Business Intelligence in Higher Education Management Systems: A Systematic Mapping Study

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Abstract. *Higher Education Institutions have expanded considerably in recent years. Along with this expansion, which has increased the total number of students enrolled, places, courses offered, and employees, there has also been a considerable increase in the data they generate. However, this data may need to be used more effectively, especially when supporting strategic decision-making. Business Intelligence (BI) techniques can be helpful in this process. In this study, we sought to understand and to systematize which BI strategies have been used in these institutions by a systematic mapping study. The results revealed some tools and techniques are used, but there are still difficulties in properly implementing BI in this context.*

Resumo. *As Instituições de Ensino Superior expandiram consideravelmente nos últimos anos. Junto com essa expansão, que abrangeu o aumento do total de alunos matriculados, vagas, cursos ofertados e trabalhadores, também houve considerável aumento dos dados gerados por elas. Contudo, esses dados possivelmente não são utilizados de forma eficaz, principalmente no que tange ao apoio para a tomada de decisões estratégicas. Técnicas de Business Intelligence (BI) podem ser úteis nesse processo. Nesse estudo, buscou-se compreender e sistematizar quais estratégias de BI têm sido utilizadas nessas instituições por meio de um estudo de mapeamento sistemático. Os resultados revelaram que algumas ferramentas e técnicas são utilizadas, porém ainda existe dificuldade na implementação adequada de BI nesse contexto.*

1. Introduction

In Brazil, according to data from the 2022 Census, there are 2,595 public and private Higher Education Institutions (HEIs) accredited by the Ministry of Education (MEC), including Universities, University Centers, Colleges, Federal Institutes (IFs), and Federal Technological Education Centers (CEFETs). Also in 2022, these HEIs registered 9,443,597 students enrolled in one of the 44,951 undergraduate courses recognized by the MEC [INEP/MEC 2022]. Since the implementation of the REUNI Program, there has been a growing number of places on offer for undergraduate courses at Brazilian Federal Universities [Brasil 2021]. In this scenario, national education and HEIs are constantly expanding, requiring a strategic vision to improve their quality [Porto and Régnier 2003].

In a business perspective, HEIs use various management systems to handle administrative and academic processes in educational institutions by using information and communication technologies [Mulyani 2022]. In an operational perspective, academic management systems can support isolated initiatives for academic, people,

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budget, and research management, among others [Combita Niño *et al*. 2020], generating a significant volume of different types of data.

Therefore, it is crucial for HEIs to implement solutions that collect, organize, and analyze data within their systems. This allows generating new knowledge to develop business strategies aimed at enhancing their services [Kabakchieva 2015]. For this, the data collected and stored in academic management systems could be utilized more effectively to make predictions or obtain quick answers in various sectors and for diverse purposes [Bichsel 2012]. One viable option is to implement BI techniques to enable multiple analyses based on this data.

BI is a decision support methodology based on data collection and analysis, combining four main components: (i) Data Warehouse (DW) – data source; (ii) Business Analytics – data analysis environment; (iii) Data Monitoring; and (iv) Dashboard – user interface [Damasceno *et al*. 2018; Mirwansyah *et al*. 2021].

Improving data management, primarily to obtain information that supports decision-making, is necessary for HEIs [Castillo-Rojas 2018]. The use of BI techniques and tools to enhance data management, as well as the integration, visualization of information, and improvement in academic and corporate governance, are described in the literature [Azevedo *et al*. 2021; Kopnova *et al*. 2022]. Other examples include research by Medeiros Neto (2017), Santos (2017), and Alves (2018), who developed BI systems to provide strategic information and data to support managerial decision-making in HEIs.

It is thus argued that BI techniques have the potential to significantly improve the management of data stored in HEI systems, including helping to monitor student evasion. Student evasion is currently one of the greatest concerns for Federal University managers, stemming from both internal and external factors affecting the institutions. In this study, we sought to understand and to systematize which BI strategies HEIs have used in academic management by a systematic mapping to support decision-making. The systematic identification of these strategies could contribute to future work on selecting tools for this purpose and represents the main contribution of the research.

The remainder of the paper is structured as follows. Section 2 discusses the background. Section 3 presents the research methodology used to search for, extract, and classify information from the papers analyzed. Section 4 discusses the results. Finally, Section 5 outlines the conclusions.

2. Background

University management is considered a complex and relatively recent field of study, driven by the growing demand for efficiency, especially in public universities. This management comprises a set of practices aimed at planning, organizing, directing, and controlling academic and administrative activities, to align the institution’s performance with social, political, economic, and cultural demands. This requires the implementation of strategic management practices that enable heterogeneous organizational structures to function efficiently and that effectively link decision-making and execution levels [Goulart and Esteves 2024].

It is also necessary for these institutions to promote knowledge management and anticipate changes in the context in which they operate, given that HEIs are organizations focused on the production and dissemination of knowledge. As such, they play a fundamental role in training professionals to work in a society characterized by continuous change. The rapid social, technological, and economic transformations impose a challenge on HEIs to adapt continuously, at the risk of losing their relevance and efficiency in fulfilling their essential function: meeting the demands of society in a context of constant instability. This demands the continuous evaluation of knowledge creation, transfer, and management processes [Cajueiro *et al*. 2009].

The strategic use of information encourages continuous updating and enables the identification of opportunities and threats, demanding a holistic vision from organizations [Senger and Brito, 2022]. For knowledge to become the central element of organizational success, strategic decisions must be aligned to obtain, develop, use, and retain this knowledge [Almeida 2024]. Within HEIs, information systems play a crucial role in management, as they enable the efficient administration of internal processes and the processing of large volumes of data and information, providing support for informed decision-making. The adoption of these technologies has therefore become inevitable, as they give institutions a competitive advantage [Senger and Brito 2022].

BI is a conceptual model designed for decision support, integrating architecture, databases, analysis tools, and applications. The term encompasses a set of methodologies, tools, and technologies designed to collect, analyze, and interpret data, enabling managers and analysts to make informed decisions. In essence, raw data is contextually transformed into strategic information, allowing hidden phenomena to be visualized and guiding business decisions and actions [Turban *et al*. 2009; Braghittoni 2017].

This term was introduced by the Gartner Group, a consulting firm specializing in business and technology, in the 1990s; however, the origins of the first functionalities and concepts date back to earlier times. In the 1970s, Report Generation Systems (RMS) emerged, generating static and limited reports. In the 1980s, Executive Information Systems (EIS) emerged, bringing dynamic reports, predictive analysis, and management monitoring tools. In the 2000s, BI incorporated advanced techniques such as artificial intelligence and data mining, becoming an essential component in the strategic management of organizations [Turban *et al*. 2009; Braghittoni 2017].

The primary objective of BI is to enable interactive access to data, allowing it to be manipulated and providing managers with the necessary resources to conduct appropriate analyses. When designing a BI project, it is essential to have access to the organization's information. When well-structured, information supports decision-making and, consequently, guides strategic actions [Sharda *et al*. 2019; Rezende 2024].

Some concepts related to BI can be highlighted, such as DW, ETL (Extract, Transform, Load), OLAP (Online Analytical Processing), and data visualization. DW is a structured data repository designed to support decision-making processes in organizations, providing a comprehensive, integrated view of historical and current information relevant to management. It is a database oriented by specific themes – such as customers, products, or academic performance – which brings together information from various sources, standardizing it and reconciling possible differences between them [Braghittoni 2017; Sharda 2019]. The ETL process is essential for building and maintaining a DW. Data can be extracted from multiple sources, including transactional databases, external files, and spreadsheets. After extraction, the data undergoes a transformation process based on business rules, whereby it is standardized, consolidated, and corrected before being loaded into the DW [Kimball and Ross 2013].

OLAP refers to a set of operations performed by end-users in online systems to analyze data. The primary feature of OLAP is to provide a multidimensional view of data, enabling users to explore information from various perspectives and levels of aggregation. These tools often offer functionalities for modeling, visualizing, and analyzing large volumes of data and are widely used in Database Management Systems and DW [Turban *et al*. 2009]. Data visualization is a resource used to communicate information clearly and effectively. It consists of a graphic representation of information to facilitate its understanding, communication, and analysis. Its use is essential in the face of the growing volume of data available, as it enables humans, whose cognition is highly visual, to identify patterns, trends, and anomalies more quickly and clearly than using isolated textual or numerical information [Ward *et al*. 2015; Marquesone 2016].

3. Definition of Research

The systematic mapping proposed herein follows the procedures defined by Kitchenham and Charters (2007). The main goal is to identify, analyze, and categorize BI strategies in management systems used in HEIs. The research protocol, which contains the research questions, search method, selection criteria, quality assessment, and data extraction, is presented below.

3.1 Questions of Interest

Four research questions were defined:

Q1: What BI strategies and solutions have been adopted or proposed by the HEIs? Rationale: This question aims to understand the BI strategies and solutions HEIs have adopted or proposed, investigating how these technologies are applied to enhance academic management.

Q2: Where have these BI strategies been developed, and by whom? Rationale: This question seeks to map the origin of these BI strategies, identifying where and by whom they were developed, whether by universities or third parties.

Q3: For what purposes have the BI strategies been used? Rationale: This question intends to provide details about the objectives of the BI strategies adopted and analyze the specific purposes for which these solutions are being employed in HEIs.

Q4: What benefits do HEIs seek by using BI? Rationale: This question investigates the benefits expected from implementing these BI strategies and assesses their positive impact on educational institutions.

3.2 Search Strategy

To design the search string, the PICOC elements were considered, as suggested by Wohlin *et al.* (2012): **Population** – management systems; **Intervention** – BI strategies; **Comparison** – not applicable; **Outcome** – characterize the BI strategies used for academic management; **Context** – Higher Education Institutions. The leading scientific databases were selected: ACM Digital Library, IEEE Xplore, Scielo, and Scopus. Several tests were carried out on the databases to adjust the calibration of the search strings and to optimize the search results. The complete search strings, adapted for each database, are listed in Table 1.

Table 1. Search strings in digital databases (continued). Source: The authors.

Source	Source Strings
ACM Digital Library	[[Abstract: management] OR [Abstract: control] OR [Abstract: governance] OR [Abstract: administration]] AND [[Abstract: university] OR [Abstract: "higher education"] OR [Abstract: academic]] AND [Abstract: "business intelligence"] AND [E-Publication Date: (01/01/2011 TO 03/31/2024)] [[Keywords: management] OR [Keywords: control] OR [Keywords: governance] OR [Keywords: administration]] AND [[Keywords: university] OR [Keywords: "higher education"]

	OR [Keywords: academic]] AND [Keywords: "business intelligence"] AND [E-Publication Date: (01/01/2011 TO 03/31/2024)] [[Publication title: management] OR [Keywords: control] OR [Keywords: governance] OR [Keywords: administration]] AND [[Keywords: university] OR [Keywords: "higher education"] OR [Keywords: academic]] AND [Keywords: "business intelligence"] AND [E-Publication Date: (01/01/2011 TO 03/31/2024)]
IEEE Xplore	("Document Title": "management" OR "Document Title": "control" OR "Publication Title": "governance" OR "Document Title": "administration") AND ("Document Title": "university" OR "Document Title": "higher education" OR "Document Title": "academic") AND ("Document Title": "business intelligence") ("Abstract": "management" OR "Abstract": "control" OR "Abstract": "governance" OR "Abstract": "administration") AND ("Abstract": "university" OR "Abstract": "higher education" OR "Abstract": "academic") AND ("Abstract": "business intelligence") ("Author Keywords":"management" OR "Author Keywords": "control" OR "Author Keywords":"governance" OR "Author Keywords":"administration") AND ("Author Keywords":"university" OR "Author Keywords":"higher education" OR "Author Keywords":"academic") AND ("Author Keywords":"business intelligence")
Scielo	(management OR control OR governance OR administration) AND (university OR higher education OR academic) AND (business intelligence)
Scopus	TITLE-ABS-KEY ((("management" OR "control" OR "governance" OR "administration") AND ("university" OR "higher education" OR "academic") AND ("business intelligence"))) AND PUBYEAR > 2011 AND PUBYEAR < 2025

3.3 Selection Strategy and Quality Assessment

Primary studies are considered relevant for this secondary study when they accomplish the inclusion criteria. Otherwise, studies are excluded when they fulfill at least one of the exclusion criteria. The selection criteria are listed in Table 2.

Table 2. Inclusion (IC) and exclusion (EC) criteria. Source: The authors.

Criteria	Description
IC-01	The study proposes a BI strategy for an academic management system.
IC-02	The study uses a BI strategy in an academic management system.
EC-01	Duplicate studies.
EC-02	The study is written in a language other than English, Portuguese, or Spanish.
EC-03	The study is not available for download.
EC-04	The study has not been peer-reviewed (it has not been published in a journal, congress/conference, or similar publication).
EC-05	Studies published before 2012.
EC-06	The study deals with BI but is not related to university management systems.
EC-07	The study deals with university management systems but does not address BI strategies.
EC-08	The study is a short paper, poster, or extended abstract.

To assess the quality of the studies selected, questions were defined which weight each study selected in scores. The questions were: ***1) Are the research objectives defined?; 2) Is the research design appropriate and justified?; 3) Is the context of the academic system (e.g., sector or academic objective) adequately described?; 4) Are BI strategies well-defined and applied to the objectives of the systems?; 5) Are the findings and contributions of the study clearly stated and substantiated?***

The weights refer to the scores given to each answer: *I totally agree* (weight 5); *I agree* (weight 4); *I partially agree* (weight 3); *I partially disagree* (weight 2); *I disagree* (weight 1); *I totally disagree* (weight 0). Based on the questionnaire proposed for checking quality, the maximum score for each article could have been 25 points. The cut-off score was set at 13 points, and studies with scores lower than or equal to this were excluded.

3.4 Data Extraction and Analysis

Data extracted for included primary studies is categorized in the demographic information of the study (i.e., authors list, country, venue, year); information on the BI technology, such as name, creator, and license; lists of HEIs goals and benefits of BI technologies;

Artificial Intelligence/Machine Learning Algorithm used in BI technologies; and BI solution proponents.

A digital extraction form in Parsifal (https://parsif.al/) was used to extract data from primary studies. Qualitative and narrative synthesis methods were used to analyze the extracted data, as recommended by Scannavino *et al*. (2017).

4. Results and Discussion

The results of the search are illustrated in Figure 1. The searches were conducted between January 22 and March 21, 2024, yielding 422 articles, considering all the sources: ACM Digital Library – 19; IEEE Xplore – 46; Scielo – 17; Scopus – 340. Fifty-one duplicate articles were removed from the total number of papers identified; therefore, 371 studies were considered in the first selection stage.

The inclusion and exclusion criteria highlighted in Table 2 were first applied after reading the primary studies title, abstract, and keywords. In some cases, reading more elements of the article was necessary. This process resulted in 63 primary studies being selected for a second-stage selection. After reading the entire paper of those 63 works and conducting a snowballing, 43 studies were selected. Finally, the quality assessment was applied to 43 studies, of which 33 were chosen as the final set of primary studies in this systematic mapping, as listed in Table 3.

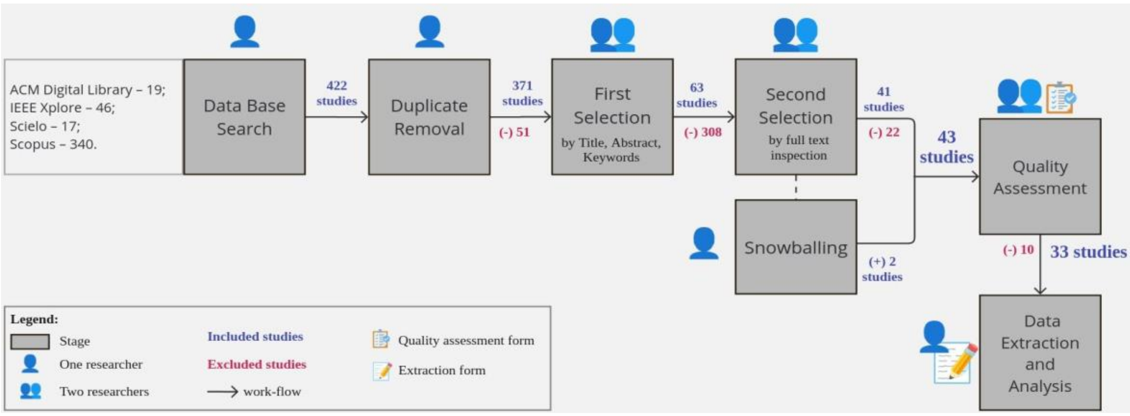

Figure 1. Systematic mapping conduction. Source: The authors.

Table 3. Catalog of publications selected (continued). Source: The authors.

ID	Reference	Authors' Countries	ID	Reference	Authors' Countries
S1	[Ong *et al*. 2012]	United Kingdom	S18	[Ortiz and Hallo 2019]	Ecuador
S2	[Gupta *et al*. 2015]	India	S19	[Moscoso-Zea *et al*. 2019]	Ecuador/Spain
S3	[Wyne *et al*. 2015]	United States of America	S20	[Villegas-Ch *et al*. 2020]	Ecuador/Spain
S4	[Ribeiro and Ribeiro 2015]	Brazil	S21	[Kumaran *et al*. 2020]	Malaysia/Saudi Arabia
S5	[Gubalová 2015]	Slovakia	S22	[Piri *et al*. 2020]	Iran
S6	[Moscoso-Zea *et al*. 2016]	Ecuador/Spain	S23	[Azevedo *et al*. 2021]	Brazil
S7	[Hussein and Khan 2017]	Kuwait	S24	[Mirwansyah *et al*. 2021]	Indonesia
S8	[Jayakody and Perera 2016]	Sri Lanka	S25	[Mamykova *et al*. 2021]	Kazakhstan
S9	[Somya *et al*. 2018]	Indonesia	S26	[Braccini *et al*. 2021]	Italy
S10	[Bharara *et al*. 2018]	India	S27	[Freitas Júnior *et al*. 2022]	Brazil

S11	[Castillo-Rojas *et al.* 2018]	Chile	S28	[Kopnova *et al.* 2022]	Kazakhstan
S12	[Peralta 2018]	Ecuador	S29	[Sênchez-Ticona *et al.* 2023]	Peru
S13	[Damasceno *et al.* 2018]	Brazil/Portugal	S30	[Alkayed *et al.* 2023]	Jordan
S14	[Haque 2018]	Canada	S31	[Karabtsev *et al.* 2023]	Russia
S15	[Ali and Klett 2018]	Sudan/Germany	S32	[Tran and Kuula 2023]	Finland/the Netherlands
S16	[Yashchuk and Golub 2019]	Ukraine	S33	[Boulila *et al.* 2023]	Saudi Arabia/Tunisia
S17	[Chacón *et al.* 2019]	Colombia			

The works identified in the mapping were analyzed to answer the research questions proposed in the article.

Regarding the first research question – ***Q1: What BI strategies and solutions have HEIs adopted or proposed?***, the studies described used 14 different software or platforms for the implementation phases of BI. Some of the types of software cited are used for multiple stages, such as data integration, analysis, monitoring, and data visualization. Other types of software only perform one of these stages. Also, some of the studies did not mention any specific software. The leading software mentioned by the primary studies is depicted in Figure 2 and detailed as follows:

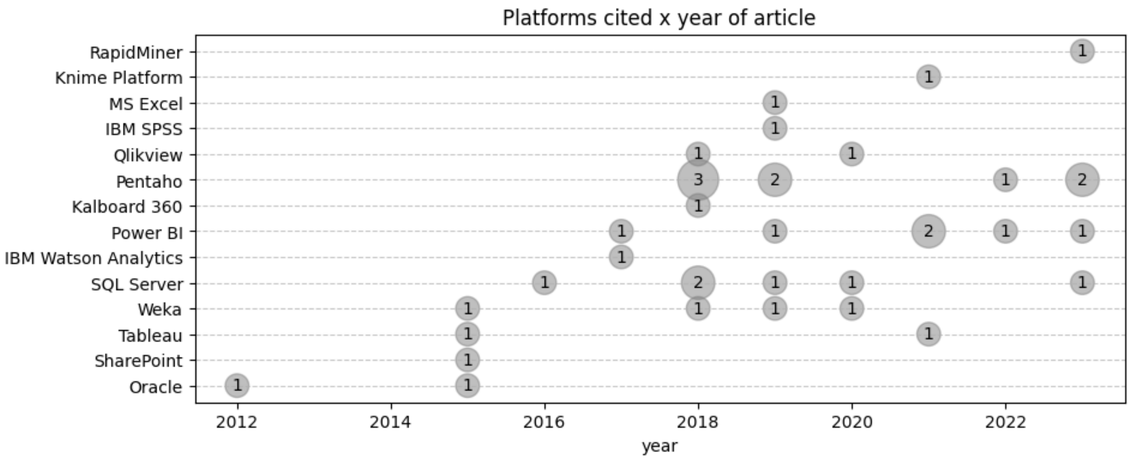

Figure 2. Number of platforms cited by year. Source: The authors.

- *Pentaho*: It was the most mentioned open-source BI software, developed in Java. Its application allows for extracting, transforming, loading, reporting, online analytical processing, and data mining (S11, S12, S13, S17, S18, S27, and S29).
- *Power BI*: A tool developed by Microsoft for business analysis and data analysis (S8, S16, S24, S25, S28, and S31).
- *SQL Server*: A relational database management system developed by Sybase in a partnership with Microsoft (S5, S9, S14, S16, S20, and S33).
- *WEKA platform*: This is a collection of ML algorithms for data mining and clustering tasks (S2, S12, S17, and S20). Among the ML algorithms possible in this platform, the J48 algorithm was the most widely used and proved to be the most efficient, as described by the authors in S12, S17, and S20.
- *Qlikview*: Analytics solution that enables to create and to implement guided analysis applications and interactive dashboards (S11 and S22).
- *Tableau*: Visual analysis platform belonging to Salesforce (S3 and S23).
- *Oracle*: Oracle Corporation is an American multinational technology company specializing in developing and marketing hardware, software, databases, and

cloud services. In S3, *Oracle Database*, a database management system, was described. In S1, the *Oracle BI* platform was only mentioned.

- *IBM Watson Analytics*: It is a data analysis engine based on cognitive computing that guides data discovery and predictive analysis with automatic visualizations (S7). *IBM SPSS – Statistical Package for the Social Sciences* was also mentioned (S17).
- *Knime*: A free and open-source platform for data analysis, report building, and data integration (S26).
- *Kalboard 360*: A cloud-based learning management system (LMS) designed to help schools improve their learning using cutting-edge technology (S10).
- *RapidMiner*: It is a data science platform that can perform data preparation, machine learning, and predictive analysis tasks (S30).
- Generic tools such as *Microsoft SharePoint* (S4) and *MS Excel* (S16).

Among the types of software identified in primary studies, some studies were perceived to use more than one type of software: S11 used *Pentaho's Data Integration* (PDI) for extracting, transforming, and loading (ETL) process and *QlikView* for the *Online Analytical Processing* (OLAP) stage. In S03, ETL procedures and data mart organization were carried out using *Oracle* software, directly linked to *Tableau* for dashboard design. In S16, *Power BI* was used for visualization, *SQL Server* for developing the database, and *MS Excel* tool for some data analysis operations. S17 reported that the data were initially collected and analyzed using *IBM SPSS* software. Later, this data was processed with the *WEKA* data mining tool. Additionally, the data warehouse and the database developed were said to be hosted on Oracle servers, and Pentaho was used to perform the ETL process.

In the studies that did not mention the use of commercial or open-source BI software (S6, S15, S19, S21, and S32), the following contributions were observed: (i) study S6 presents a guide for designing a data warehouse (DW) in educational institutions; (ii) study S15 proposes a framework called *Business Intelligence Enhanced Learning Analytics* (BIELA), that combines BI and learning analytics to improve data access for decision-making; (iii) in S19, big data infrastructure is proposed, using BI and Analytics (BI&A) for data analysis, for an academic system. It also presents a list of tools used for data mining; (iv) in study S21, the metaheuristic algorithm, the *Ant Colony Optimization* (ACO) technique, was used to identify the most relevant student characteristics to assess their ability to graduate on time or not, as well as the reasons for the inability to complete their studies within the expected timeframe. To validate performance and accuracy, the *Support Vector Machine* (SVM) was used; (v) study S32 conducts a case study of a system implemented in a HEI that uses BI strategies to facilitate data-driven decision-making, quality management, and service efficiency.

Studies S8, S12, S25, and S26 reported integration with BI tools to support academic activities using the *Moodle Learning Management System* (LMS), a system used to support teaching. For example, for the application of BI in this LMS, platforms such as *Power BI* (S8, S25), *Pentaho* (S12), and *Knime* (S26) were integrated. Data mining was mentioned in S2, S6, S8, S10, S12, S13, S15, S17, S19, S20, S21, S25, S26, S27, and S30 as an important strategy by some institutions, especially for extracting knowledge and for detecting hidden patterns. The specific objectives of applying data mining techniques were searching for patterns to detect dropout risks (S27), identifying possible relationships between student attributes and their academic performance (S30), and evaluating the effect of students interactional characteristics and parental involvement on their educational performance (S10). Software used for data mining were the *RapidMiner* tool, the *WEKA* platform, the *Knime* platform, and *Kalboard 360*.

Concerning the second research question – ***Q2: Where have these BI strategies been developed, and by whom?***, no clear dominance of any specific country of origin was observed among the authors of the papers. Articles from 28 different countries were analyzed. The most frequent were Ecuador, with five articles; Brazil, with four; and Spain, with three. Additionally, there were two articles with authors from the following countries: Saudi Arabia, Kazakhstan, India, and Indonesia.

Note that the interest in applying BI techniques in HEIs is a global trend. In eight articles, there was participation from authors in more than one country. The proposed solutions and studies were carried out by researchers from both public and private universities. Of the selected articles that reported specific HEIs regarding the implementation of BI techniques, 15 were from public universities, and nine were from private universities. Of the nine articles in which no specific institution was mentioned, all the authors were affiliated with some HEI. Only in S1, although the authors were affiliated with a university, did the paper mention the use of a BI system developed by the University of Bedfordshire and an unspecified vendor. The remaining articles did not mention the involvement of vendors in the implementation or study of the proposals. However, 28 articles utilized third-party platforms or software.

Figure 3 shows the platform selected by the type of institution. Public and private HEIs used six tools: *Pentaho*, *Power BI*, *SQL Server*, *Weka*, *Oracle*, and *Tableau*. This suggests that the tools can meet the requirements for both types of institutions.

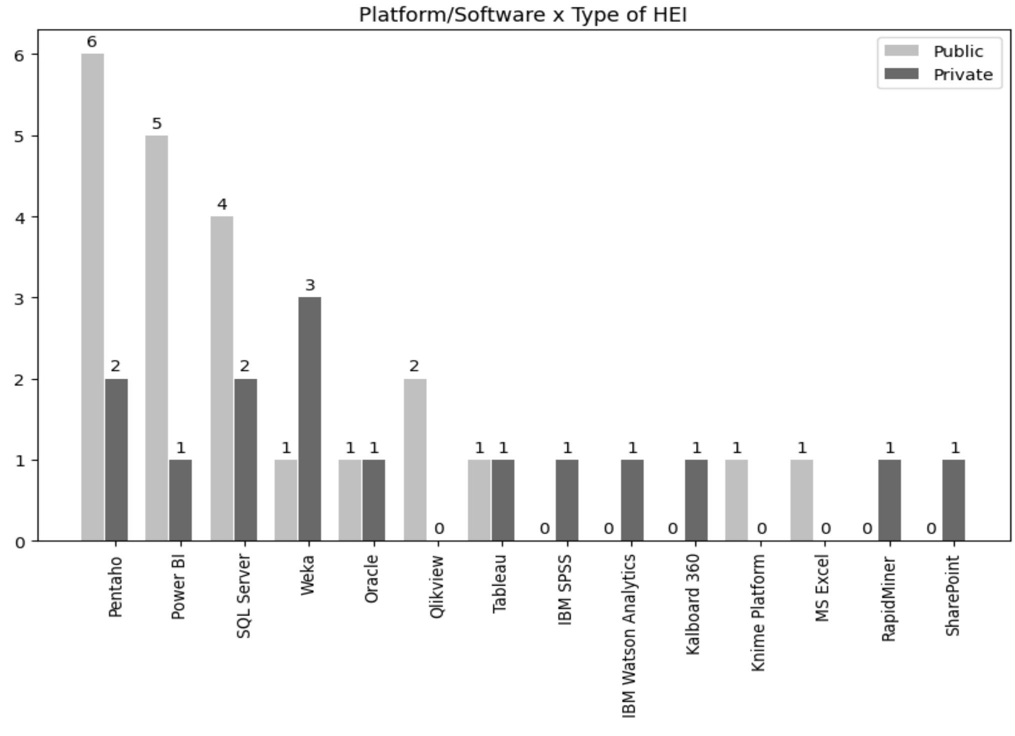

Figure 3. Platform used by type of institution. Source: The authors.

In the third research question – ***Q3: For what purposes have the BI strategies been used?***, the main objective of using BI techniques in HEIs was to support decision-making, and this was mentioned in more than 75% (25/33) of the studies selected. Among the motivations related to decision-making support, we can highlight student retention

(S1), detection of potential dropouts (S17), student dropout rates (S27), faculty workload (S14), faculty performance (S31), and alumni information (S29).

Another frequently cited motivation for applying BI was the limitations and delays in obtaining data (S3, S12, S14, S23, S26, and S33). This could be explained by the fact that educational institutions use different systems for different processes, as previously mentioned in the introduction of this paper. Difficulties were actually reported in quickly and effectively accessing all the necessary information due to the lack of a unified system. Studies S7, S9, S11, S22, and S25 reported using more than one system at HEIs for academic and administrative processes. These different systems generate isolated data that do not communicate with other similar systems, commonly referred to as information silos [Miller and Tucker 2014], which hinders data integration.

Improving information visualization, data integration (S9, S12, S25), and process automation (S4, S14) were also mentioned. Visualization can enhance decision-making support, and in the articles with this objective, the identification of student levels and performance (S8, S30) was particularly highlighted. It was observed that educational institutions must improve data management, especially to obtain information to support decision-making. We observed that using BI techniques and tools is exploited for this improvement, in addition to data integration, information visualization, and improved corporate governance [Azevedo *et al*. 2021; Kopnova *et al*. 2022].

The motivations found in the articles align well with the concept of BI, as BI encompasses data integration, information processing, and decision support systems within an organization. Most institutions use BI to support decision-making and improve data visualization, regardless of the type of institution. There is also a trend towards applications to more specific areas, such as student retention, reducing dropout rates, improving the quality of education, and facilitating the accreditation process. The recurrence of these goals suggests that HEIs face similar challenges.

Figure 4 shows the relationship between the desired benefit and the platform chosen. Additionally, the expected benefits, such as greater data integration, process automation, and support for corporate governance, reflect the growing need for institutions to transform their data into knowledge for more efficient and strategic management.

In the fourth research question – ***Q4: What benefits do HEIs seek by using BI?***, it was observed that HEIs generally seek various improvements by implementing BI. As already highlighted in the Introduction, the use of BI techniques can improve data management (S5, S11, S13, S15, S20, S22), data integration (S9, S25) – including financial data (S9), administrative and academic data (S6, S7, S12) – improvement in information visualization (S18, S23, S24), and corporate governance (S4). From the studies analyzed, we can list the following specific expected benefits:

- Improvement in the management of education, educational quality, and scientific output: By integrating data and providing performance indicators, HEIs can monitor and enhance the quality of their academic and scientific activities (S3, S6, S7, S11, S22, S23, S25). Moreover, predictive analytics identifies problem areas and adjustments in pedagogical practices, improving educational quality and student performance (S10).
- Support for more well-founded decisions: BI tools, such as OLAP and data warehouses, allow for quick and detailed analyses that increase the quality of strategic decisions, improving planning and resource allocation (S11, S16, S19). Furthermore, BI implementation enables the creation of a valuable data repository

for continuous analysis, allowing for more efficient knowledge management and for obtaining important insights into institutional performance (S11, S19, S20, S21, S22, S23).

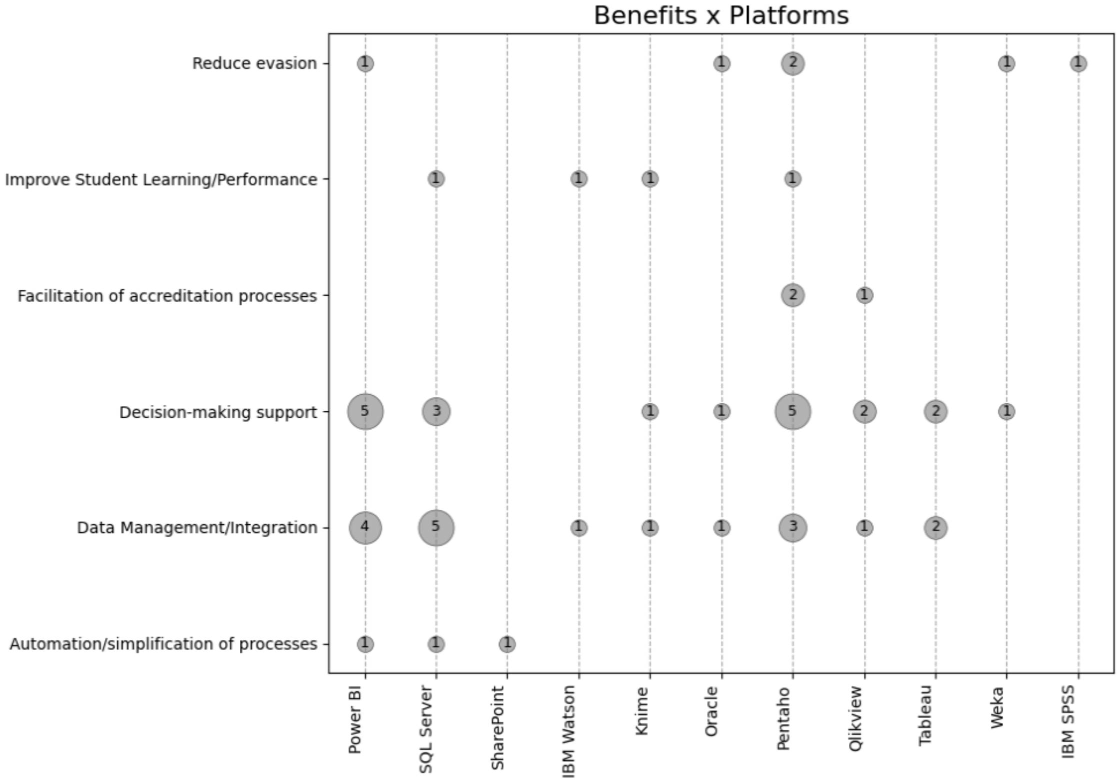

Figure 4. Benefits sought and platform chosen. Source: The authors.

- Improvement in administrative and academic efficiency and institutional performance: Process automation and data integration enable effective and quicker management of institutional resources, optimizing governance and response time (S2, S4, S5, S9, S11). Additionally, BI helps HEIs remain competitive by providing tools for quick adaptation to changes and for optimizing educational and administrative processes in highly competitive environments (S2, S11, S19).
- 12% (4/33) of the studies reported that BI benefits the analysis of student retention and the reduction of dropout rates; by identifying the causes of dropping out and monitoring academic performance, BI enables the implementation of corrective actions that increase student retention and successful course completion (S1, S8, S17, S20).
- Optimization of academic undergraduate and post-graduate programs management and their respective subjects: HEIs use BI to make decisions about course scheduling, faculty management, and resource allocation (classroom, laboratories, etc.) based on data, improving the efficiency of academic administration (S3, S7).

Finally, the authors highlight two issues that threaten the validity of this research: the selection of the scientific databases researched and the manual search for the papers. In the first case, although four renowned databases for primary research studies were selected, other publication outlets could have been included, allowing more relevant work to be identified. In the second case, although the searches were well planned and executed, some work related to the topic may not have been included due to human error. To mitigate the latter threat, the authors of this research reviewed the papers identified to resolve possible discrepancies.

5. Final Considerations

We aimed to understand and systematize the BI strategies employed by HEIs in academic management using a systematic mapping to support decision-making. The study began with a comprehensive search of scientific databases, which resulted in 422 publications. After applying selection and exclusion criteria, a final set of 33 publications was obtained.

In general, the academic management systems used in HEIs were observed not to be originally designed with BI capabilities in mind. Tools were observed to be adapted or integrated, mainly to bring decision-making and data visualization capabilities. Also noted was that difficulties have been reported in the ETL process, as well as the implementation of the Data Warehouse due to diverse data sources and issues related to information security [Somya *et al*. 2018; Castillo-Rojas *et al*. 2018].

In some studies, integration was conducted manually; data from the base system were exported into spreadsheets and then processed by BI tools. The lack of standardized tools or APIs to enable automated integration between academic systems and BI systems was highlighted.

After conducting the systematic mapping study, it can be concluded that although educational institutions strive to implement BI, this process is challenging, particularly with data extraction, due to the use of various systems and data sources. Different tools, including open-source software, support the implementation of BI, and various techniques and methodologies are described for its application. Data mining also has a positive impact on the data analysis process.

We found that improving information systems and managing the data generated in these institutions is still needed. We also concluded that implementing BI and data mining techniques can be great allies in improving systems and analyzing information to support decision-making. Future work could address potential solutions for automated integration between academic systems and BI systems and explore new contexts or emerging technologies, such as data science, artificial intelligence, or machine learning applied to educational analysis.

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