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

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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 address 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.

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