A SYSTEMATIC REVIEW ON THE IMPLEMENTATION OF BUSINESS INTELLIGENCE AT FEDERAL UNIVERSITIES

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ABSTRACT
Institutions (companies or organizations) due to the high level of complexity of their processes and the need to expand competitive advantages make use of Management Information Systems (MIS) to give their managers correct and immediate information for decision-making. Specifically, federal universities, that search for other objectives (quality, efficiency in their final area - education) also depend on these same MIS to achieve their management objectives. However, the lack of data systematization, lack of systems models, and a wide and complex decision-making structure make these institutions have difficulties in presenting their information correctly, unified, and standardized. From this context, this paper presents a Systematic Literature Review (SLR) on the implementation process of Business Intelligence (BI) in federal institutions of education with the premise of characterizing the information model contained in these institutions. As a methodology, a Systematic Review was established with an emphasis on three aspects: delimitation of the theme; review protocol and conducting the review. The results obtained in the analysis point towards the use of Big Data and Data Mining to support decision-making.

KEYWORDS
Business Intelligence, Information Systems, Decision-Making, Big Data, Data Mining

1. INTRODUCTION
In the current context of organizations in a highly competitive scenario, the decision-making process happens all the time and in different sectors within an institution. However, to ensure the right decisions within a business, a crucial factor is to obtain accurate information at the right time. To assist in this purpose, one of the technologies used is the Management Information Systems (MIS).

Such technologies, according to (Oliveira, 2008), allow managers to obtain, in a dynamic and practical way, the necessary information to support the decisions that guide the institutions, in internal administrative matters; in sales strategies; or other areas that need more accurate management of indicators. The same author reinforces that management information systems become indispensable because, in most companies that use computerized systems, there is a lot of data available, but this data alone cannot be used in the decision-making process without first going through a process of conversion, transformation, making them effectively become information. It is at this stage where management information systems work, compiling these data sets into processed information.

In the public sector, according to (Barros, 2016), information management is usually more complex, as the strategies are not intended to obtain competitive advantages over competitors or seek to maximize their profits, but rather, the quality, efficiency, and consequently, accountability for those who are under (community) and/or under its jurisdiction (control bodies). Furthermore, paraphrasing the same author, there are still several factors in government organizations that hinder the agility of information, such as changes in governments, with new policies and lines of action, and naturally, the already common budget restrictions.

Bearing in mind these inherent barriers to the public sector, it is still necessary to take into account that the Information Systems used by public institutions do not always comply with recommended practices to ensure greater data quality and, consequently, efficiency in the generation of information, such as: Integrated
IT; a suitable tool for data processing; standardization; investments and efforts in the area (Oliveira, 2008). And these peculiarities come down to the problem of this research, the lack of systematization of data from federal educational institutions, making it difficult to make strategic decisions in administrative and/or academic management.

Public bodies described as federal educational institutions or related entities (In Brazil), by decrees (MEC, 2021) are classified into: a) Federal Technological Education Centers (6 units); b) Universities Foundations (2 units); c) Federal University Foundations (26 units); d) Federal Institutes (38 units), and e) Federal Universities (44 units). Of interest to this research, the Federal Centers and Institutes are excluded from the previous list, the others, which are also designated as IFES (Federal Institutions of Higher Education) according to their body (ANDIFES - National Association of Directors of IFES - (ANDIFES, 2021)) of congregation and representation. These bodies (institutions) have specificity in structuring their information, not having a single model of management information system. In these, each chooses a model or a version of a more widespread system model. This lack of standardization arises from the very dynamics of the structures resulting from the university's own guiding documents (INEP, 2021) (bylaws, regulations, Institutional Development Plan, and others). These documents establish in their organizational structures peculiar forms according to the understanding of their members or participants, without differing from other institutions in the legal and formal scope, but sufficiently different to require specific informational systems.

In addition to these characteristics, the federal university (a term that will be generalized in this research) as an agency linked to the Federal Government makes use of specific systems at the federal level, called Structuring/Structuring Systems (SIAFI, SIASG, SIORG, and others) of the Public Administration (Estruturadores, 2019) which are modular systems that do not always connect and also do not interact causing, in most cases, the need to create data redundancy to supply them.

That said, (Barros, 2016) states that it is important that there is a single information system that involves and enables interaction between the academic and administrative areas. This is because, at the federal university, new situations are always emerging, and an organized and updated system is increasingly necessary to meet demands in the administrative and academic spheres, in short, so that professors, technicians, students, and the whole society have access to all information needed.

Given this context, on the premise that it is natural for the institution to adapt to systems that communicate with other levels of government and considering the impossibility of exchanging all Structuring Systems for a single Information System model, the proposal of this research arises from a Systematic Literature Review that points to some paths that will be presented in the Analysis and Conclusions section.

2. METHODOLOGY

The method used to carry out this SLR was approached by (Kitchenham, 2004), highlighting the phases for implementing a review in these terms that include: a) Delimitation of the Theme; b) Review Protocol; c) Conducting the Review. The strategy was chosen to guarantee the researcher the quality of the results obtained during the process, and the reassessment until it is approved. The theme in its raw state was refined from the first results of the searches, allowing the authors, through an incremental/spiral method, to clearly obtain the object of study, the related problem, and mainly, the area of the solution. Therefore, the delimitation of the theme is already the result of the analysis of the Systematic Literature Review, giving it a broader aspect than a mapping. Also, the review protocol presented in this research is the latest version that allowed the authors to conclude the contribution they could make to the method based on the analysis of the results found in the data extraction. And they present the research questions, the search strategy, the quality criteria, and inclusion/exclusion criteria.

2.1 Research Questions

In Table 1, four research questions were defined, which aim to guide the main hypotheses.
Table 1. Definition of Research Questions

<table>
<thead>
<tr>
<th>Identification</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>What are the main difficulties encountered in implementing BI in universities?</td>
</tr>
<tr>
<td>Q2</td>
<td>May the use of technologies such as BI be a means of facilitating decision-making in an academic environment?</td>
</tr>
<tr>
<td>Q3</td>
<td>Is the lack of systematization, standardization, and organization of data from universities and/or public higher education institutions an obstacle in the generation of data/information?</td>
</tr>
<tr>
<td>Q4</td>
<td>May the use of Data Mining and Big Data minimize the difficulties of managing data and information when used in conjunction with BI?</td>
</tr>
</tbody>
</table>

2.2 Search Strategy

At this stage, three classifications were defined for the composition of the search strategies: Research source; Search Terms, and Search Strings. Table 2 summarizes this structure. And Table 3 presents a classification of terms according to specific criteria that allow validating the research questions.

Table 2. Search Sources and Strings

<table>
<thead>
<tr>
<th>Search Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Sources</td>
<td>Banco de Teses e Dissertações; ACM Digital Library; IEEE Xplore</td>
</tr>
</tbody>
</table>

Table 3. Classification of Research Questions

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Term</th>
<th>Synonym/Similar</th>
<th>Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Universidades</td>
<td>Academic Environment Higher education institutions Non-standard Data</td>
<td>Universities</td>
</tr>
<tr>
<td>Intervention</td>
<td>Business Intelligence</td>
<td>Data Mining Big Data</td>
<td>Data Mining</td>
</tr>
<tr>
<td>Context</td>
<td>Tomada de Decisão</td>
<td>Data/Information Management</td>
<td>Decision-Making</td>
</tr>
<tr>
<td>Comparison</td>
<td>Impactos</td>
<td>Contributions</td>
<td>Impacts</td>
</tr>
<tr>
<td>Results</td>
<td>Processo de Facilitar</td>
<td>Minimize the Difficulties</td>
<td>Improvement</td>
</tr>
</tbody>
</table>

2.3 Inclusion and Exclusion Criteria

In order to have previously defined, based on the results found, fundamentals to include or exclude an article from the research, inclusion and exclusion criteria were defined, represented in Tables 4 and 5.

Table 4. Classification of Inclusion Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1</td>
<td>Articles that include Business Intelligence</td>
</tr>
<tr>
<td>IC2</td>
<td>Articles that have at least the abstract available</td>
</tr>
<tr>
<td>IC3</td>
<td>Articles in which the year of publication is after 2015</td>
</tr>
<tr>
<td>IC4</td>
<td>Articles in which the “population” is companies/universities or similar</td>
</tr>
</tbody>
</table>
Table 5. Classification of Exclusion Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC1</td>
<td>Articles in the abstract or expanded summary (short paper) format</td>
</tr>
<tr>
<td>EC2</td>
<td>Articles without full version available for web access</td>
</tr>
<tr>
<td>EC3</td>
<td>Articles in languages other than Portuguese and English.</td>
</tr>
<tr>
<td>EC4</td>
<td>Duplicate articles</td>
</tr>
</tbody>
</table>

2.4 Quality Criteria

At this stage of the design, a methodology was established to carry out the quality analysis of the articles. For this, four criteria and scores from 1 to 5 were stipulated, where the objective is to assess whether the work contemplates them or not. It is also important to emphasize that the proposal is not to compare the works themselves, but to verify their importance for the theme proposed in this systematic review.

Listed below are the criteria and their respective definitions:

1. **Presentation**: How the researcher presents his study including the planning that was used
2. **Methodology**: Quality related to how the work was prepared and conducted
3. **Validation**: How the analysis was performed, and the metrics used to achieve the results
4. **Survey Question**: Application of the question or research question

2.5 Conducting the Review

The pre-established research method was applied to identify potential articles related to the theme of this systematic review. Initially, 391 articles were retrieved, 28 from the main Theses and Dissertations Banks (Brazilian Library of Theses and Dissertations), 231 from ACM DL, and 132 from IEEE Xplore. Subsequently, the title, abstract, and keywords of the recovered works were read. At this stage, 356 articles were excluded and 35 were included. Finally, the inclusion and exclusion criteria were applied. At this stage, another 13 articles were excluded. The result is presented below:

Table 6. Data Extraction Results

<table>
<thead>
<tr>
<th>Research Sources</th>
<th>Initial Results</th>
<th>Excluded</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banco de Teses e Dissertações</td>
<td>28</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>ACM Digital Library</td>
<td>231</td>
<td>221</td>
<td>10</td>
</tr>
<tr>
<td>IEEE Xplore</td>
<td>132</td>
<td>124</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>391</td>
<td>369</td>
<td>22</td>
</tr>
</tbody>
</table>

3. ANALYSIS

**Q1 - What are the main difficulties encountered in implementing BI in universities?**

Among the main difficulties observed in the implementation of Business Intelligence in universities, one is the organizational culture. This problem was directly cited by (Santos, 2017) and (Apraxine & Stylianou, 2017), the authors argue that it is important to take into account the data at the time of decision-making and not base it only on intuitions. Therefore, other impasses could also be overcome with the change in the institution's culture, it must embrace the idea of a BI system and be willing to learn and understand how they can benefit from its use.

Another limiting factor cited by (Neto, 2017) and (Barros, 2016) is the constant changes in the management of a university, implying the constant updating of the set of informational requirements. (Barros, 2016), cites the importance of creating a sector that is responsible for updating the system.
In addition, (Neto, 2017) reports that there were limitations regarding the development of an integrative BI, mainly due to the unavailability of data that could be used in some sectors of universities, such as the treasury. Being limited to creating only one Data Mart with academic data.

Given the above, other obstacles that were observed mostly among researchers should also be taken into account, such as the improvement of technological infrastructure with the investment in hardware, software, and training of employees responsible for registering data in the system and administrative techniques, such as the creation and analysis of performance indicators and the strategic use of information.

Q2 - May the use of technologies such as BI be a means of facilitating decision-making in an academic environment?

The idea that BI systems can facilitate decision-making in an academic environment is unanimous among selected articles involving BI in universities.

According to (Neto, 2017), the term Business Intelligence, created by Howard Dresner of the Gartner Group in 1989, is part of the need for competitive advantages, aiming at better business decision-making. However, with the evolution of technology, it started to be used in different types of organizations, currently widely used in educational institutions. (Apraxine & Stylianou, 2017), mentions that BI practices can lead to the desired result, providing quality and value that lead to an improvement in the decision-making process. Educational institutions have a large amount of data, which has a critical influence on the decision-making process, as it can be available across the department from a single source and analyzed to report the need for change and improvement in the internal and external environment of a university. (Gubalova, 2016), reinforces the same idea and says that BI tools allow a simplification of the analysis process, also offer government officials an integrated reporting and analysis environment to help university managers in the process of decision-making.

Q3 - Is the lack of systematization, standardization, and organization of data from universities and/or public higher education institutions an obstacle in the generation of data/information?

Considering the works analyzed, it was concluded that none of them have as their main focus the lack of data organization, but rather the cause of this problem. In short, the lack of integration between information systems used in universities. Thus, this research question is not considered in the construction of a taxonomy for the evaluation of related works. This generated a new research question related to the lack of integration between systems, which, according to the qualitative analysis, is the main obstacle in the generation of information in universities. According to (Santos, 2017), there are several explanations for the lack of information in universities, highlighting the lack of integration between data from different systems, in addition to the lack of a favorable environment and adequate tools for data processing. (Barros, 2016), shares the same idea and states that to minimize the difficulties of generating information, it is highlighted that IT needs to be integrated, to visualize the strategic objective of the organization and the services provided for her. For (Neto, 2017), there is a high need to use MIS’s that provide information reliable to provide greater control over academic monitoring and improvements in the strategic and managerial decision process, with an integrated administrative, financial, and academic management.

Q4 - Can the use of Data Mining and Big Data minimize the difficulties of managing data and information when used in conjunction with BI?

The Data Mining analytical tool, according to (Santos, 2017), consists of a process that uses techniques to extract and identify useful information and, consequently, knowledge (or patterns) from large volumes of data, and these patterns can be presented as trends, business rules, correlations, or predictive models. Data Mining, for many authors (including retrieved articles) and in the literature in general, is considered essential and used as part of the basic architecture of a BI system. However, recent research points to the need for an updated BI architecture, using, in addition to the usual components, Big Data techniques to deal with the increase in the volume, variety, and speed of generated data. For (Bousty, et al., 2018), most current BI solutions are not able to keep up with the rapid evolution of data generation. (Santos & Costa, 2016), exemplify the migration from a traditional Data Warehouse to the Big Data scenario, thus supporting BI.
3.1 Quantitative Analysis

According to the established research questions, Table 7 presents the quantitative for each research question in relation to obtaining or not the answer through the selected research articles.

Table 7. Quantitative Analysis

<table>
<thead>
<tr>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>9</td>
<td>8</td>
<td>17</td>
</tr>
</tbody>
</table>

Based on these results presented in Table 7 it is possible to state that:

1. Questions 1 and 2 returned a fair number of answers, as the topic "BI implementation to facilitate decision-making" is really relevant in the context of BI in universities.

2. Question 3 initially did not return any answer, as the research question was premised on the lack of data systematization, however, most of the works present the analysis of the consequence of this problem, which is the lack of integration between systems. Thus, the question was readjusted and also returned a number considered to be low, but sufficient for analysis.

3. Question 4 returned the highest number of answers, as this research question is more comprehensive compared to others, in which the scope was reduced to universities only. Among the 17 responses returned, 15 addressed Data Mining, 9 Big Data, and 7 both technologies. The reduced number of returns on Big Data is mainly because this term has become popular recently.

3.2 Qualitative Analysis

1. What are the main difficulties encountered in implementing BI in universities?
   This question, which was answered by 9 of the 22 selected works, presents as a premise, from this analysis, that the following criteria must be observed in a work in terms of BI implementation in universities:
   - Business understanding
   - Organizational culture
   - Staff training
   - Technological infrastructure (hardware and software)
   Thus, in the construction of taxonomy, this first item will be titled "Structure for BI".

2. May the use of technologies such as BI be a means of facilitating decision-making in an academic environment?
   This question, which, like the previous one, was answered by 9 of the 22 works retrieved, from this analysis, presents as a condition that the following criteria must be observed in a work with the purpose of facilitating decision-making in an academic environment:
   - Easy access
   - Reliability of Answers
   In taxonomic terms, this item will be titled "Data Availability".

3. Is the lack of integration between university management information systems an obstacle in the generation of information?
   This question, which was answered by 8 of the 22 selected papers, as a result of this analysis, shows that the following criteria should be analyzed in a paper for the purpose of integrating Management Information Systems from universities:
   - Enabling environment (unique information management system)
   - Decision support systems
   Therefore, in the construction of taxonomy, this item will be called "System Integration".
4. **May the use of Data Mining and Big Data minimize the difficulties of managing data and information when used in conjunction with BI?**

This question that had the highest response rate, 17 of the 22 selected works, exposes as a premise, from this analysis, that some criteria must be observed in a work in terms of applying Big Data and Data Mining in a BI system.

- DM Methodology
- DBMSs
- Big Data Systems

Thus, for a taxonomic model, this last item will be titled "BI Optimization".

**4. CONCLUSION**

The paths found as a possible proposal to alleviate the problem presented earlier in this research, which, again emphasizing, arises from a systematic literature review, explore the use of advanced analytical technologies such as Business Intelligence (BI), Big Data, and Mining tools to support decision-making in administrative/academic environment.

In this way, the conclusion is reached that the natural path, from these technologies presented, is to be able to transform data (even if from an unknown organization) into useful information and knowledge for the important and already mentioned decision-making process, making the integration from multiple sources, and getting “a single version of the truth” for all members of an organization.

In view of this evaluation, considering the results obtained in the qualitative analysis of the articles found, the following taxonomy of work evaluation was generated that have the same theme, designated here as related articles. This taxonomy is described below:

a) Structure for BI.

b) Data Availability.

c) Systems Integration.

d) BI Optimization.

In view of this and assuming a solution to the research problem, this research presents the following contribution: **Creation of a methodology using Big Data and Data Mining to implement a Business Intelligence system in a federal institution of higher education.**

And, in addition, the following specific objectives would be introduced:

1. Analyze the structure of information systems in Federal Universities.
2. Survey the specific informational needs of managers and the respective departments of the institution.
3. Analyze the availability of information and its respective correctness in decision-making at federal universities.
4. Explore the analytical technologies necessary for the development of the Business Intelligence system.
5. Evaluate and validate a methodology for developing a BI system.

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