (HEI), in their academic and administrative processes, are oriented towards quality, understood as the proper management of their resources and the way they optimize the decision-making supported by indicators. This can be achieved based on the use of information, maximizing benefits, capitalizing on opportunities and gaining competitive advantage, becoming a source of knowledge for decision-making. Unless the information is organized, processed and available to the right person in a format that facilitates understanding, this becomes a burden, not a benefit [7]. This concept inherits characteristics of corporate governance in order to ensure transparency in the management and control of IT assets; through corporate governance, the effective management of IT resources is assured through IT management [7]. Therefore, senior management is increasingly involved in the implementation of IT governance frameworks to provide structure, processes and mechanisms for efficient decision making with IT support [8].

The implementation of BI strategies to denote the generation of competitiveness must be adapted to each organization [9]. Within the academic context, there are applications such as the one developed by [10], where a strategy is proposed so that the academic community can make the most of its data, obtaining as a result the design of a BI model to support the institutional self-assessment processes.
Another BI application is in the admission and enrollment area, making possible to give support to
the information extraction requirements and facilitating the analysis associated with the regulation,
behavior and evolution of these processes [11]. In the same context, the students with higher risk of
desertion [12], and work groups with similar weaknesses can be identified. For [13] “traditional systems
used in HEIs difficult the strategic analysis of information for decision making”. This review addresses
how BI has been used in the context of HEI, from the management and academic aspects.

2. Development
To apply a BI solution within any organizational context, it is necessary to decide which components to
work with, or which combination is suitable to provide a complete BI solution.

2.1. Business intelligence (BI)
According to [14], BI is the set of tools, methodologies and practices that allow analyzing, exploring
and transforming data in a way that optimizes the decision-making process, a necessary element to
continuously improve the competitiveness. BI [15], is the “key technology that allows organizations to
understand and act on the information received from, and stored in, several sources”.
Reference [16] establishes that the volume of data related to processes is rapidly growing; however,
organizations often fail to convert this data into strategic intelligence and tactics; therefore, they propose
a process analysis based on queries using BI. On the other hand, BI is currently the largest area of IT
investments in organizations and has been qualified as the technological priority by those responsible
for information technology systems (CIOs) throughout the world. This coincides with that expressed by
[17], who determined patterns of use of BI systems in organizations to help understand and plan their
BI environment. On the other hand, [18] examined the ability of BI systems to help organizations to
tackle the challenges and opportunities by proposing a general theoretical framework to understand how
organizations get value from BI systems.

In [19], they define some of the tools that can be used to do BI such as the BSC, DM, DW and on-
line analytical processing (OLAP). This research considers BSC, DM and DW.

2.1.1. Balanced scorecard (BSC). For [20], the BSC is a tool that allows describing and communicating
a strategy in a coherent and clear way, it presents a methodology of link between the company strategy
and the action. The aim of the BSC is to convert the company strategy into results by aligning it from
different perspectives: financial, processes, clients and strategic capabilities, establishing indicators
capable of offering a global vision of the organizations associated with quality control.

2.1.2. Data mining (DM). DM is defined as the non-trivial task of extracting implicit, previously-
unknown and potentially-useful information from databases [21]. According to this definition, [22]
establishes the discovery of knowledge within data warehouses.

2.1.3. Data warehouse. The Data Warehouses organize and redirect the data from the end-user view
extracting data from different applications (internal and external) [19], saving and managing historical
information, that will be presented in an understandable way to people. It requires a technological
architecture capable of understanding extraction processes, consulting and analyzing the data that
provide easy-to-interpret information.

3. Methodology
To guarantee better results in the search process, rules were defined. The first rule regarding BI, the
second rule regarding the BSC, the third rule regarding DM and finally the fourth rule regarding the DW,
all associated with higher education. For the specificity of the literature search, only one Boolean
operator was used in the rules “business intelligence AND education”, “balanced scorecard AND
education”, “data mining AND education” and “Data warehouse AND education”. The following were
also defined as specialized databases: ScienceDirect, ACM Digital Library and IEEE Computer Society, as well as Scopus as a multidisciplinary database.

3.1. Criteria for the paper inclusion and exclusion
The chosen papers were taken from the indexed scientific databases, in English; the chosen results of each rule in each database were those that fulfilled relevance, publication date and additionally, that involve research related to the application of BI in university contexts at national and international level, seeking the improvement of the management and academic processes of the universities.

As an exclusion criterion, it was defined that studies where only one of the components of the rules is used would not be taken into account.

4. Results
The search of papers in the databases yielded a total of 102 papers. Starting from this number, we eliminate the duplicates and apply the exclusion criterion, obtaining a total of 61 papers, published in the period of time from 2010 to 2017. The 61 selected papers were ordered by common categories to each search rule. In the education sector, 34.9% use DM techniques to solve specific academic problems like student desertion and academic performance for instance; secondly, 31.1% define that BI can be used to support decision-making based on three broad factors (organizational, technological and social), followed by the quality assurance with a frequency of 23.3% using the BSC and finally, the implementation of data warehouse with 10.7% but only as a support for any of the three previous categories.

4.1. Business intelligence (BI)
BI is based on knowledge [23], which is considered one of the main production resources and a source of sustainable competitive advantage [24]. Various evaluations of IES knowledge management ability levels agree that the consideration of knowledge as an asset is not clear [25], and IT does not provide adequate tools for the use of knowledge management, hindering the implementation of business intelligence practices in the education industry in order to support the process of decision-making and knowledge transfer in organizations [26], through the integration of data and methods that impact on organizational alignment [24], since factors that affect the optimal management of HEIs are similar to those that affect the company management [27]. According to [28], the real-time ability of the systems will allow universities to update themselves on market conditions and to follow trends related to the education industry.

4.2. Quality assurance
The performance evaluation of HEIs generally refers to the high educational standards issued by state and private institutions in each country [29,30], specifically the application process indicator, which is not only seen from the data obtained by universities from their information systems [31] but there is some data resulting from the process of management, adaptation and processing of institutional information, that complement the measurement, incorporating elements such as the level of understanding of the material presented by the teachers, the students’ level of interest and satisfaction, and other administrative services. Therefore, the BSC model is integrated into dynamic and holistic models [32-34] in order to monitor students [35], commercial operations [36], strategies [37], results [38], finances [39,40], user needs [41] and guarantee quality in relation to agreed objectives [42]. All the aforementioned elements coincide in the need to improve the performance of HEI [43,44].

4.3. Academic performance
DM has become a key tool for measuring academic performance [45] in the HEI, where information is manually analyzed, consuming large amounts of time becoming a disadvantage and providing the opportunity for new technologies due to its potential to analyze and describe the hidden information of the data. According to [46], the adequate analysis of the information allows to examine the behavior of
the students [47] and the educational phenomena such as the admission indicators [48], desertion [49] [50-52], learning [53], the determination of a correct program [54], the performance [55,56], obtaining results such as the relationship among failed courses by the students [57], predict whether some of them are becoming prone to deviant ideologies that can lead to terrorism [58], or automatically create student groups considering their individual learning styles [59]. All these analyses lead to providing information relevant to decision making, maximizing the generation of value [27] and contributing to the dialogue on the role of academic information systems to make decisions based on data in order to provide education according to each student’s needs [53].

4.4. Data warehouse as a support of the analysis of information
Understanding the evolution of education as a mechanism that generates information about the strength and weakness of an educational system in order to provide improvements [60], generated the need to analyze the produced data, and, at the same time, consolidate them in a data warehouse that later would allow the analysis of indicators using different techniques [61]. In this review, we took into account the DM and the BSC associated with education, obtaining that 54.5% of the reviewed papers had in common, as the first phase of the investigation, the consolidation of a data warehouse.

Finally, the relationship between the categories and the publication dates vary according to the specification of the rule. Between 2016 and 2017 a change was made in the main topic: now most articles talked about business intelligence 25%; in the same years, 24% of the papers were related to BSC and DW. The BI concept has been used for group any these techniques, this is the reason, why it shows an increase in recent years. Before 2014, the most studied topic in the articles reviewed was data mining.

5. Conclusions
This paper is focused on a literature review of research related to BI associated with education. In general, it is possible to establish a relationship with a specific category. In the case of BI, the results were oriented to administrative management, BSC-related results showed that it focused on quality assurance, DM was specifically focused on academic performance and finally, the data warehouses acted transversally in the three previous categories to support the information analysis. The literature review suggests a behavior between the research topics. It has had, between the years 2016 and 2017, a rise in relation to business intelligence; regarding BSC and data warehouses, the academic production has been maintained from 2010 to 2017 in a balanced way, but the case of DM has shown a small decline.

References
[1] Artieta Pinedo I y Gonzalez Labra M J 2005 La toma de decisiones Introducción a la Psicología del pensamiento ed González Labra M J (Madrid: Trotta) capítulo 9 pp367-407
[2] Castro F E 2013 Indicadores de gestión para la toma de decisiones basada en inteligencia de negocios Revista TIA: Tecnología, Investigación y Academia 2 87-99
[3] Acosta A 2014 Evaluación y acreditación de programas educativos en México: revisar los discursos, valorar los efectos Revista de la Educación Superior 43 151-157
[4] Tünnermann C 2008 La calidad de la educación superior y su acreditación: la experiencia centroamericana Revista de la Educación Superior 13 313-336
[5] Ugido I and Haug G 2006 La acreditación como mecanismo de garantía de la calidad: tendencias en el espacio europeo de educación superior Revista Española de Educación Comparada 12 81-112
[6] Martínez J, Tobón S and Romero A 2017 Problemáticas relacionadas con la acreditación de la calidad de la educación superior en América Latina Innovación Educativa 17 79-96
[7] Pollard C and Cater-Steel A 2009 Justifications, strategies, and critical success factors in successful ITIL implementations in US and Australian companies: an exploratory study Information systems management 26 164-175
[8] Joshi A, Bollen L, Hassink H, De Haes S and Van Grembergen W 2018 Explaining IT governance disclosure through the constructs of IT governance maturity and IT strategic role Information & Management 55 368-380
[9] Tello E and Velasco J 2016 Inteligencia de negocios: estrategia para el desarrollo de competitividad en
empresas de base tecnológica. Contaduría y administración 61 127-158
[10] Camargo-Vega J, Joyanes-Aguilar L and Giraldo-Marín L 2016 La inteligencia de negocios como una herramienta en la gestión académica-Business intelligence as a tool in academic management Revista Científica 24 110-120
[11] Fuentes L and Valdivia R 2010 Incorporación de elementos de inteligencia de negocios en el proceso de admisión y matrícula de una universidad chilena Revista chilena de ingeniería 18 383-394
[12] Galindo A and García H 2010 Minería de datos en la educación (España: Universidad Carlos III) pp 1-8
[13] Rosado A 2016 Consolidación de indicadores institucionales usando bodega de datos Revista Ingenio UFPSO 11 53-63
[14] Cano J 2007 Business intelligence: Competir con información (Madrid: Fundación Banesto)
[15] Parrilla J 2014 Cómo hacer inteligente su negocio: Business intelligence a su alcance (México: Grupo Editorial Patria)
[16] Polyvyanyy O, Ouyang C, Barros A and van der Aalst W 2017 Process querying: enabling business intelligence through query-based process analytics Decision Support Systems 100 41-56
[17] Arnott D, Lizama F and Song Y 2017 Patterns of business intelligence systems use in organizations Decision Support Systems 97 58-68
[18] Trieu V 2017 Getting value from business intelligence systems: A review and research agenda Decision Support Systems 93 111-24
[19] Rosado A and Rico D 2010 Inteligencia de negocios: Estado del arte Scientia et Technica 16 321-326
[20] Kaplan R and Norton D 2001 Transforming the balanced scorecard from performance measurement to strategic management: part I Accounting Horizons 15 87-104
[21] Frawley W, Piatetsky-Shapiro G and Matheus C 1992 Knowledge discovery in databases: An overview AI Magazine 13 57-70
[22] Jia-Wei H, Jian P and Xi-Feng Y 2004 From sequential pattern mining to structured pattern mining: A pattern-growth approach Comput SCI & Technol 19 257-274
[23] Petrova G, Smokotin V, Kornienko A, Ershova I and Kachalov N 2015 Knowledge management as a strategy for the administration of education in the research university Procedia-Social and Behavioral Sciences 166 451-455
[24] Hartl K, Jacob O, Mbp B, Budree A and Fourie L 2016 The impact of business intelligence on corporate performance management 49th Hawaii International Conference on System Sciences (USA: IEEE)
[25] Demchig B 2015 Knowledge Management Capability Level Assessment of the higher education institutions: Case study from mongolia Procedia-Social and Behavioral Sciences 174 3633-3640
[26] Moscoso-Zea O and Lujan-Mora S 2017 Metodologías sugeridas de evaluación y selección de software de arquitectura empresarial para la digitalización del conocimiento Enfoque UTE 7 315-328
[27] Njenga J, Rodello I, Hartl K and Jacob O 2017 Identifying opportunities and challenges for adding value to decision-making in higher education through academic analytics Advances in Intelligent Systems and Computing (Switzerland: Springer)
[28] Praxine D and Stylianou E 2017 Business Intelligence in a higher educational institution: the case of University of Nicosia IEEE Global Engineering Education Conference (EDUCON) (Greece: IEEE)
[29] Akbar R and Anshary M 2017 Model and prototype application performance measurement based on collaboration of higher education standards Advanced Science Letters 23 2354-2357
[30] Del Sordo C, Orelli R, Padovani E and Gardini S 2012 Assessing global performance in universities: an application of balanced scorecard Procedia-Social and Behavioral Sciences 46 4793–4797
[31] Al-Hosaini F and Sofian S A 2015 Review of Balanced Scorecard Framework in Higher Education Institution (HEIs) International Review of Management and Marketing 5 26-35
[32] Hawari N and Tahar R 2015 Microworlds of the dynamic balanced scorecard for University (DBSC-UNI) AIP Conference Proceedings 1691 030009
[33] Wu M, Nurhadi D and Zahro S 2016 Integrating the talent management program as a new concept to develop a sustainable human resource at higher educational institutions Journal of Organizational Innovation 8 146-60
[34] Nupap S 2016 Knowledge management system for Thai small and medium-sized enterprises Int. J. Innovation and Learning 19 2
[35] Cardoso E, Santos D, Costa D, Caçador F, Antunes A and Ramos R 2017 Learning scorecard: Monitor and foster student learning through gamification Lecture Notes in Computer Science Book Series 10180
[36] Rammansamy N, Rajesh R, Pugazhendhi S and Ganesh K 2016 Development of a hybrid BSC-AHP model for institutions in higher education Int. J. Enterprise Network Management 7 1
[37] Hladchenko M 2015 Balanced Scorecard—A strategic management system of the higher education institution International Journal of Educational Management 4 167

[38] Al-Ashaab A, Flores M, Doultsinou A and Magyar A 2011 Un cuadro de mando integral para medir el impacto de la colaboración industria-universidad Production Planning & Control 22 554-570

[39] Kádárová J, Durrkárová M and Lenka K 2014 Balanced Scorecard as an issue taught in the field of industrial engineering Procedia Social and Behavioral Sciences 143 174-179

[40] Yüksel H and Coşkon A 2013 Strategy focused schools: An implementation of the balanced scorecard in provision of educational services Procedia-Social and Behavioral Sciences 106 2450-2459

[41] Khalid S, Kouzni Z, Tanane O and Talbi M 2014 Marcador equilibrado, la herramienta de rendimiento en la educación superior: establecimiento de indicadores de rendimiento Procedimientos sociales y del comportamiento 116 4552-4558

[42] Chalaris M, Gritzalis S, Maragoudakis M, Sgouropoulou C and Tsolakidis A 2014 Mejorando la calidad de los procesos educativos proporcionando nuevos conocimientos usando técnicas de minería de datos Procedia-Ciencias sociales y del comportamiento 147 390-397

[43] Özyeşirmici R, Yücenursen M, Apak İ and Polat Y 2015 A comparative analysis of accounting education’s effectiveness with the balanced scorecard method: A case study of KMU Procedia-Social and Behavioral Sciences 174 1849-1858

[44] De-Andrade-Guerra J, Garcia J, de-Andrade-Lima M, Barbosa S, Heerd M and Berchin I 2018 A proposal of a balanced scorecard for an environmental education program at universities Journal of Cleaner Production 172 1674–1690

[45] Pineda-Báez C, BERMúdez-Aponte J, Rubiano-Bello A, Pava-Garcia N, Suárez-Garcia R and Cruz-Becerra F 2014 Compromiso estudiantil y desempeño académico en el contexto universitario Relieve 20 1-20

[46] Khadijiah M and Tasir Z 2013 Educational data mining: A review Procedia. Soc. Behav. Sci. 97 320-324

[47] Casto M and Lizasoain L 2012 Las técnicas de modelización estadística en la investigación educativa: minería de datos, modelos de ecuaciones estructurales y modelos jerárquicos lineales Revista Española de Pedagogía 70 131-148

[48] Al-Twiiri M and Noaman A 2015 A new data mining model adopted for higher institutions Procedia Computer Science 65 836-844

[49] Kaur P, Singh M and Singh G 2015 Classification and prediction based data mining algorithms to predict slow learners in education sector Procedia Computer Science 57 500-508

[50] Miranda M and Guzmán J 2017 Análisis de la deserción de estudiantes universitarios usando técnicas de minería de datos Formación Universitaria 10 61-68

[51] Treviño M, Ibarra S, Castán J, Laria J and Guzmán J 2013 A framework to avoid scholar desertion using artificial intelligence Proceedings of the World Congress on Engineering vol III (London: International Association of Engineers) pp 1493-1497

[52] Timárán R, Calderón A and Jiménez J 2013 Descubrimiento de perfiles de deserción estudiantil con técnicas de minería de datos Revista Vínculos 10 1

[53] Villegas-Ch W and Luján-Mora S 2017 Analysis of data mining techniques applied to LMS for personalized education IEEE World Engineering Education Conference (EDUNINE) (Brazil: IEEE)

[54] Abdullah Z, Herawan T, Ahmad N and Deris M 2011 Mining significant association rules from educational data using critical relative support approach Procedia-Social and Behavioral Sciences 28 97-101

[55] Peral J, Maté A and Marco M 2017 Application of data mining techniques to identify relevant key performance indicators Computer Standards & Interfaces 54 76-85

[56] Asif R, Merceron A, Ali S and Haider N 2017 Analyzing undergraduate students' performance using educational data mining Computers & Education 113 177-194

[57] Buldu A and Üçgün K 2010 Data mining application on students' data Procedia-Social and Behavioral Sciences 2 5251-5259

[58] Kim Y and Ahn J 2016 A study on the application of big data to the korean college education system Procedia Computer Science 91 855-861

[59] Costaguta R and de los Angeles M 2014 An assistant agent for group formation in CSCL based on student learning styles Proceedings of the 7th Euro American Conference on Telematics and Information Systems (EATIS) (Valparaiso, Chile: ACM)

[60] Ramos T, Machado J and Cordeiro B 2015 Primary education evaluation in Brazil using big data and cluster analysis Procedia Computer Science 55 1031-1039

[61] Figlio D, Karbowinski K and Salvanes K 2016 Education research and administrative data Handbook of the Economics of Education vol 5 ed E A Hanushek et al (Amsterdam: Elsevier B.V.) chapter 2 pp 75-138