Business Intelligence for Academic Management Systems: Results of a Study in a Brazilian Federal University

Alana R. R. Vieira
Graduate Program in Computer Science and Technology, Federal University of Itajubá
Itajubá, MG, Brazil
alanaraiza@unifei.edu.br

Rodrigo D. Seabra
Institute of Mathematics and Computing, Federal University of Itajubá
Itajubá, MG, Brazil
rodrigo@unifei.edu.br

Lina Garcés
Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo
São Carlos, SP, Brazil
linagarces@usp.br

Abstract

Context: Brazilian public universities require managing vast and diverse academic and administrative information. The government requires periodic reports about finances, education, research, and social impact to obtain enough economic resources for universities' continuous operations. Additionally, since the approval of the National Law nº 12.527 (LAI - Lei de Acesso à Informação) of 2012, all public organizations must provide information as requested by any civilian, public, or private organization. **Problem:** Answering diverse information requests by public universities demands a lot of time and effort from public officials since, to produce a report, they must consult different systems and documents. These tasks increase the workload of public employees, which is repetitive and manual work. **Solution:** This work investigates the information necessities of public universities in Brazil to manage their academic sectors strategically, using Business Intelligence (BI) techniques. **IS Theory:** This work was developed using organizational information processing theory, which helps to understand how information is processed and exchanged within organizations and among their members. **Method:** Observations and semi-structured interviews were conducted with experts working in a public university's academic sector. The interviews were transcripted, and topic analysis was conducted to identify necessary functional and non-functional requirements. **Results:** Requirements were specified using the Personas method, containing stakeholders' needs, motivations, and goals for using a BI solution. Moreover, the required structured, semi-structured, and non-structured data to support operational, managerial, and strategic activities in the academic sector were identified. A preliminary conceptual model of the BI solution is also proposed. Additionally, important data integrations among university sectors were defined. **Contributions:** The results of this study are hoped to be used as an asset to define a BI solution to support academic management in Brazilian public universities. As a future work, it is intended to develop an initial BI tool and create a national reference architecture to guide the development of these solutions.

CCS Concepts

• **Information systems** → **Information integration**; **Decision support systems**;

Keywords

Business Intelligence, BI, Academic management information systems, Requirement engineering

1 Introduction

Public Higher Education Institutions (HEIs) in Brazil are funded by public resources and, consequently, are required to comply with the principle of public transparency and accountability. To demonstrate their social responsibilities, HEIs must report to both the government and society [47].

Transparency in the public sector has become one of the primary demands directed toward institutions and public officials worldwide. One way to regulate transparency is through freedom of information laws, which have been enacted in several countries [1]. In Brazil, this regulation was formalized in November 2011 with the publication of Law No. 12.527, commonly known as the Access to Information Law (LAI) [8].

Following the enactment of this law, the government made available the Electronic Citizen Information Systems (e-SIC), which allow citizens to request access to information from public agencies and entities [1]. As a result, HEIs must not only ensure transparency but also respond to various information requests from citizens within defined deadlines. In some cases, fulfilling these requests requires processing a large volume of data in a short time frame to meet the stipulated deadlines.

However, HEIs manage a wide range of information necessary for their operations, including academic, administrative, scientific, and outreach data [12]. For managing academic information, HEIs may use academic management systems, alongside various other support systems. In some cases, separate systems are needed for different tasks [26], which can lead to the creation of information silos.

Information silos are data generated in isolation, without interaction with other related systems, making data integration more difficult [23]. This model of multiple isolated systems can complicate the retrieval of information, leading to higher operational costs, longer data processing times, and a lack of assurance of effective transparency [10, 29, 44]

In addition to transparency challenges, the information generated by HEIs may not be fully utilized. The data collected and stored by HEIs could be used more effectively to make predictions or provide quick responses [3]. This data could also help HEIs improve their services by gaining a better understanding of their students [17], as well as improving decision-making processes [5, 24].

Business Intelligence (BI) technologies can help address these issues, as highlighted in several studies [2, 5, 6, 10, 13–15, 25, 29, 34, 42, 46]. From the information systems theory, BI is considered the process of collecting, transforming, analyzing, and distributing data with the aim of improving the decision-making process in

organizations [35]. Through using BI technologies and processes, organizations can understand important elements and factors (internal or external) affecting their operations and productivity [27]. With BI, organizations can use parameters and sophisticated analysis to reveal data opportunities and new information that can be transformed into benefits [27].

During the last decade, BI has been studied as a solution to support financial and academic processes in HEIs. Various significant motivations drive HEIs to adopt BI solutions, primarily aimed at improving decision-making processes in areas such as student retention [28], identifying potential dropout students [7], calculating dropout rates [16], managing faculty workload [15], assessment of faculty performance [18], and gathering alumni information [37], among others.

The benefits found in HEI by using BI solutions include improving data management[10, 13, 44] and information visualization[2, 24], along with data integration between different university sectors in a unique repository or data warehouse[21, 42]. However, there is limited knowledge regarding the expectations, objectives, and actual information needs of the academic management sector that BI tools could support.

This work contributes to identifying and specifying important functional, non-functional, and data requirements of a BI solution to support the academic sector of a Brazilian Federal University - Federal University of Itajubá (UNIFEI). This knowledge will guide the development of future BI solutions for this domain and can be replicated for other HEIs."

This paper is structured as follows: Section 2 provides a summary of related works. Section 3 outlines the methodologies and techniques used in this study, with brief explanations. Section 4 discusses the results obtained after applying the described methods. Section 5 presents discussions and analysis of the findings, as well as addressing research limitations and suggesting future work. Finally, Section 6 concludes this work.

2 Related Work

In [11], the study aimed to investigate the factors influencing the adoption of BI through a systematic literature mapping. This work employed the PRISMA model and Kitchenham's guidelines for article selection and is expected to assist administrators and researchers in making decisions regarding implementing BI systems.

In [22], the technical, human, and organizational requirements for applying BI systems in small and medium-sized enterprises (SMEs) were discussed. The study considered the characteristics of these types of companies compared to large enterprises. It highlighted that BI enhances competitiveness, improves performance, and supports decision-making processes. The application of BI in SMEs was also the focus of [39]. This article sought to understand the functional requirements and constraints that must be considered to accept a BI system in such enterprises. The research followed the Design Science Research Methodology (DSRM). A literature review and interviews were conducted to identify problems, challenges, and the state of the art. Another round of qualitative interviews was performed to gather BI system requirements. The study identified nine functional requirements and three non-functional requirements.

In [36], a literature review was conducted, and the Delphi decision-making method was used to develop a checklist for extracting BI requirements in bio-surveillance systems. Ten distinct categories were defined in the checklist, which was finalized with 94 items. The researchers stated that the study resulted in a versatile tool capable of identifying and consolidating BI requirements across various fields.

In [31], 20 BI solutions available in the market in 2018 were compared using a comparison matrix. The features of each tool were evaluated and categorized into basic and advanced features. The article also addressed guidelines for selecting a BI solution and explored future market trends.

In [43], a framework was presented for modeling and eliciting BI system requirements, enabling the specification of tasks and actors. This framework introduces a Goal-Oriented Requirements Engineering language tailored to collaborative BI. It allows the modeling and identification of decision-making tasks requiring collaboration among participants, the individuals or groups involved in collaborative decisions, and the information needed or shared among them.

In the academic context, an exploratory research design was adopted in [32] to identify the requirements and challenges of Big Data Analytics in education. The study explored how data mining and analytics could enhance teaching and learning processes and the challenges educational institutions face. For primary data collection, interviews, surveys, and observations were conducted. Secondary data collection was also done through a literature review to identify significant data solutions for education.

This work stands out from the ones mentioned above since it applies techniques for requirements elicitation to understand how a BI system can support the academic sector decision-making and data analysis in a Brazilian public university.

3 Material and Methods

To have the necessary knowledge about the real problems and information necessities in academic sectors of HEIs, the following steps were followed:

Step 1 - Understanding: Initially, observational studies [38] were conducted to identify stakeholders and gain a fundamental understanding of how activities are carried out (for example, frequency, execution patterns, difficulties, and goals) at the Undergraduate Provost's Office of the Federal University of Itajubá. The main researcher, who has nine years of experience at the university and over two years of experience in the academic sector, was primarily responsible for conducting the initial observational study.

Step 2 - Interviews: The understanding obtained during the observational study served as the basis for planning and executing guided semi-structured interviews [45] with a selected group of stakeholders with the profiles illustrated in Figure 1: Vice-Rector for undergraduate studies, Director of Student Affairs, Director of Management and Teaching Quality, Director of Academic Prospecting, Academic Registration Coordinator and the Admissions Process Coordinator.

Interviews allowed to gather information from or about a representative group of stakeholders to describe, compare, or explain their knowledge, attitudes, and behaviors [45]. Interviews have been

widely used for requirements elicitation in software systems [30, 41]. The questionnaires allowed the software engineer to gather stakeholders' needs, desires, problems, and suggestions, complementing thus their domain's knowledge and problem understanding.

Step 3 - Coding: Audio recordings during the interviews were transcribed in text using the Python library *SpeechRecognition*[1]. Following, for identifying stakeholders' requirements for each stakeholder, it was used the coding method [40], a technique utilized in qualitative research to organize and analyze non-numerical data, such as the content in transcriptions. The process involves assigning descriptive labels, or codes, to data segments to identify themes and patterns, i.e., important necessities that an information system could support. For each interview, two researchers selected and coded requirements found in each interview's transcription. The *Taguette* tool [33] was used to select text parts, allocate codes to them, and summarize or modify stakeholders' necessities.

Step 4 - Stakeholders Needs Specification: To quickly validate the problem specification, an initial version of the stakeholders' goals was modeled using the Personas approach [19]. We chose to use PERSONAS rather than use-cases, based on the advantages highlighted in recent research that supports this approach for specifying stakeholder requirements [19]. In this study, the methodology outlined by [20] was followed, which consists of using interviews to understand users' actions, their difficulties, and the factors that generate satisfaction. These interviews are transcribed and analyzed to identify key terms that represent patterns. Based on these key terms, behavioral variables are extracted, enabling the construction of a "behavioral mapping." The behavioral variables from all interviews are then clustered. Subsequently, the Refinement and Description phase begins, during which personas are created to appear realistic and accurately represent users, with defined personalities and scenarios. The use of this methodology is valuable for understanding the target audience, preventing design biases influenced by personal objectives, and ensuring that solutions are developed based on users' actual needs.

Step 5 - Requirements Specification: Stakeholders' goals informed the refinement of functional requirements. Finally, non-functional requirements related to quality attributes were specified to enhance the overall understanding of the BI solution for academic management at UNIFEI.

4 Results

This section provides a more detailed overview of the results of applying these methods to investigate business intelligence needs in the academic management sector of UNIFEI.

4.1 Stakeholders

For the definition of the stakeholders, individuals holding positions related to academic management at the university were considered. All stakeholders operate within the undergraduate provost's office of the university where the study was conducted, at the levels of provost, director, or coordinator. A total of six stakeholders were identified: the head of the department; the undergraduate provost; three directors: of Teaching Management and Quality, Academic Prospecting, and Student Affairs; and two coordinators from the Teaching Management and Quality Directorate: the Admissions Coordinator and the Academic Records Coordinator. Figure 1 illustrates the hierarchical relationship among the stakeholders.

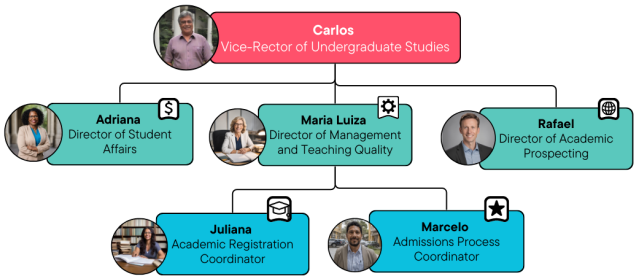

Figure 1: Hierarchy of academic management sector in UNIFEI.

4.2 Interviews

After identifying the stakeholders, guided semi-structured interviews were conducted. The interview questionnaires were divided into four parts:

- "Part I: Collection of demographic data": aimed at gathering information regarding the position, role, and experience of the interviewees;
- "Part II: How is it today?": designed to collect information on the types of demands, data, processes, and procedures carried out by the department, as well as the time spent, technologies employed, and other individuals involved in these activities;
- "Part III: What are the problems?": where the goal was to understand the challenges and difficulties faced according to the perception of each interviewee;
- "Part IV: How can it improve?": focused on understanding the expectations and priorities of each participant.

In Table 1 it is possible to check the completed questionnaire. The same interview script was applied to all stakeholders, considering that, despite their different roles, they use the same data and systems, and their demands are interconnected. Each interview was recorded for further analysis. On average, each interview lasted one hour. A Free and Informed Consent Form (FICF) was prepared and signed by the participants before the interviews. All interviews were conducted in person, and the audio was recorded with the necessary permissions. Subsequently, these interviews were transcribed to facilitate analysis and keyword extraction.

4.3 Personas

After the interviews were transcribed, keywords were identified according to each user profile interviewed. Based on these keywords, functional and non-functional requirements were determined for a tool that should meet all the stakeholders' needs. From the identified requirements, the objectives for each Persona were defined.

[1]SpeechRecognition version 3.11.0. Available in https://pypi.org/project/SpeechRecognition/

Part I: Collecting demographic data
Position / function
Department
Years of experience in the function
Part II: How is it today?
How are undergraduate vacancies monitored today? Could you explain the current process?
What admission selection processes are there today? Do they all follow the same process, or are there variations depending on the type of admission?
How are vacancies distributed for these selection processes?
How long does this process of quantifying vacancies for use in selection processes that use idle vacancies take? How are vacant vacancies identified?
How are vacant vacancies identified due to dropouts? How long does it take to perform these calculations?
How is the survey for responding to the annual Census conducted?
How long does it take to respond to the annual Census?
What technologies or systems do you currently use in these processes?
What other sectors or actors (course coordinators, institute directors, professors) are involved in the vacancy control process? And how?
Part III: What are the problems?
What problems or difficulties do you consider to exist in controlling undergraduate vacancies at the university?
What problems or difficulties are encountered in identifying vacant vacancies?
Are there difficulties in identifying vacant vacancies due to dropouts? If so, what difficulties are encountered?
What problems or difficulties are encountered in responding to the Census?
Do you consider the data available in the academic system to be easily accessible and viewable for controlling undergraduate vacancies?
Part IV: How can it be improved?
Do you think that a tool that supports the control of vacancies offered, with an easily accessible list of admissions and alumni, would make your day-to-day easier?
What do you think could be improved in the current process of controlling vacancies, related to the information available from undergraduate data?
What do you expect the tool to provide to support your day-to-day activities?
Do you think it is important to easily obtain data on the relationship between graduation and student dropout rates, with filters by admission method, gender, age, among others? If so, which filters do you believe are relevant?
Do you think that having a forecast of vacant vacancies that may occur in the next semesters would be relevant data for the administration? How could this help your work?

Table 1: Questions used for semi-structured interviews

Fictitious names and faces were created for each Persona, with the help of an artificial intelligence tool (Canva[2]).

Figure 2 presents the Persona representing the needs of the Academic Records Coordination (Interview 01). Figure 3 shows the Persona representing the needs of the Admissions Processes Coordination (Interview 02). Figure 4 depicts the Persona representing the needs of the Directorate of Teaching Management and Quality (Interview 03). Figure 5 shows the Persona representing the needs of the Directorate of Student Affairs (Interview 04). Figure 6 illustrates the Persona representing the needs of the Directorate of Academic Prospecting (Interview 05). Finally, Figure 7 presents the Persona representing the needs of the Vice-Rector of Undergraduate Studies (Interview 06), which reflects the strategic needs.

[2]https://www.canva.com/

4.4 Functional and Non-Functional Requirements

By identifying the objectives of each Persona, it was possible to refine the functional requirements. Table 2 shows all the functional requirements that were identified as necessary for the tool based on the interviews.

The non-functional requirements related to the quality attributes were also specified to improve the general understanding of the proposed tool. Table 3 shows all the detected non-functional requirements.

Interview	Keyword ID	Keyword identified in interview	Functional Requirement ID	Requirement
01, 03, 04	KW01	Information demand/Variable demands	FR01	The system must allow academic sector staff to query various information to meet external information requests to the university.
01, 03, 04	KW01	Information demand/Variable demands	FR02	The system must allow academic sector staff to query various information to meet internal information requests within the university.
01, 02, 03, 04, 05, 06	KW03	Report generation	FR03	The system must allow academic sector staff to generate reports with various information to meet external information requests to the university.
01, 02, 03, 04, 05, 06	KW03	Report generation	FR04	The system must allow academic sector staff to generate reports with various information to meet internal information requests within the university.
01, 02, 03, 04, 05, 06	KW03	Report generation	FR05	The system must allow course coordinators to query various information.
03, 04, 05	KW04	Fixed demands	FR06	The system must allow the scheduling of periodic report generation to meet fixed demands.
01, 02, 03, 04, 05, 06	KW05	Vacancy control	FR07	The system must allow control and monitoring of vacancies.
01, 02, 03, 04, 05, 06	KW05	Vacancy control	FR08	The system must allow control and monitoring of idle vacancies.
02, 03	KW06	Vacancy distribution	FR09	The system must allow the prediction of available vacancies per call notice.
1	KW07	Course efficiency	FR10	The system must allow monitoring of vacancy statuses by course.
1	KW07	Course efficiency	FR11	The system must allow monitoring of student statuses by course.
1	KW07	Course efficiency	FR12	The system must allow analysis of the most effective admission type.
1	KW08	Student efficiency	FR13	The system must allow monitoring of student situations.
1	KW09	Admission type efficiency	FR14	The system must allow analysis of students' academic performance (academic index) by admission type, course, and campus.
1	KW09	Admission type efficiency	FR15	The system must allow analysis of student dropout rates by course, admission type, and campus.
1	KW10	Data access necessity	FR16	The system must have different access levels for each profile.
01, 03, 04, 05, 06	KW11	Data integration	FR17	The system must allow integration and processing of available data in the academic management system database.
01, 02, 05, 06	KW12	Internal regulations	FR18	The system must comply with internal regulations - Graduation Standards.
01, 03, 06	KW14	Initial student profile	FR19	The system must display information about incoming students: cities of origin, high school of graduation, and school type.
01, 02, 03, 06	KW15	Causes of idle vacancies	FR20	The system must register the causes/reasons for idle vacancies (withdrawal form).
2	KW16	Student status	FR21	The system must allow monitoring of the number of students by status and course (active, graduating, graduated, completed, canceled, on leave).
02, 03	KW17	Offered vacancies	FR22	The system must include the number of vacancies offered per course.
01, 02, 03	KW18	Selection processes	FR23	The system must include information about offered selection processes.
02, 04, 05, 06	KW19	Search types/Data filtering	FR24	The system must allow search and filter options.
2	KW20	Offered courses	FR25	The system must include information about offered courses.
03, 04	KW22	Historical data	FR26	The system must allow viewing of historical series data related to vacancies, admissions, enrollments, dropouts, and graduates.
03, 04	KW22	Historical data	FR27	The system must store data from previous years.
3	KW23	Date of requested data	FR28	The system must allow the generation of reports for a specific period defined by the user.
3	KW24	Data standardization	FR29	The system must include information and legends for criteria used in filters.
3	KW25	Auditable information	FR30	The system must allow querying the list of students included in the figures shown in the generated reports.
3	KW26	Information outside the database	FR31	The system must allow manual inclusion of information as some data is not available in the database.
3	KW27	Origin of idle vacancies	FR32	The system must allow monitoring of the number of idle vacancies by reason (non-occupation in selection process, cancellation, penalty, death, etc.).
4	KW28	External information sources	FR33	The system must allow importing standardized CSV files for integrating data not in academic management system.
4	KW29	External information sources	FR34	The system must allow manual inclusion of information requested by external superior bodies not present in the system (e.g., MEC, CGU, AGU).
4	KW31	Data updates	FR35	The system must allow real-time monitoring of the number of vacancies.
4	KW32	Data visualization types	FR36	The system must include charts and visual resources for undergraduate data.
5	KW33	Pending workload for student completion	FR37	The system must allow viewing of individual student information.
5	KW33	Pending workload for student completion	FR38	The system must allow viewing of the pending workload for student completion.
6	KW35	Comparative data with other HEIs	FR39	The system must allow viewing of comparative data on the university rates with other HEIs using information from the Census/INEP.
6	KW36	National admissions data	FR40	The system must allow viewing of comparative data on admissions with other HEIs using information from the Census/INEP.
6	KW36	Public information	FR41	The system must allow viewing of some information, such as numbers of admissions, graduates, and dropouts, on a public webpage.

Table 2: Functional Requirements

4.5 Data Model for the BI Solution

Figure 8 depicts the conceptual model for the BI solutions based on the stakeholders' requirements analysis.

Important knowledge in this model is related to vacancy management, a main concern of the academic sector in the university. A course opens a fixed amount of vacancies in each selection process. A vacancy is a spot that can be filled by a student. However, when a student egresses the course for any reason (e.g., course competition, internal or external transfer, withdrawal, or dismissal), the vacancy is opened again for a new student. A student can gain a vacancy by

Interview	Keyword ID	Keyword identified in interview	Non-Functional Requirement ID	Requirement
01, 02, 03, 04, 05, 06	KW11	Data integration	NFR01	Integration - The system must integrate information from the university's academic management systems.
01, 02, 03, 04, 05, 06	KW03	Report generation	NFR02	Availability - The system must allow report generation at any time.
01	KW13	Intuitive	NFR03	Usability - The system must be easy to use.
01, 02	KW15	Student status	NFR04	Privacy - The system must protect students' personal data, ensuring data anonymization.

Table 3: Non-Functional Requirements

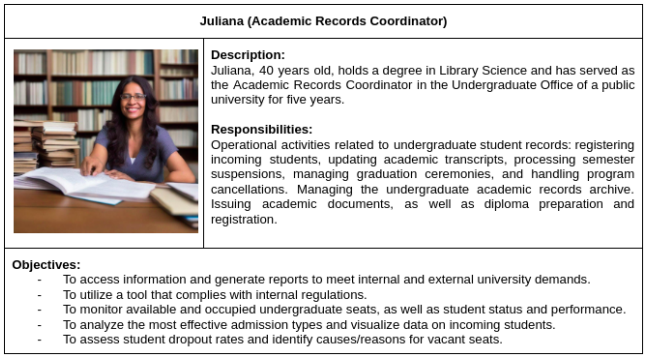

Figure 2: Persona representing the needs of the Academic Records Coordination

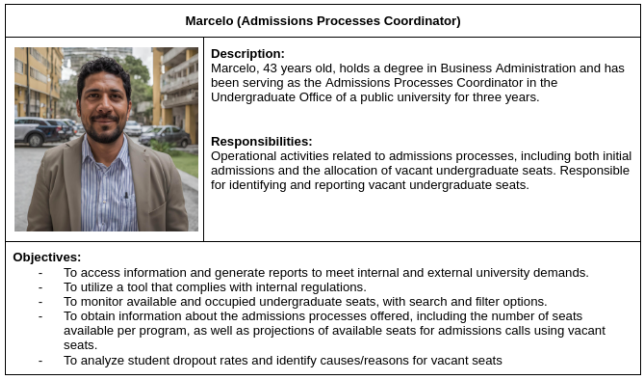

Figure 3: Persona representing the needs of the Admissions Processes Coordination

applying to a quotas group or through wide competition. A vacancy can have an occupied status when it is allocated to an active student. Otherwise, the vacancy can have one of the following statuses: idle when the student temporarily stops the course, blocked when the course decides not to offer such vacancy, or available when the vacancy is free to be used by a new student.

Another concern reported by the interviewed stakeholders is understanding students' performance and the reasons for idle vacancies and dropout rates. For this reason, the conceptual model proposed the class *student_performance*, which contains information (attributes) to understand the student's performance by subject. Moreover, the class *student_vacancy* includes the data to understand the vacancy status depending on the student's characterization of

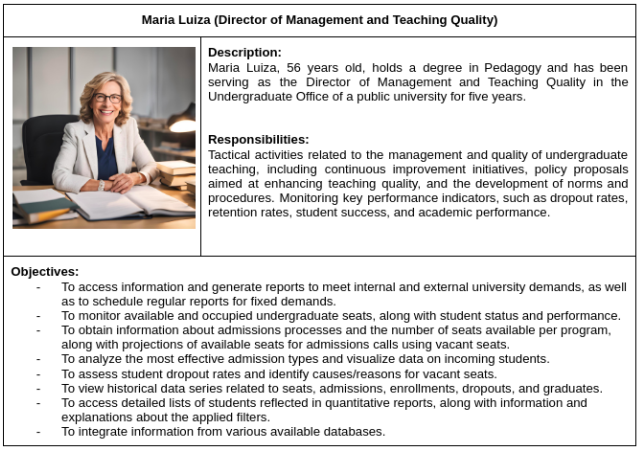

Figure 4: Persona representing the needs of the Directorate of Teaching Management and Quality

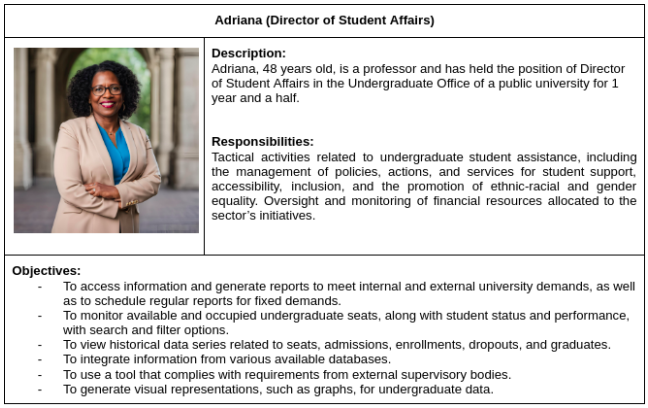

Figure 5: Persona representing the needs of the Directorate of Student Affairs

who uses such a vacancy over time. Students are characterized depending on the entrance and egress forms, enrollment and entry groups (by a specific quota or not), course grade, course load carried out, and the academic index (considering course failures).

5 Discussion

It was observed that, although the current Academic Management System used by the institution offers a wide range of functionalities and supports the operationalization of the university's academic

Rafael (Director of Academic Prospection)

Description:
Rafael, 38 years old, holds a degree in Business Administration and has been serving as the Director of Academic Prospection in the Undergraduate Office of a public university for three years.

Responsibilities:
Tactical activities related to academic prospection, including the implementation of initiatives for alumni tracking and fostering relationships and partnerships between the university and organizations operating in various fields of education.

Objectives:
- To access information and generate reports to meet internal and external university demands, as well as to schedule regular reports for fixed demands.
- To generate reports with filters for user-defined time periods.
- To utilize a tool that complies with internal regulations.
- To monitor available and occupied undergraduate seats, along with student status and performance, with search and filter options.
- To access individual student information.

Figure 6: Persona representing the needs of the Directorate of Academic Prospecting

Carlos (Vice-Rector of Undergraduate Studies)

Description:
Carlos, 65 years old, is a professor and has held the position of Dean of Undergraduate Studies at the Undergraduate Office of a public university for three years.

Responsibilities:
Strategic activities related to the Undergraduate Office, including coordination of institutional action programs, implementation of support measures for processes regarding the organization and operation of undergraduate programs, and academic activities. Preparation of management reports and risk management for the department. Supervision of activities carried out by subordinate sectors and undergraduate-related initiatives.

Objectives:
- To access information and generate reports to meet internal and external university demands.
- To utilize a tool that complies with internal regulations.
- To monitor available and occupied undergraduate seats, along with student status and performance.
- To analyze the most effective admission types and visualize data on incoming students.
- To assess student dropout rates and identify causes/reasons for vacant seats.
- To view comparative data and rates of admissions between the university and other higher education institutions.
- To make public information, such as enrollment numbers, graduates, and dropout rates, automatically available to external audiences.

Figure 7: Persona representing the needs of the Vice-Rector of Undergraduate Studies

management, some essential requirements are lacking. The inability to generate reports that fully meet the department's needs was highlighted by all interviewees.

A solution should enable the generation of various reports related to undergraduate activities, especially with flexible filtering options. The filtering criteria identified by stakeholders as critical include:

- Gender;
- Age;
- Race;
- Admission type (e.g., entrance exam type, quota or non-quota admission);
- Income;
- Type of high school attended (public or private);
- Student's hometown.

Additionally, the ability to generate quantitative reports over specific periods, with selections for the start year, graduation year, type of admission, and type of graduation, was deemed essential. Most of the data mentioned is already recorded in the current system; however, it cannot be queried through the system's interface.

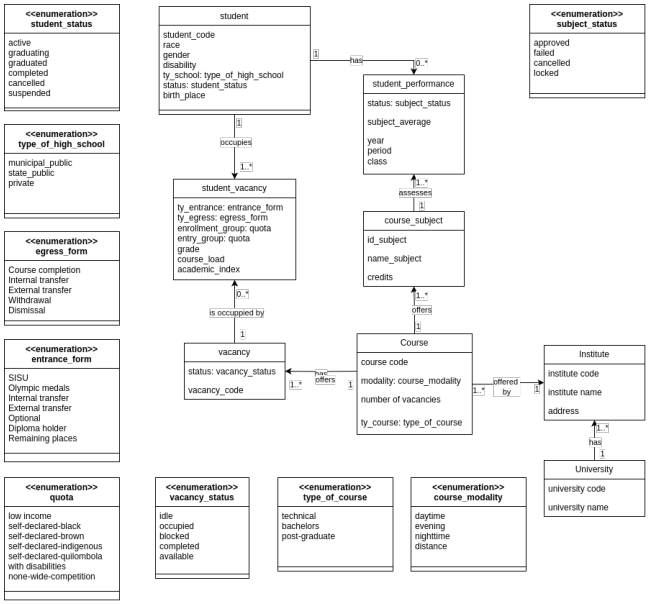

Figure 8: Conceptual model for the BI solution

Several interviewees reported that addressing both internal and external demands requires a considerable amount of operational effort. Even for simple information requests, such as obtaining the number of incoming, enrolled, and graduated students for a specific year, multiple reports must be generated and manually combined outside the system, typically using spreadsheets. In some cases, it is necessary to request assistance from the IT department for direct database extraction due to the lack of options in the system's interface.

Data integration issues were also widely mentioned by the interviewees. It was reported that separate data controls and even isolated systems are used for processes where the current system's functionality does not fully align with their needs. For instance, the admission process relies on an isolated system provided by another university, which only partially meets the requirements. Similarly, student aid data is managed using spreadsheets.

In this context, a BI tool that simplifies report generation and data integration could significantly reduce operational workload while directly supporting responses to information access requests and enhancing the university's active transparency efforts.

Several articles identified challenges in quickly obtaining data and accessing the necessary information as key motivations for implementing BI, which result in limitations and delays in retrieving information. The application of BI for improved data integration was specifically mentioned in [21, 29, 42].

The challenges and difficulties reported by the interviewees align with the issues and motivations identified in the articles analyzed in a Systematic Mapping Study previously conducted by the authors, currently under publication. Based on the benefits reported in the literature, the application of BI could benefit the university in the following aspects:

- Improved data management and integration;

- Enhanced information visualization and report generation;
- Better knowledge management and the ability to generate valuable insights about institutional performance, supporting decision-making;
- Increased academic efficiency and process automation;
- Faster response times to internal and external demands.

5.1 Stakeholders Expectations

From the conducted interviews, it became evident that stakeholders shared common expectations, particularly regarding improvements in the manner and speed of obtaining information and reports. Other expectations for improvement included standardization of concepts and data storage, adaptation of support tools to effectively handle all processes assigned to the department, the ability to generate auditable information and reports, and the use of system data to support decision-making processes.

5.2 Challenges

The application of BI in the sector faces several challenges, including:

- Data Integration: The university's Database Management System (DBMS) contains data from the current academic management system and the legacy system. Additionally, some older data are only available in physical format. There are also controls maintained outside the DBMS, typically in spreadsheets, due to the lack of functionality in the current system. Implementing a Data Warehouse would be necessary to consolidate all electronic data. This would directly contribute to the total Interoperability of the institution's systems, in accordance with Challenge 3 - Complexity of Information Systems of [4].
- Conceptualization Challenges: Interviewees reported issues with undefined concepts within the university, such as: what constitutes an unused seat and how long it should be considered unused; whether student admissions through non-standard processes (e.g., Undergraduate Student Agreement Program [PEC-G], exchange programs, judicial decisions, or ex officio transfers) should be included in admission statistics; which formulas should be used for calculating unused seats, completion rates, success rates, and other metrics. To address these issues, the tool would need to comply with internal regulations and Brazilian legislation, and all utilized parameters would need to be documented. Specific filters could also be employed to address this challenge.
- Privacy and Public Information Availability Challenges: In Brazil, the General Data Protection Law (LGPD), enacted in 2018 [9], regulates the handling of personal data. This may limit researchers' access to databases required for BI implementation. To address this, ethics committee (CEP) approval and the signing of responsibility agreements would be necessary. It is also essential to ensure that no personal or confidential information is made publicly available, employing techniques to protect data from unauthorized access. In return, the availability of public data that would be made possible with the tool would directly contribute to transparency, in accordance to Challenge 2 - Information Systems and the Open World Challenges of [4].
- Strategic Decision-Making Challenges: As a public institution, changes to policies and regulations are generally limited and require significant time to implement. Interviewees noted the absence of certain records that could be used to gain insights about students but are not currently available for entry in the system. High turnover in some departments, with frequent managerial changes, results in information loss and challenges in data standardization. Additionally, there may be resistance to change and cultural barriers to adopting a BI system. Standardizing data and providing regular training and capacity-building for managers and staff would be essential.
- Resource Challenges: Developing and implementing the BI tool may be hindered by a lack of financial, human, and technological resources. Support from the university's senior administration would be crucial for the successful implementation of a BI system.

5.3 Threats to Validity

The authors identify the following potential threats to the validity of this research:

(i) Interviewee Bias: Although semi-structured interviews with various questions were conducted, stakeholders may have provided responses they believed were more desirable to the interviewer rather than their genuine opinions or experiences. This could distort the collected data and affect the practical relevance of the identified requirements.

(ii) External Changes: Significant changes in legislation in the coming years or modifications to the academic management system used during the interviews could lead to shifts in the institution's requirements.

(iii) Stakeholder Changes: Although the personas method was employed to identify sector needs, high turnover and management changes may result in new stakeholders with differing perceptions. This could impact the practical relevance of the identified requirements.

(iv) External Validity: The results were specified based on the specific needs of the institution where the study was conducted. The identified requirements may not be directly applicable to other institutions, particularly universities with significant differences in size, organizational culture, structure, or context. This could limit the study's external validity.

6 Conclusion

This research was approved by the Ethics Committee with the code CAAE 76830423.0.0000.0356. This study aimed to gather requirements for a BI solution to support the academic management department of UNIFEI. Initially, an observational study was conducted to understand the department's operations. Subsequently, semi-structured interviews were carried out with key stakeholders. The interviews were then coded, and stakeholders' needs were identified. Finally, the requirements specifications were determined.

A total of 41 functional requirements and four non-functional requirements were identified, outlining the features a tool would need to meet the current needs of the undergraduate management sector. Such requirements were the basis for proposing an initial conceptual model that would guide the development of a further BI tool.

This research contributes to the specification and modeling of an information system for data, information, and knowledge management, applied to the domain of public higher education. The BI solution would allow the integration of data in the various systems used, contributing to interoperability. The tool would also enable the automation of service delivery and information processing, providing quicker and more precise responses to information access requests. Additionally, it would facilitate public information visualization, promoting active transparency within institutions.

Future work could explore the assessment of costs and impacts of BI implementation in the sector, the requirements for implementing a Data Warehouse, creating a reference architecture to guide the development of these BI solutions, and the application of BI in the department.

Acknowledgments

We express our gratitude to the UNIFEI for its support and for enabling the execution of this research. In particular, we extend our thanks to the staff members who agreed to participate in the interviews and directly contributed to this study.

Thanks to the Brazilian National Council for Scientific and Technological Development - CNPq (Process: 440425/2024-7) and the PRPI-USP (Process: 22.1.09345.01.2).

References

[1] Naiara Sandi Almeida Alcantara. 2023. Lei de Acesso à Informação nas principais universidades federais brasileiras. *Intercom: Revista Brasileira de Ciências da Comunicação* 46 (2023), e2023112.

[2] Ana Azevedo, José Manuel Azevedo, and Michelle Eiko Hayakawa. 2021. Designing and Implementing a Dashboard with Key Performance Indicators for a Higher Education Institution.. In *CSEDU (1)*. 165–172.

[3] Jacqueline Bichsel. 2012. *Analytics in higher education: Benefits, barriers, progress, and recommendations.* EDUCAUSE Center for Applied Research.

[4] Clodis Boscarioli, Renata Mendes de Araujo, Rita Suzana Maciel, Valdemar Vicente Graciano Neto, Flavio Oquendo, Elisa Yumi Nakagawa, Flavia Cristina Berrnardini, José Viterbo, Dalessandro Vianna, Carlos Bazilio Martins, et al. 2017. I GranDSI-BR: Grand Research Challenges in Information Systems in Brazil 2016-2026. (2017).

[5] Wadii Boulila, Muhib Al-Kmali, Mohammed Farid, and Hamzah Mugahed. 2023. A business intelligence based solution to support academic affairs: case of Taibah University. *Wireless Networks* (2023), 1–8.

[6] Wilson Castillo, Fernando Medina Quispe, and Francisco Fariña Molina. 2018. Una metodología para procesos data warehousing basada en la experiencia. (2018).

[7] Luz Yamile Caicedo Chacón, Cristian Noé Cárdenas Parra, Juan Sebastián Müller Rueda, and Jeniffer Tatiana Ortiz Bernal. 2019. Aplicación para la gestión y el análisis de información relacionada con la deserción estudiantil universitaria. *Revista Colombiana de Computación* 20, 2 (2019), 6–19.

[8] Presidência da República do Brasil. 2011. *LEI Nº 12.527, DE 18 DE NOVEMBRO DE 2011.* Casa Civil. Subchefia para Assuntos Jurídicos., Brasília, Brasil. https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2011/lei/l12527.htm

[9] Presidência da República do Brasil. 2018. *LEI Nº 13.709, DE 14 DE AGOSTO DE 2018.* Casa Civil. Subchefia para Assuntos Jurídicos., Brasília, Brasil. https://www.planalto.gov.br/ccivil_03/_ato2015-2018/2018/lei/l13709.htm

[10] Ernani Vinicius Damasceno, Ana Azevedo, and Agostinho Sousa Pinto. 2018. Business Intelligence-Implantation on Federal Institute of Triângulo Mineiro (IFTM) System. In *In Proceedings of the 10th International Conference on Computer Supported Education (CSEDU 2018)-Volume 2*. 528–535.

[11] Abdelhamid El Malki and Samira Touate. 2024. An overview of human and organizational determinants in business intelligence adoption. *Multidisciplinary Reviews* 7, 11 (2024). https://doi.org/10.31893/multirev.2024253 Cited by: 0.

[12] José Carlos Abbud Grácio. 2012. Preservação digital na gestão da informação: um modelo processual para as instituições de ensino superior. *http://hdl. handle. net/11449/144956* (2012), 214–p.

[13] Jolana Gubalová. 2015. The use of Business Intelligence Tools for leadership and university administration. In *2015 13th International Conference on Emerging eLearning Technologies and Applications (ICETA)*. IEEE, 1–7.

[14] Preeti Gupta, Deepti Mehrotra, and TK Sharma. 2015. Identifying knowledge indicators in higher education organization. *Procedia Computer Science* 46 (2015), 449–456.

[15] Waqar Haque. 2018. An Interactive Framework to Allocate and Manage Teaching Workload using Hybrid OLAP Cubes. In *2018 IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)*. IEEE, 694–700.

[16] Olival de Gusmão Freitas Júnior, Victor Diogho Heuer de Carvalho, Petrucio Antonio Medeiros Barros, and Marcus de Melo Braga. 2022. Uma Experiência com Business Intelligence para apoiar a Gestão Acadêmica em uma Universidade Federal Brasileira. *Revista Ibérica de Sistemas e Tecnologias de Informacão* 46 (2022), 5–20.

[17] Dorina Kabakchieva. 2015. Business intelligence systems for analyzing university students data. *Cybernetics and Information Technologies* 15, 1 (2015), 104–115.

[18] Sergei Karabtsev, Roman Kotov, Ivan Davzit, and Evgeny Gurov. 2023. Building data marts to analyze university faculty activities using power BI. In *E3S Web of Conferences*, Vol. 419. EDP Sciences, 02014.

[19] Devi Karolita, Jennifer McIntosh, Tanjila Kanij, John Grundy, and Humphrey O. Obie. 2023. Use of personas in Requirements Engineering: A systematic mapping study. *Information and Software Technology* 162 (2023), 107264. https://doi.org/10.1016/j.infsof.2023.107264

[20] Adler Looks Jorge. 2005. Dealing with interviews when creating Personas: a practical approach. *Student Interaction Design Research Conference (SIDER05)* (January 2005), 129 – 138.

[21] Zhanl Mamykova, Mukhtar Bolatkhan, Oksana Kopnova, Malika Zubairova, Natalya Surina, and Shyngys Rabat. 2021. Development of the information and analytical system of the university. *Journal of Mathematics, Mechanics and Computer Science* 112, 4 (2021).

[22] Hichem Mezhoud. 2024. *Requirements of adopting SMEs for business intelligence systems: A field study in the industrial zone of setif in Algeria.* 125 – 154 pages. https://doi.org/10.4018/979-8-3693-1846-1.ch007 Cited by: 0.

[23] Amalia R Miller and Catherine Tucker. 2014. Health information exchange, system size and information silos. *Journal of health economics* 33 (2014), 28–42.

[24] Dedy Mirwansyah, Dewi Wulan Sari, et al. 2021. Implementation of Business Intelligence in Data and Information for Student Admission Process in Mulia University. In *Journal of Physics: Conference Series*, Vol. 1807. IOP Publishing, 012015.

[25] Oswaldo Moscoso-Zea, Sergio Luján-Mora, et al. 2016. Datawarehouse design for educational data mining. In *2016 15th International Conference on Information Technology Based Higher Education and Training (ITHET)*. IEEE, 1–6.

[26] Harold Arturo Combita Niño, Johana Patricia Cómbita Niño, and Roberto Morales Ortega. 2020. Business intelligence governance framework in a university: Universidad de la costa case study. *International Journal of Information Management* 50 (2020), 405–412.

[27] James A. O'Brien and George M. Marakas. 2013. *Administração de sistemas de informação.* (15a ed.). Mc Graw Hill., Porto Alegre, Brasil.

[28] Vincent Koon Ong, Yanqing Duan, and Stephen Jackson. 2012. Supporting institutional decision making with an intelligent student engagement tracking system. IADIS International Conference Information Systems.

[29] Malhena Sánchez Peralta. 2018. Business Intelligence in E-learning, a case study of an Ecuadorian University. In *2018 XIII Latin American Conference on Learning Technologies (LACLO)*. IEEE, 29–32.

[30] Roger S. Pressman. 2011. *Engenharia de Software. Uma Abordagem Profissional.* (7a ed.). The McGraw-Hill Companies, Inc., São Paulo, Brasil.

[31] Marko Pribisalić, Igor Jugo, and Sanda Martinčić-Ipšić. 2020. Selecting a business intelligence solution that is fit for business requirements. *32nd Bled eConference Humanizing Technology for a Sustainable Society, BLED 2019 - Conference Proceedings* (2020), 443 – 465. https://doi.org/10.18690/978-961-286-280-0.24 Cited by: 5; All Open Access, Bronze Open Access.

[32] Hifza Qureshi, Anil Kumar Sagar, Rani Astya, and Gulshan Shrivastava. 2021. Big Data Analytics for Smart Education. *2021 IEEE 6th International Conference on Computing, Communication and Automation, ICCCA 2021* (2021), 650 – 658. https://doi.org/10.1109/ICCCA52192.2021.9666389 Cited by: 2.

[33] Rémi Rampin and Vicky Rampin. 2021. Taguette: open-source qualitative data analysis. *Journal of Open Source Software* 6, 68 (2021), 3522. https://doi.org/10.21105/joss.03522

[34] Caio Eduardo Ribeiro and Anna Izabel Joao Tostes Ribeiro. 2015. Methodology for generation of business intelligence platforms to university evaluation committees. In *Proceedings of the annual conference on Brazilian Symposium on Information Systems: Information Systems: A Computer Socio-Technical Perspective-Volume 1*. 187–194.

[35] Alessandro Marco Rosini and Angelo Palmisano. 2016. *Administração de sistemas de informação e a gestão do conhecimento.* (2a ed.). CENGAGE Learning., São Paulo, Brasil.

[36] Taha Samad-Soltani, Marjan Ghazisaeedi, Hossein Masoumi-Asl, Peyman Rezaei-Hachesu, Kayvan Mirnia, and Reza Safdari. 2017. A general approach to extract the business intelligence requirements of bio-surveillance systems. *Annals of Tropical Medicine and Public Health* 10, 4 (2017), 816 – 820. https://doi.org/10.4103/ATMPH.ATMPH_258_17 Cited by: 1.

[37] Robert J SÊNCHEZ-TICONA, Oscar R ALCÊNTARA-MORENO, José A GOMEZ-AVILA, Marcelino TORRES-VILLANUEVA, Jhordan M ROMERO-ARCE, and Juan P SANTOS-FERNÊNDEZ. 2023. Inteligencia de negocios y la dinamización de la toma de decisiones en la gestión de egresados de una universidad estatal peruana. *gestión* 60 (2023), 37.

[38] Forrest Shull, Janice Singer, and Dag I. K. Sjøberg. 2007. *Guide to Advanced Empirical Software Engineering.* Springer London. 388 pages. https://doi.org/10.1007/978-1-84800-044-5 Cited by: 0.

[39] Christian Siemen, Nico Clever, Benjamin Barann, and Jörg Becker. 2018. Requirements elicitation for an inter-organizational business intelligence system for small and medium retail enterprises. *Proceeding - 2018 20th IEEE International Conference on Business Informatics, CBI 2018* 1 (2018), 129 – 138. https://doi.org/10.1109/CBI.2018.00023 Cited by: 11.

[40] M. Skjott Linneberg and S. Korsgaard. 2019. Coding qualitative data: a synthesis guiding the novice. *Qualitative Research Journal* 19, 3 (2019), 259–270. https://doi.org/10.1108/QRJ-12-2018-0012

[41] Ian Sommerville. 2011. *Engenharia de Software.* (9a ed.). Pearson Education do Brasil., São Paulo, Brasil.

[42] Ramos Somya, Danny Manongga, and Magdalena A Ineke Pakereng. 2018. Service-oriented business intelligence (SoBI) for academic and financial data integration in university. In *2018 International Seminar on Application for Technology of Information and Communication.* IEEE, 1–5.

[43] Miguel A. Teruel, Roberto Tardío, Elena Navarro, Alejandro Maté, Pascual González, Juan Trujillo, and Rafael Muñoz-Terol. 2014. CSRML4BI: A goal-oriented requirements approach for collaborative business intelligence. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 8824 (2014), 423 – 430. https://doi.org/10.1007/978-3-319-12206-9_36 Cited by: 4.

[44] William Villegas-Ch, Xavier Palacios-Pacheco, and Sergio Luján-Mora. 2020. A business intelligence framework for analyzing educational data. *Sustainability* 12, 14 (2020), 5745.

[45] Claes Wohlin, Per Runeson, Martin Höst, Magnus C Ohlsson, Björn Regnell, and Anders Wesslén. 2012. *Experimentation in Software Engineering.* Springer, Germany. https://doi.org/10.1007/978-3-642-29044-2

[46] Mudasser Fraz Wyne, Jodi Reeves, Frank Xavier Montes, and Tom J Gurbach. 2015. Business Intelligence Dashboard for Academic Program Management. In *2015 ASEE Annual Conference & Exposition.* 26–312.

[47] Luzia Zorzal. 2016. Transparência das informações das universidades federais: estudo dos relatórios de gestão à luz dos princípios de boa governança na Administração Pública Federal. (2016). https://doi.org/10.26512/2015.12.T.19202