Roadmap for Implementing Business Intelligence Systems in Higher Education Institutions: Exploratory Work

Nuno Sequeira[1][a], Arsénio Reis[1,3][b], Frederico Branco[1,3][c] and Paulo Alves[2][d]
[1]*School of Science and Technology, University of Trás-os-Montes and Alto Douro, Quinta dos Prados, Vila Real, Portugal*
[2]*Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Bragança, Portugal*
[3]*INESC TEC - Institute for Systems and Computer Engineering, Technology and Science, Porto, Portugal*

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Abstract: Higher Education Institutions must define and monitor strategies and policies essential for decision-making in their various areas and levels, in which Business Intelligence plays a leading role. This research addresses the problem of Business Intelligence system adoption in Higher Education Institutions, with a view, in the first instance, to identify and characterise the strategic objectives that underpin decision-making, activities, processes, indicators and information in Higher Education Institutions. After a literature review, it was found that the absence of a roadmap that can serve as a reference to implement a Business Intelligence system in Higher Education Institutions may limit the adoption of this type of solution. Therefore, this research intends to present the methodology of a proposed roadmap for the implementation of Business Intelligence systems in Higher Education Institutions, that allows for increasing its capacity for analysis and evaluation of the data and information available in the various systems and platforms.

1 INTRODUCTION

Higher Education Institutions make decisions in several domains, namely strategic and internal management, without using systematised data that support these decisions, which may jeopardise the success of their actions or even their efficiency. The HEIs are characterized by having different specificities in their mission and management strategies (Nieto et al., 2019). Nevertheless, they all need clear and concise strategies that allow them to create more value and follow through on their vision (Valdez et al., 2017). On the other hand, HEIs need relevant information to monitor their performance, according to the goals established in their strategic plans (Calitz et al., 2018).

The challenges Higher Education Institutions (HEI) face today are notorious, especially with increased competition in the higher education sector. Thus, there is a need on the part of HEIs to achieve better decision-making in all their areas and levels (Sanchez-Puchol et al., 2017; Scholtz et al., 2018; Valdez et al., 2017). In this way, HEIs are increasingly committed to ensuring a better quality of their services and an increase in the degree of satisfaction of their students, as these are two important differentiation factors that can be decisive for their sustainability (Calitz et al., 2018). Thus, HEIs assume today an essential role in promoting their internal change towards sustainable development models, involving the main areas of activity of HEIs, such as teaching, research, operational management and extension. On the other hand, another major challenge that should not be disregarded is to holistically involve all activities of HEIs that are inherent to their sustainability (Yáñez et al., 2019). The decision-making activity can be defined as a management process to frame a specific situation in which it is necessary to make a decision. By defining a decision model consisting of a set of

[a] https://orcid.org/0000-0002-9733-1097
[b] https://orcid.org/0000-0002-9818-7090
[c] https://orcid.org/0000-0001-8434-4887
[d] https://orcid.org/0000-0002-0100-8691

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actions and evaluation criteria, it is possible to select the most appropriate action flow and acquire learning from the decision-making process (Mora et al., 2017).

The organisational culture of an HEI is a vital aspect to consider, as it influences decision-making and the processes implemented to ensure the efficiency of the HEI's activity, taking into account the established strategy or goals (Deja, 2019). HEIs make their decisions according to their institutional priorities, strategies, goals and allocation of resources, ensured by different officials with governance functions (Nieto et al., 2019).

Information Systems (IS) play a key role in the management of HEIs, supporting their activities and decision-making processes. Although, the IS must be developed according to the HEIs' needs, and there should be an integration of the various IS and Information Technologies (IT), to enable better access and processing of information. To Bessa et al. (2016), the IS have a class called Decision Support Systems (DSS) that is oriented to this purpose, particularly concerning the tactical and strategic levels, with analytical specificities that allow the creation of knowledge and organizational intelligence. Although the DSS capacity to support decision-making is recognized, the degree of complexity required, with the need to involve all the HEI's IS, leads to the adoption of Business Intelligence (BI) systems. A BI solution consists of a data-driven DSS that supports a set of operations such as historical data querying, summary reporting, executive reporting, Online Analytical Processing (OLAP) and BI systems (Tripathi et al., 2020).

This paper is organised into sections as follows: the first section presents the problem and highlights the contribution and motivation for this work. The second section describes the related work and then shows the preliminary view of the roadmap to aim for. Finally, current and future work is mentioned, followed by acknowledgements and the list of all bibliographical references used for this research.

1.1 Contribution

This position paper presents the methodology of a roadmap that can serve as a reference to implement a BI system in HEIs, to support decision-making in their various areas and levels, taking into account the following dimensions of the HEIs' activities: teaching, research, internationalisation and extension. The roadmap will include a set of dashboards for decision support and a BI system reference architecture, scientifically validated through a review of state of art and an expert panel.

The research methodology to be used is Design Science Research (DSR) with recurring cycles of design, demonstration and evaluation, intending to improve the artefact's usefulness concerning the identified problem (Paul et al., 2021).

Finally, the results of this research will be communicated to determine if the proposed methodology allows aims a roadmap that enables the improvement of the HEI decision quality.

1.2 Motivation

Often, decision-making in HEIs is carried out without specific data or analysis (Nieto et al., 2019). Thus, our starting point begins with the systematised presentation of how HEIs are using the data generated by their various IS in decision-making, as well as analysing to what extent modern IS that simplify an entire process of exchange, access and use of data, information and knowledge, could be decisive for good institutional performance.

An HEI can collect relevant performance indicators through the data generated by its IT structures, which may enable the ascertainment of certain events in its internal management (Al-Rahmi et al., 2019). Early dropout identification is one of these cases, consisting, inclusively, of a phenomenon quite common and worrying for HEIs (Maldonado et al., 2021).

Decision-making in planning the activities of an HEI is a rather complex process since the data they are based on are in large quantities and are scattered across several sources, making it difficult to analyse them (Perez-Castillo et al., 2019). Nowadays, accurate information and data represent a substantial competitive advantage. When appropriate, the implementation and exploitation of IS may be the basis for the success of a sustainable strategy at the management level (Stojkic et al., 2020).

The advances verified in the integration of IT, namely BI, have been determinant in the evolution of HEIs, allowing decision-making based on data analysis to be a constant reality today (Ain et al., 2019; Scholtz et al., 2018; Viberg et al., 2018). BI is dependent on processes related to data quality management and classification and the definition of processes (Zavale et al., 2017). BI tools and technologies have followed this evolution, as a way to respond to the greater complexity of organisational requirements and decision-making. In addition, the lack of specific data mining tools to deal with unstructured data has leveraged the use of BI (Calitz et al., 2018). Following this, it can be considered that BI can take advantage of the various information

generated to provide more efficient answers (Jalil & Hwang, 2019), improving the capacity to handle the data generated and the quality of the information obtained, thus significantly supporting HEIs in their decision-making (Bordeleau et al., 2018; Calitz et al., 2018; Sorour et al., 2020a). However, the implementation of a BI system requires an adequate infrastructure, as well as the identification of operational indicators to measure it, to ascertain the conditions under which the HEI is to implement a BI system (Jahantigh et al., 2019). Thus, HEIs need to find the best way to implement BI systems and maximise their benefits (Ain et al., 2019; Jalil & Hwang, 2019). Although, these benefits can only be achieved if a BI system is implemented properly (Musa et al., 2019).

The literature review that we are conducting, allowed us to conclude that there is space for developing research in this area since it was possible to identify several studies on the use of BI in HEIs, although there is a need to define a roadmap for the implementation of BI systems that can serve as a reference for HEIs.

2 RELATED RESEARCH WORK

This section presents a set of analyses that result from the exploration of several studies that address the use of BI solutions in HEIs. Although multiple cases were found, the following studies provide the best support for the work in progress.

The authors Combita Niño et al. (2020) created a BI governance framework which aims to take advantage of data generated by the HEI to obtain patterns and forecasts that are important in formulating strategies. An HEI was used as a case study to be easily replicated in other HEIs, and a diagnosis was carried out to identify the level of maturity in analytics. On this basis, a decision-making model was designed to strengthen organisational culture, infrastructure, data management, data analysis and governance, which includes defining a governance framework, guiding principles, strategies, policies, processes, decision-making bodies and functions. The framework aims to implement adequate controls that ensure the success of BI projects, as well as enable an alignment of the objectives of the development plan with the analytical vision of the HEI.

Several frameworks enable the monitoring of quality assurance in HEIs. Sorour et al. (2020b) identified five frameworks with differentiated orientations and perspectives. However, all of their support uses data to measure the performance of HEIs. There is a consensus that BI tools, such as dashboards, can help provide real-time information about the quality assurance performance in HEIs.

Morais and Lopes (2019) describe the implementation of a BI solution in a HEI, which aims to support its quality system and improve its future strategy based on the HEI's area of activity: Teaching and Learning. The project contemplated several stages: mission, strategy and process analysis, Key Performance Indicator (KPI) identification, KPI validation by the process managers, identification of the IS in use at the HEI, identification of the existence of necessary information in these systems, the definition of the access profiles, according to the different process users and the BI system selection and implementation. As a result, it was possible to obtain valuable dashboards for management and identify potential improvements for the quality assurance mechanisms, which should simplify the continuous improvement process of HEIs (Morais & Lopes, 2019).

HEIs need tools for effective academic analysis, which requires a systematic and balanced process for collecting, synthesising and assessing relevant data. To support the accreditation process of HEIs, Ortiz and Hallo (2019) presented an analytical data mart to obtain adequate information for its rapid interpretation and management and to avoid the dispersion of the data required for the respective accreditation. The solution was developed through a BI tool, taking into account the student criterion indicators according to an institutional evaluation model, allowing the efficient monitoring of indicators before university accreditation, reducing response time and resources in the report generation process.

Al Rashdi and Nair (2017) created a BI framework implemented in an HEI to collect helpful information through the big data generated by the HEI. The framework was tested within the critical business activities, teaching and learning, and the results show that the aggregation of these activities and KPIs contributes to the overall performance of the HEI, even allowing a better perception of the operationality of the HEI.

3 BUSINESS INTELLIGENCE SYSTEMS

IS have a central role in HEI management, supporting their activities and decision-making processes. IS have a class called Decision Support Systems (DSS)

that is oriented to this objective, namely at the tactical and strategic levels, with analytical features that allow the creation of knowledge and organizational intelligence. Although the DSS capacity to support decision-making is recognized, the degree of complexity required, with the need to involve all the HEI's IS, leads to the adoption of BI systems (Bessa et al., 2016). Given the fact that HEIs have difficulty leveraging their data and that their success depends on accurate, fact-based decisions, BI can simplify the decision-making process through the information that is commonly produced by HEIs daily. (Jalil & Hwang, 2019; Dadkhaha et al., 2019).

To enable the implementation of a BI system, it becomes essential to design a plan consisting of a roadmap, an architecture and some guidelines (Mishra & Pani, 2021). Several studies similarly present the architecture of a BI system. In general, and as can be seen in Figure 1, for Sorour et al. (2020a) and Boulila et al. (2018) a BI architecture in HEIs comprises three main layers or components: 1) data source layer: in which data are collected from different sources; 2) Extract Transform Load (ETL) process layer: extraction, transformation and loading, in which there is the collection of relevant data for analysis, and then they are loaded into a data warehouse, which stores the data for analysis; 3) data presentation layer: dashboards are used to present analysis in a synthesised form, although they can be detailed to enable better decision-making assistance when reviewing objectives and monitoring HEI KPIs.

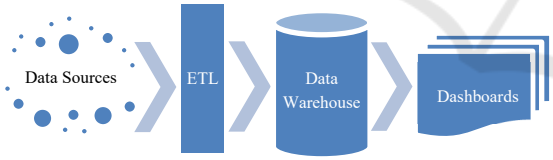

Figure 1: Business Intelligence Architecture. Adapted from Boulila et al. (2018) and Sorour et al. (2020a).

In this sense, the architecture is a guideline for developing the roadmap (Ma et al., 2018). A roadmap can be considered an established concept regarding knowledge management, aiming at collecting knowledge and obtaining solutions to problems in a structured way (Johannsen, 2020). On the other hand, a roadmap can be used as a guide for developing a strategy (Mishra & Pani, 2021), in this case, responsible for presenting the processes required for implementing a BI system in HEIs (Chofreh et al., 2018). According to Bhushan and Rai, cited by Ebrahimi et al. (2018), the strategic decision-making process can be categorised into seven steps, as presented in Figure 2.

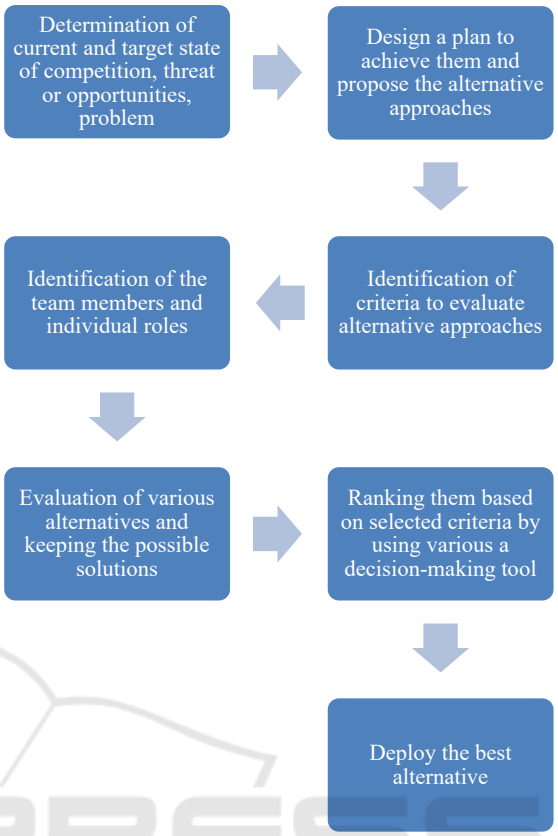

Figure 2: Strategic decision-making process. Adapted from Ebrahimi et al. (2018).

Although some studies are carried out on BI in HEIs, BI has progressed along two paths, theoretical and practical. Most studies on BI aim to describe the advantages of its usage, and there is little research on BI implementation (Jahantigh et al., 2019). Ain et al. (2019) reinforce this position by finding in their research that previous studies do not comprehensively discuss the issues and challenges related to the adoption, use, and success of BI systems. In our research, it was not possible to find any reference regarding creating a roadmap for implementing BI systems in HEIs. Despite this, it is perceptible that the development of a BI system consists of a progressive process in which it is possible to identify the various stages that should constitute a roadmap, aiming at the use of BI to support the decision-making process of HEIs (Gastaldi et al., 2018).

We found that it is essential to take some steps before implementing a BI system. In the first place, it is necessary to assess whether the HEI is prepared from the technical point of view, as well as from the management point of view, and it is vital to have clear support from its management. According to Jahantigh

et al. (2019), there are two predominant factors to determine the quality of BI support management: the familiarity of those responsible with IT and the relevance of the information presented. In addition, the compatibility of the systems with the BI application must be ensured (Jalil & Hwang, 2019), and the BI solution should have the ability to manage technological assets, people and processes (Moscoso-Zea et al., 2019). Before a BI architecture is implemented, all the data stored by HEIs from their various sources must be integrated into a data warehouse by applying the ETL process.

After the development of the data warehouse, different servers can efficiently access their data through front-end applications (Dadkhaha et al., 2019). Thus, it is essential to identify all data sources that should be subject to analysis. Only then is the respective data selection performed to ensure that the BI process assures reliable results. This process involves a data dictionary, which consists of a technical description for one of the HEI repositories, in which the data fields, origin, availability and responsible party are recorded. Through the information collected from the data sources and dictionaries, it will be possible to identify the variables that will guide the operation of the BI system (Villegas-Ch et al., 2020). Given the amount and diversity of this data, it is necessary to extract the related data before proceeding with the execution of the respective query.

Finally, the BI solution must be able to present the data appropriately and within an appropriate period, for which dashboards should be used, their integration being ensured through the data warehouse that has quality data. A generic BI system should integrate data from different sources to be subsequently transferred. Another option is integrating data presentation applications with the data mining tool (Villegas-Ch et al., 2020). In addition to the data warehouse, a diverse range of tools and techniques can support HEIs in developing BI capabilities, such as Enterprise Resource Planning (ERP) systems, document management systems, and knowledge repositories, among others. The data considered are grouped in data marts, from which the data is accessed through applications that create customised visualisations. Thus, it becomes essential to mention that HEIs should seek the right balance between standardisation and customisation of BI. Being necessary to standardise the memory of HEIs and the integration of information, although, as previously referenced, one can customise the creation and presentation of insights (Calitz et al., 2018).

4 FUTURE WORK

Our research aims to verify whether, through the proposed methodology, it will be possible to define a roadmap to facilitate data processing and the detection of trends and patterns, and thus obtain an adequate visual representation that allows HEIs to make decisions based on concrete data. Thus, our research will consist of the following steps: to review BI systems in HEIs; to identify and characterize the strategic objectives that underlie decision-making, activities, processes, and information in HEIs; to identify and characterize the computer systems that support HEIs; to propose a set of dashboards to support decision-making in HEIs; to propose a BI system architecture of reference, and, finally, to propose the implementation roadmap.

We are currently developing a literature review, according to the protocol proposed by Kitchenham and Charters (2007), aimed at identifying other academic contributions which have scientific validation regarding the main areas of interest addressed in this research, mainly, regarding the application of BI in HEIs. Thus, this literature review aims to identify and characterise the strategic objectives that underlie decision-making, the activities, the processes and the information of the HEIs, to obtain a perspective of the use of data and information that HEIs produce, as well as their use in obtaining knowledge and intelligence, to support decision-making processes. As far as decision-making processes are concerned, the aim is to identify and characterise the HEIs' processes in general, in terms of areas, levels, actors and decision-making points. It is also intended to identify and characterise the typologies of computer systems used in the HEIs, the processes they support and the information they own, as well as to identify a BI system reference architecture. In the next phase, it is intended to carry out a set of individual semi-structured interviews with a range of a Portuguese HEI managers to find out how this HEI is using the data generated by its various IS in decision-making, intending to identify the characteristic processes of an HEI, mainly the tactical planning processes, as well as identify the information required for each process. It is also intended that these interviews can complement the literature review to identify and describe the characteristic processes of an HEI, as well as the respective performance indicators, which can serve as a basis for the definition and development of the roadmap proposal.

Next, a set of dashboards for decision support will be defined, based on the processes, decision points,

and actors, among others, previously identified and characterised. The next phase consists of the proposal of a BI system reference architecture, showing the various elements of the system, the relationships among them and the information flow and processing, from the sources to the dashboards, to then design the final design of the reference roadmap, in the form of project template, for the implementation of a BI in an HEI.

In the last stage, our roadmap proposal will be scientifically validated through interviews, which will be performed with a set of specialists of that HEI to verify if the roadmap satisfies the proposed requirements and helps to solve the specified problem. In this sense, a questionnaire will be developed to perform the validation based on previous studies and recommendations of Pestana et al. (2018) and Apandi and Arshah (2016). The interviews will be divided into three phases: presentation of the research and demonstration of the dashboards; testing of the dashboards by the experts; and finally, answers to the questions by the experts.

The results obtained be communicated to ascertain whether the proposed dashboards and architecture allow the improvement of the quality of the HEI's decision, the follow-up of their strategic axes, and the prediction of abnormal situations, among other actions. In summary, it will be verified if the proposed roadmap can serve as a reference for HEIs, and some considerations can be presented so that HEIs can adopt it in their strategies.

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