Systematic review of process management and interoperability for higher education institutions

Revisão sistemática sobre gestão de processos e interoperabilidade para instituições do ensino superior

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Abstract
This research presents a systematic literature review focused on process management and interoperability in Higher Education Institutions in Brazil, highlighting the need to enhance strategic decisions through effective management practices and the use of interoperability. It identifies a significant gap in the literature regarding efficient management methods in educational institutions, despite the urgency to address risks and promote sustainability. The findings suggest categorizations of technical, syntactic, semantic, and organizational interoperability, each with specific barriers that need to be overcome to optimize educational administration. The study concludes that improvements in process management and interoperability can bolster the administration of educational institutions, making them more resilient and capable of effectively handling operational and strategic challenges.
Keywords: interoperability; process management; sustainability.

Resumo
A pesquisa apresenta uma revisão sistemática da literatura focada na gestão de processos e interoperabilidade em Instituições de Ensino Superior no Brasil, destacando a necessidade de melhorar as decisões estratégicas através de práticas de gestão eficazes e uso de interoperabilidade. Evidencia-se uma lacuna significativa na literatura sobre métodos eficientes de gestão nas instituições de ensino, apesar da urgência em enfrentar riscos e promover sustentabilidade. Os resultados sugerem categorizações de interoperabilidade técnica, sintática, semântica e organizacional, cada uma com barreiras específicas que devem ser superadas para otimizar a administração educacional. O estudo conclui que aprimoramentos na gestão de processos e na interoperabilidade podem fortalecer a administração das instituições de ensino, tornando-as mais resilientes e capazes de lidar com desafios operacionais e estratégicos de forma eficaz.
Palavras-chave: interoperabilidade; gestão de processos; sustentabilidade.

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1 Introduction

According to data from the Higher Education Census of 2022, there are 2,595 Higher Education Institutions (HEIs) in Brazil, of which 2,283 (87.98%) are private. Among these, 1,449 (55.8%) are for-profit, and 834 (32.1%) are non-profit. In contrast, public institutions total 312 (12.02%), with state HEIs predominant at 133 units (5.1%), followed by federal ones at 120 (4.6%) and municipal at 59 (2.3%). Given this panorama, it becomes imperative to reflect on the management of HEIs, especially the private ones, whose management should be guided by principles of sustainability and institutional permanence.

The literature indicates that levels of uncertainty in strategic decision-making represent a significant challenge for the maintainers and managers of HEIs. For example, Monteiro & Braga (2005) point out that strategic decisions in marketing, investment, and technology are less than 50% successful in the educational sector. This scenario is exacerbated by a scarcity of market data, misinterpretations of information, absence of strategic planning, and internal conflicts.

In the realm of process management practices, responsible adoption can mitigate risks and amplify benefits, ensuring both social responsibility and financial sustainability of institutions. The dimension of social responsibility, as articulated by Silva (2009) in the context of the National System of Evaluation of Higher Education (SINAES), encompasses the contribution of HEIs to social inclusion, economic and social development, defense of the environment, and preservation of cultural heritage.

Besides their fundamental role in education and research, HEIs should act as multipliers of sustainable practices on a local scale, as already pointed out in the first International Conference on Environmental Management for Sustainable Universities (EMSU) in 2002. Careto & Vendeirinho (2003, cited in Tauchen, 2007) argue for an alignment between what universities teach and their internal practices. Even without the breadth of an industry, this extends to the management of their environmental impacts (Santos et al., 2020) and the incorporation of sustainable practices through the management of internal control processes and data interoperability.

Thus, the management processes of these institutions should be grounded in principles and concepts disseminated in the literature. However, a clear overview of this literature is lacking, which could indicate the topics of greatest interest to authors and provide directions for institution leaders.

In light of this, this study seeks to develop a systematic literature review (SLR) focused on process management, university management, and interoperability within HEIs. Interoperability can be conceptualized as the ability of two or more systems to exchange information between them and utilize it (Pingaud, 2009a; Sun and Xie, 2019; Wagemans and Johnson, 2020). Therefore, this review aims to elucidate the state of the art of these critical topics and provide a clear view of the paths to be followed to enhance administrative practices in HEIs.

The goal of this article is, therefore, to explore three crucial dimensions of HEI administration (process management, university management, and interoperability) through a systematic literature review, involving specific criteria and encompassing broad-spectrum databases, whose definitions will be presented during the article, especially in section 3.

It should be noted that this study has a significant practical contribution to the field, as it seeks to present the literature on the subject, with solutions supported by existing information

technologies (Feitosa et al., 2014; Chen et al., 2021; Costa and Oliveira, 2022; Saghiri et al., 2022), as in the case of interoperability between management information systems, which should show institutions the importance of the topic and, possibly, lead them to improve their processes (Ribeiro and Santos, 2019; Carvalho and Almeida, 2021).

This study underscores the importance of competitive intelligence and environmental analysis in the face of challenges from poorly structured scenarios that can generate significant uncertainty. Duncan (1972) attributes uncertainty to the complexity and dynamism of the organizational environment. Thus, literature reviews suggest that the effective use of environmental information for study and knowledge generation can mitigate uncertainties, including market-related ones. Campos (2007 cited in Feitosa; 2010) highlights that professionals well-informed about their work environment tend to experience lower levels of uncertainty.

2 Related Works

This section presents a preliminary review of the concepts and related works on process management, university management, and interoperability, serving as the starting point for the systematic literature review (SLR) proposed in this article. The research strategy adopted follows the recommendations of Kitchenham & Charters (2007), who clarify that research strategies are often iterative, beginning with preliminary surveys aimed both at identifying existing systematic reviews and at assessing the volume of potentially relevant studies.

In line with Costa et al. (2016), this SLR study will start with a preliminary survey. The purpose of this section, then, is to highlight the most relevant topics on process management, university management, and interoperability discussed in the literature. This initial research will constitute a foundational base for the SLR that will develop in the following sections.

In this regard, the research began with an analysis of the concept of interoperability, historically linked to software issues. According to Geraci (1991), interoperability is defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged." Building on this definition, Chen et al. (2008) expand the concept to encompass broader dimensions, covering from interoperability within a single company to collaborative networks.

Pingaud (2009a) offers a contemporary view by describing interoperability as the "ability of systems, natively unknown to each other, to interact among themselves to establish harmonious and intentional collective behaviors, without significantly altering their structures or individual behaviors." This definition emphasizes the capacity for adaptation and integration between different systems, a central aspect for university management in a context of advanced technology.

In the context of analyzing interoperability in Brazilian federal universities, Ribeiro and Santos (2019) suggest the need for the advancement of institutional policies and greater investment in technological infrastructure.

Wagemans and Johnson (2020) address the challenges and potential solutions for data interoperability in higher education. The authors identify problems such as the fragmentation of information systems and propose solutions based on open standards and system integration to improve the management of academic data. These results are corroborated by Souza and Silva (2020), who examine the interoperability between academic management systems in Brazilian universities. These findings are also supported by Lima and Pereira (2020).

Carvalho and Almeida (2021) present the challenges and solutions for interoperability in higher education institutions in Brazil. That work suggests a model based on middleware technologies to facilitate the integration between different educational systems. The findings in that work align with the findings of Costa and Oliveira (2022).

Interoperability can be divided into four main types: technical, syntactic, semantic, and organizational. This article focuses on organizational interoperability (OI), which Yahia (2011) defines as the creation of "business interfaces" that consider the roles of interacting actors and entities. Chen and Shorter (2008) add that OI deals with three main issues: interoperability concerns, barriers, and approaches. The term "concerns" is used in the sense of attention or interest in an issue, in contrast to "worry," which indicates existing problems causing distress.

Finally, interoperability frameworks are also vital in the literature (Chen et al., 2008), with emphasis on models such as LISI, EIF - European Interoperability Framework (Guedria, 2012), AIF - ATHENA Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Applications (Vernadat, 2009), IDEAS (Chen et al., 2008), and INTEROP NoE (Chen et al., 2008). These frameworks are fundamental for understanding the approaches and methods applied in the practice of interoperability and will be detailed in Section 4, which presents the results of the SLR.

3 Methodology

This section details the fundamental concepts of the Systematic Literature Review (SLR) employed in this study, which focuses on university management and data interoperability. The SLR is a well-established methodology that allows for a structured and objective survey of the state of the art in a specific area, grounded on a clearly defined research question (Kitchenham, 2004; Kitchenham & Charters, 2007; Keele, 2007; Green et al., 2008; da Costa et al., 2016). In this regard, Petersen et al. (2008) emphasize that, although traditionally associated with medical research, the SLR is equally applicable to other fields such as software engineering, where it can reveal valuable insights not yet fully explored.

The SLR differs from traditional reviews by starting with a defined protocol that details research questions, review methods, and search strategies to optimize relevance and coverage (Kitchenham & Charters, 2007). This methodology requires specific inclusion/exclusion criteria for studies, information to be extracted, and quality criteria for assessment.

The SLR process in this study follows a structured protocol in Planning, Conducting the Review, and Disseminating Results, based on the guidelines of Kitchenham & Charters (2007), adapted for computer science in education (Van der Braak et al., 2022).

Specifically, regarding this study, the following stages were followed in the SLR process:
1. Preliminary literature survey;
2. Definition of theoretical constructs and descriptors to research;
3. Selection of databases for research;
4. Segmentation of the search into categories;
5. Definition of search filters by category;
6. Organization and tabulation of results;
7. Selection of articles, discarding those not related to the theme;
8. Reading the abstracts of selected articles;
9. Final selection of articles.

This method allows not only a deep understanding of the state of the art on the researched topic but also the identification of pathways for future research. In the next section, the results of this rigorous search process will be presented, discussing the selected articles and the key points addressed by the literature on university management and interoperability.

4 Results and Discussion

The executed SLR focused on the careful identification and analysis of scientific knowledge in process management and interoperability, as established by Ferenhof and Fernandes (2016, p. 551): "a method of scientific investigation with a rigorous and explicit process to identify, select, collect data, analyze, and describe the relevant contributions to research."

Stage 1: Preliminary Literature Survey
The results were organized into three main categories for better structuring of the data found: Process Management and University Management, Catalogs of Theses and Dissertations, and Studies on Interoperability.

Stage 2: Theoretical Constructs and Descriptors
The descriptors used for the bibliographic search are detailed in Table 1, ensuring broad coverage of relevant themes in the titles, abstracts, and keywords of the documents analyzed.

Table 1

Descriptors for Process Management, University Management, and Interoperability

Groups	Descriptors
Group1	higher education institutions OR educational management OR university management OR universidad gestión OR universities OR higher education institutions OR instituciones de enseñanza superior OR higher education institution OR institución de enseñanza superior.
Group 2	process management OR process architecture OR process mapping OR mapeo de procesos OR gestión de procesos OR process portfolio OR BPM OR CBOK.
Group 3	interoperability definitions OR types of interoperability OR interoperability concerns OR interoperability barriers OR interoperability frameworks OR organizational interoperability assessment (AIO).

Source: Developed by the authors.

Stage 3: Consulted Databases
Diverse databases such as Redalyc, Oasis, Scielo, EbscoHost, Scopus, Web of Science, and the Capes Catalog of Dissertations and Theses were used.

Stages 4 to 7: Search Details and Filtering

The search was rigorously categorized and filtered. Applied filters included specific periods, languages (Portuguese and Spanish), and academic areas such as Business and Accounting, Education, and Social Sciences. Additionally, Table 2 presents the descriptors used.

Table 2

Base Descriptors Applied for Process Management, University Management

Groups	Descriptors
Group1	higher education institutions OR educational management OR university management OR universidad gestión OR universities OR higher education institutions OR instituciones de enseñanza superior OR higher education institution OR institución de enseñanza superior.
Group2	process management OR process architecture OR process mapping OR mapeo de procesos OR gestión de procesos OR process portfolio OR BPM OR CBOK.

Source: Developed by the authors.

Stage 8: Reading the Abstracts of Selected Articles
   This stage involved a systematic review in process management and interoperability, highlighting procedures and findings across various databases after initial selection by title:
Redalyc: Began with 5,138 publications, refined to 1,154 after filtering. Data such as title, authors, and links were tabulated for analysis.
Oasisbr: Resulted in 41 works, reduced to nine after removing duplicates and temporal adjustments.
Scielo: Seven articles were found, but none were relevant after reviewing titles and abstracts.
EBSCOhost: Four articles were identified; two were selected for their relevance.
Scopus: Found no articles directly related to the used descriptors.
Web of Science: Out of six articles, two were considered pertinent.

Stage 9: Final Selection of Articles
The process of filtering the articles, and the respective databases adhering to the theme of process management and university management, is presented in Table 3.

Table 3

Bibliographic Portfolio: Articles on Process Management and University Management

Authors	Databases
Brodbeck & Hoppen (2016); Farias Filho et al. (2014); Santos et al. (2014); Lacerda et al. (2012); Rojas et al. (2011); Pereira (2011)	REDALYC
Novoa & Gilart (2016); Salgado et al. (2013);	EBSCOHST
Moreno & Santos (2012); Oliveira et al. (2010)	Web of Science

Source: Developed by the authors.

4.1 Results from Catalogs of Theses and Dissertations on the Theme of Process Management and University Management

The publication base on theses and dissertations was considered separately as these are, as a rule, more comprehensive and in-depth studies, particularly theses, compared to general articles.

Theses and dissertations were extracted from the extensive Catalog of Theses and Dissertations of the Coordination for the Improvement of Higher Education Personnel (CAPES), which compiles academic works since 1987. During the investigation period from June 29, 2021, to August 28, 2022, using the descriptors specified in Table 1, 1,587 relevant works were identified. Subsequently, to refine the search and ensure the relevance of the data for this research, multiple filters were applied, the results of which are systematized in Table 4:

Table 4

Results from the Catalog of Theses and Dissertations by Characterization of Filters

Filter Characterization	Result
a) Types of work (Theses, Academic and Professional Master's Dissertations)	1,434
b) Year (2010 to 2021)	932
c) Broad Area: Applied Social Sciences; Engineering; Multidisciplinary	473
d) Knowledge Area: business administration; business management; public administration; information science; production engineering; engineering/technology/management; education; interdisciplinary.	331

Source: Developed by the authors.

Initially, a critical reading of the titles was conducted to eliminate records that were not directly related to the topic. This stage reduced the set to 120 records, including one thesis and 119 dissertations. Subsequently, the abstracts were analyzed, which allowed for the selection of 30 dissertations that were aligned with the objectives of this research. These works were organized for detailed analysis of the full text, as demonstrated in Table 5.

Table 5

Results from the Catalog of Theses and Dissertations

Authors	Graduate Programs	Institutions
Aires, D. (2015)	Eng. de Produção	UNESP (Bauru)
Bonilha, A. O. (2016)	Administração Pública Em Rede Nacional	UFMT
Lorena, A. L. F. (2015)	Eng. de Produção	UFPE

Schlosser, A. L. C. (2014)	Administração.	UFSM
Moreira, E. A. (2016)	Gestão Pública	UFRN
Aredes, E. L. (2014)	Administração	USP (Ribeirão Preto)
Silva, F. F. B. (2014)	Administração	UDESC
Shigunov, F. (2016)	Ppgau	UFSC
Soso, F. A. (2016)	Administração	UNISINOS
Branco, G. M. (2016)	Eng. de Produção	UFRGS
Koch, G. V. (2016)	Eng. de Produção	URGS
Rodrigues, G. O. (2016)	Eng. de Produção	UNESP (Bauru)
Torres, I. S. (2015)	Eng. de Produção	UFRGS
Silva, J. J. S. (2013)	Eng. de Produção	UFPE
Oliveira, L. C. S. (2015)	Administração	UDESC
Souza, L. S. (2016)	Gestão Pública	UnB
Gissoni, L. R. M. (2016)	Administr. Pública em Rede	UNIFENAS MG
Ellwanger, M. C. (2011)	Sistemas e Processos Industriais	UNISC
Leonardeli, M. A. (2015)	Gestão de Políticas e Organiz.Públicas	UNIFESP
Piovesan, M. L. (2016)	Gestão de Organizações Públicas.	UFSM
Garcia, M. J. (2015)	Administração de Organiz.	USP (Ribeirão Preto)
Albuquerque, M. C. (2015)	Eng. de Produção	UFPE
Souza, M. G. S. (2016)	Eng. de Produção.	UFAM
Junior, M. A. S. (2013)	Administração de Organiz.	USP (Ribeirão Preto)
Jaques, N. D. (2015)	Gestão e Estratégia	UFRRJ
Rosa, S. A. (2014)	Sistemas de gestão	UFF
Silva, S. O. (2014)	Administração de Organiz.	USP (Ribeirão Preto)
Costa, S. A. (2015)	Sistemas de gestão	UFF
Pradella, S. (2011)	Sistemas e Processos	UNISC

Source: Developed by the authors.

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4.2 Results on Studies About Interoperability

A significant portion of the research focused on the theme of interoperability, which is one of the main focuses of this study.

Stage 2: Theoretical Constructs and Descriptors on Interoperability

In this case, theoretical constructs specific to interoperability were defined, as below, and searches were conducted based on these constructs:

Theoretical Construct 1: Definitions of Interoperability;

Theoretical Construct 2: Types of Interoperability;

Theoretical Construct 3: Concerns (or points of attention) of Interoperability;

Theoretical Construct 4: Barriers of Interoperability;

Theoretical Construct 5: Frameworks of Interoperability;

Theoretical Construct 6: Assessment of Organizational Interoperability (AIO).

Thus, search descriptors were made from these theoretical constructs, as shown in Table 6, presented next.

Table 6

Base Descriptors Applied to Constructs of Interoperability

Groups	Descriptors
Group 3	definitions of interoperability OR types of interoperability OR concerns of interoperability OR barriers of interoperability OR frameworks of interoperability OR assessment of organizational interoperability

Source: Developed by the authors.

Stage 9: Final Selection of Articles on Interoperability

The results for each of the constructs are presented next.

Theoretical Construct 1: Definitions of Interoperability

Table 7 presents the search results for this theoretical construct.

Table 7

Bibliographic Portfolio: Definitions of Interoperability

Authors	Publication Vehicle
Guedria, W. A (2012)	Thesis (PhD) - University of Bordeaux, Bordeaux, France, 2012.
Geraci (1991)	Institute of Electrical and Electronics Engineers, NY
Pingaud, H. (2009)	8$^{\text{ème}}$ Congrès International de Génie Industriel, CIGI09'
Chen & Shorter (2008)	CEN/ISO 11354 In: INTEROP-Vlab Standardisation Workshop I-ESA 08,"Standards For Interoperability–How.

Charalabidis et al. (2010)	In: Enterprise Interoperability IV. London: Springer- Verlag, p. 419-428
EIF (2004)	European Commission - ISA
EIF (2010)	European Commission - ISA

Source: Developed by the authors.

The studies analyzed indicate that interoperability is an omnipresent concept that varies significantly in interpretation and application, making a universal definition challenging (Guedria, 2012). Traditionally linked to software, Geraci (1991) defines interoperability as the ability of systems to exchange and use information. This concept has evolved to include various dimensions, from business operations to collaborative networks, enabling harmonious interactions without significant structural changes (Chen et al., 2008; Pingaud, 2009). In this context, Charalabidis et al. (2010) and the EIF (2010) emphasize its relevance in organizational information systems, highlighting the potential for increasing productivity and cooperation among organizations through established standards (Framework, 2004).

Table 8 synthesizes the main definitions of interoperability found in the literature.

Table 8

Definitions of Interoperability

Sources	Definitions of Interoperability
Geraci (1991)	"The ability of two or more systems or components to exchange information and to use the information that has been exchanged."
ISO (1993)	"The ability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units."
Vernadat (1996)	"The ability of a system to communicate with systems of its peers and access their functionalities."
LISI - Levels of Information Systems Interoperability (C4ISR, 1998)	"The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively together."
WordNet 2.1	"Interoperability: (computing) the ability to exchange and use information (usually in a large heterogeneous network made up of several local area networks)."
EIF - European Interoperability Framework (EIF, 2004)	"Interoperability is the ability of an information and communication technology (ICT) system and the business processes it supports to exchange data and enable the sharing of information and knowledge."
LEGNER & WENDE (2006)	"The ability to share information between business partners, understand and process exchanged data, and seamlessly integrate it into internal IT systems with the goal of creating value."
TOGAF - The Open Group Architecture	"(1) The ability to share information and services. (2) The ability to exchange and use information between two or more systems or components. (3) The ability of systems to provide and receive services from

Framework (Open Group, 2009)	other systems and to use the services so exchanged to enable them to operate effectively together."
ISO 11354-1 (2011)	"The capability of businesses and the entities within those businesses to communicate and interact effectively."
Merriam Webster Dictionary (2018)	"The capability of a system to work with or use the parts or equipment of another system."
Dicionário Oxford	"Interoperability is the ability to operate in conjunction."

Source: Developed by the authors.

Theoretical Construct 2: Types of Interoperability

Table 9 shows the results of the search on Theoretical Construct 2.

Table 9

Bibliographic Portfolio: Concepts and Types of Interoperability

Authors	Publication Vehicles
Chalmeta et al. (2001)	The Journal of Systems and Software, ed. 57,
Charalabidis et al. (2008)	Proceedings - 12th Pan-Hellenic Conference on Informatics
Charalabidis (2010)	In: Enterprise Interoperability IV. London: Springer- Verlag, p. 419-428
Loures, E. (2018)	PPGEPS- PhD; PUC-PR
Chen, D. (2006)	EMOI - INTEROP'06, In: Proceedings of the Open Interop Workshop on Enterprise Modelling and Ontologies for Interoperability
Levine, L. et al. (2003)	Proceedings of the System of Systems Interoperability Workshop
van der Veer, H. &Wiles, A. (2008)	European telecommunications standards institute
Metcalf, C. & Lewis, G. (2006)	Integration of Software-Intensive Systems Initiative
Hall, J. & Koukoulas, S. (2008)	International Conference on e-Business
Yahia, E. (2011)	PhD Thesis. Sciences de l'ingénieur [physics]. Université Henri Poincaré - Nancy 1, 2011. França. ffNNT : 2011NAN10049ff. Ff, tel-01746201v2f
Vernadat, F. B. (1996)	Chapman & Hall
Chen & Shorter (2008)	In: INTEROP-Vlab Standardisation Workshop I-ESA 08,"Standards For Interoperability–How

Source: Developed by the authors.

Interoperability can be divided into four categories: technical, syntactic, semantic, and organizational (Levine et al., 2003; Chen, 2006).

Technical interoperability involves the effective exchange of information between electronic systems, utilizing specific hardware, software, and protocols (Levine et al., 2003). Syntactic interoperability, defined by Van der Veer & Wiles (2008), allows for the sharing of data with clear syntax for understandable communication between systems. Semantic interoperability, according to Metcalf & Lewis (2006), focuses on the common understanding of data, essential for the interpretation of content by machines (Hall & Koukoulas, 2008; van der Veer & Wiles, 2008).

Organizational, or Enterprise Interoperability (Yahia, 2011), coordinates processes and actors for efficient interactions and is linked to the alignment of information architectures with organizational goals, crucial for innovation and cost reduction (Vernadat, 1996; Charalabidis et al., 2008; van der Veer & Wiles, 2008).

As illustrated in Figure 1, IO addresses three main topics: Concerns (or points of attention) of Interoperability; Barriers of Interoperability; Approach to Interoperability (Chen & Shorter, 2008).

Figure 1

Overview of IO Concepts.
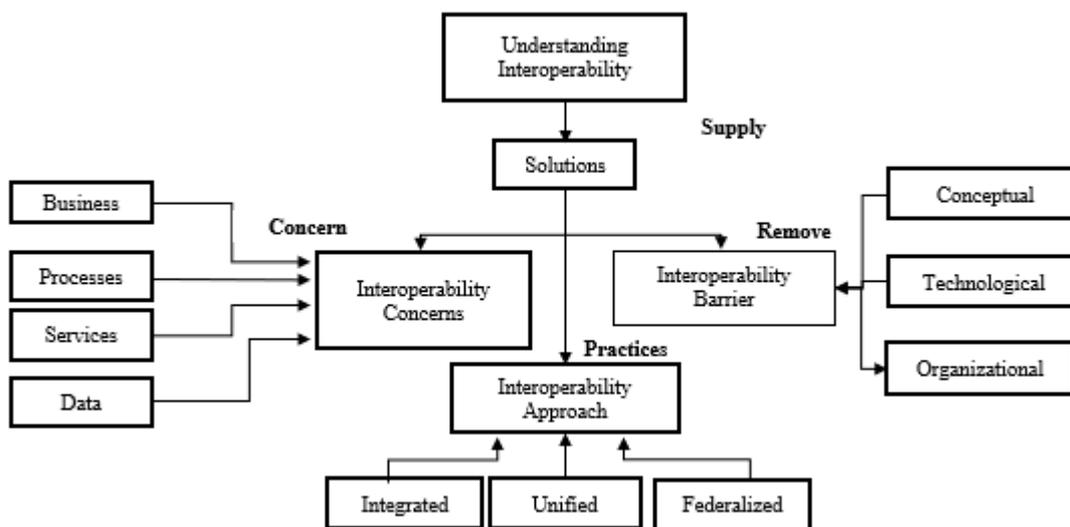
Source: Chen & Shorter (2008), adapted by the authors.
Theoretical Constructs 3 and 4: Concerns or Points of Attention of Interoperability and Barriers of Interoperability.

Table 9 presents the search results for theoretical constructs 03 and 04.

Table 9

Bibliographic Portfolio: Concerns and Barriers of Interoperability

Authors	Publication Vehicle
Chen et al. (2008)	Laps/Gral University Bordeaux
Guedria, W. (2012)	Thesis (PhD) – University of Bordeux, Bordeaux, França, 2012.
Chen & Shorter (2008)	In: INTEROP-Vlab Standardisation Workshop I-ESA 08, "Standards For Interoperability–How"

Source: Developed by the authors.

Regarding Theoretical Construct 3, Concerns (or points of attention) of Interoperability, these relate to the sector of a company that is involved in interoperability, and are depicted in Figure 2.

Figure 2

Examples of Concerns (or Points of Attention) of Interoperability
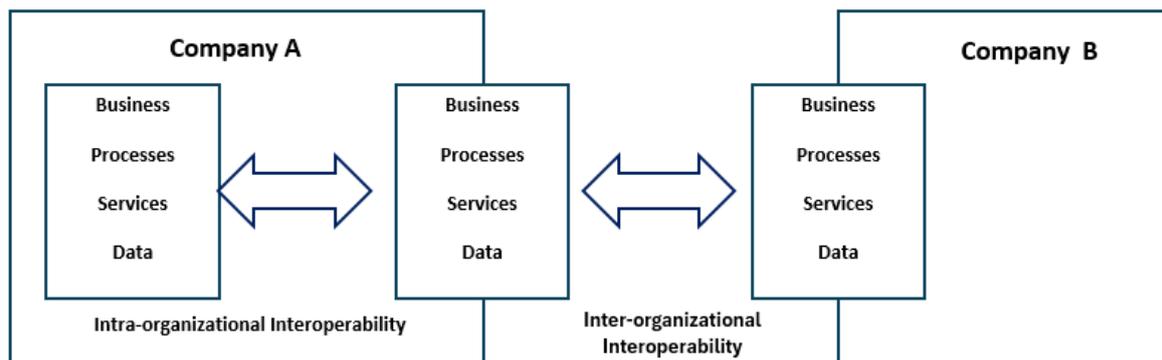
Source: Chen et al. (2008), adapted by the authors.

Business interoperability refers to an organization's ability to cooperate with other external or internal entities. It addresses how organizations or their internal subdivisions harmonize operations despite divergences in decision-making methods, work practices, legislation, and corporate cultures. Essentially, business interoperability investigates how business understandings are shared and managed among collaborators, encompassing everything from business visions and organizational culture to ICT infrastructure and compatibility between various organizational structures.

Process interoperability seeks to unite sequential activities from different parts of an organization or between distinct organizations to form a cohesive and inter-organizational workflow. This type involves linking process descriptions—whether documental or software-supported—to facilitate collaborative processes through checks, simulations, and executions.

Challenges here include semantic and syntactic differences in process modeling languages, as well as incompatibilities in execution platforms.

Service interoperability deals with the coordination and execution of independent services, resolving syntactic and semantic discrepancies and integrating various databases. This dimension is not limited to computational applications but also includes corporate functions and interactions among business networks. The main challenges are in the exchange of services and interconnection to create complex services.

Data interoperability focuses on the joint management and operation of different data models and query languages, aiming to synchronize information from heterogeneous databases that may be situated in distinct operating systems. Common barriers include conceptual differences in semantics and syntax, as well as technological and organizational challenges such as security policies and data management.

There are three main types of interoperability barriers:

Conceptual Barriers: Related to incompatibilities in exchanged information, which can occur at different levels of abstraction and programming.

Technological Barriers: Refer to limitations in the ICT systems used for communication and information exchange.

Organizational Barriers: Include management issues such as defining responsibilities and authorizations needed to facilitate interoperability.

In respect to the previously listed barriers to interoperability, it is pertinent here to relate the research problem of this study, established in the form of organizational barriers. Therefore, there is a need to define a problem space (PS) in the domain of management identifying the aspects of interoperability involved. It is also of interest in the management domain to assess which barriers prevent higher levels of interoperability.

Theoretical Construct No 05: Frameworks of Interoperability

Table 10 presents the search results for theoretical construct 05.

Table 10

Bibliographic Portfolio: Frameworks of Interoperability

Authors	Publication Vehicle
Chen, et al. (2008)	Journal Computers in Industry
Vernadat, F. (2009)	Springer, Berlin, Heidelberg
Guedria, W. (2012)	Universidade de Bordeux
Chen et al. (2008)	University Bordeaux

Source: Developed by the authors.

Several types of interoperability frameworks are highlighted in the scientific literature, including: (i) LISI - Levels of Information Systems Interoperability; (ii) EIF - European Interoperability Framework; (iii) ATHENA Interoperability Framework (AIF - ATHENA); (iv) IDEAS - Interoperability Developments for Enterprise Application and Software; (v) INTEROP NoE - Interoperability Research for Networked Enterprises Applications and

Software - Network of Excellence. The concepts and applications of these frameworks are discussed below, as per Chen et al. (2008).

The LISI framework, initially used in the US military sector to develop interoperability, serves as a reference to assess levels of information in interoperable systems (Chen et al., 2008). Its primary goal is to establish a process model that includes the assessment of information system capabilities, selection of pragmatic solutions, and promotion of transition to greater capacity and interoperability.

The European Interoperability Framework (EIF), as outlined by Chen et al. (2008) and Guedria (2012), is a comprehensive set of policies, standards, and guidelines that facilitate business agreements among organizations in a pan-European context. In addition to legal and policy perspectives, the EIF covers organizational, semantic, and technical aspects, providing recommendations for connecting systems and services to enable cross-border interactions among public administrations, businesses, and citizens.

In the ATHENA Interoperability Framework (AIF), the focus is on:

Conceptual Integration: Identifying concepts, models, meta-models, languages, and relationships necessary to develop interoperability;

Applicable Integration: Methodologies, standards, and domain models. It provides guidelines, principles, and standards that can be utilized to address interoperability issues;

Technical Integration: Technical development and ICT environments (including tools and platforms), as noted by Vernadat (2009).

Figure 3

Framework ATHENA
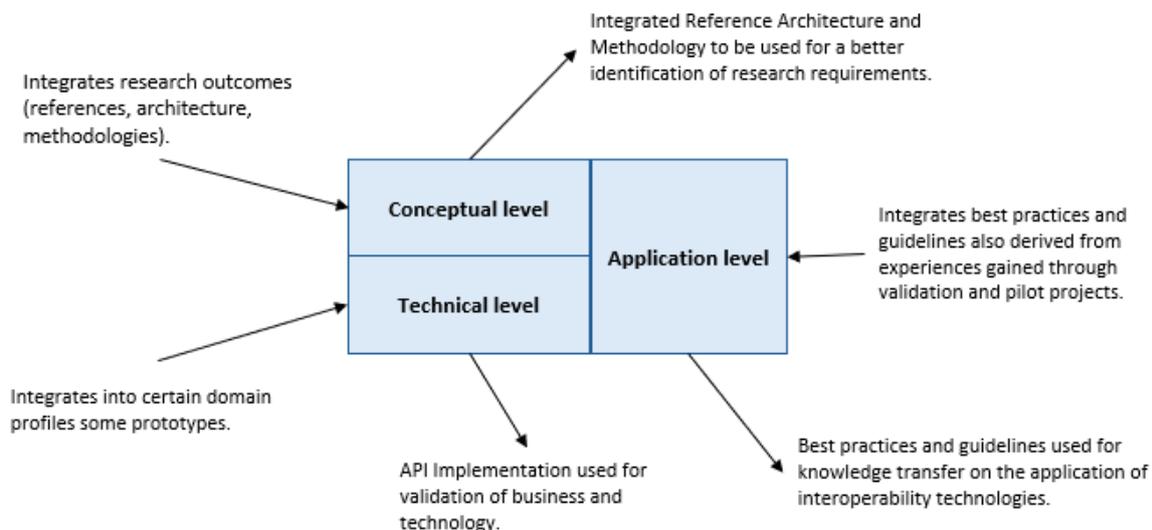
Source: Vernadat, 2009.

According to Chen et al. (2008), the IDEAS framework model is divided into the following levels: (i) 'business' - decision model, business model, and business processes; (ii) 'knowledge' - role of the organization, skills and competencies, and active knowledge; (iii) 'ICT (Information Communication Technology) system' - management solutions, interaction

location, and the logic of the process and application. These three levels are interconnected through a common semantic interface as shown in Figure 4.

Figure 4

IDEAS *Framework*
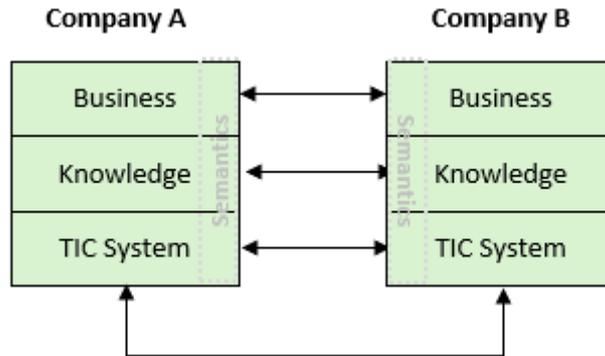
Source: Chen et al. (2008).

According to Chen et al. (2008), the INTEROP NoE framework defines the set of domain and subdomain of the enterprise and can be used to understand the structure of interoperability. This knowledge is considered relevant to interoperability if it contributes to removing at least one barrier at a given level.

Theoretical Construct 6: Assessment of Organizational Interoperability (AIO)

Table 11 presents the search results for theoretical construct 6.

Table 11

Bibliographic Portfolio: Assessment of Organizational Interoperability

Authors	Publication Vehicle
Daclin et al. (2006)	University Bordeaux.
Clark & Jones (1999)	Proceedings of the 1999 Command and Control Research and Technology Symposium
Andreas & Muguira (2003)	Fall Simulation Interoperability Workshop Orlando

Source: Developed by the authors.

The assessment of organizational interoperability can essentially be measured in two ways: (i) 'a priori', where the measure relates to the potential of a system to be interoperable with a possible future partner, whose identity is not known at the time of the assessment; (ii) 'a posteriori', where the measure is related to compatibility between two or more known systems willing to interoperate, or to the realization of a current interoperability relationship between two known systems.

The three types of interoperability measurements with their different aspects are represented in Table 12. This table demonstrates the methods to measure the potential, compatibility, and performance of organizational interoperability, defining the scope, whether it is interorganizational or intraorganizational, within a company (a priori) or between companies (a posteriori).

Table 12

Assessment of Interoperability

A Priori		A Posteriori	
Possible Measure	Measure of Potential	Measure of Performance	
Scope (Where?)	Intraorganizational	Inter e Intraorganizational	
Aplication (When?)	Before interoperability, Unkonwn partner	Before and after interoperability, Known partner	During interoperability
Objective (Why?)	Improve the capacity to interoperate	Resolve interoperability issues	Improve operational performance
Results (What?)	Assessment of potentiality; IO potential is improved	Compatibility assessment; Find solutions to IO issues	Performance assessment; Performance indicators

Source: Guedria, 2012.

The 'a posteriori' measure, as described by Daclin et al. (2006), can involve: (i) a measure of interoperability compatibility, which aims to evaluate the existence of potential interoperability issues between two or more known existing systems; (ii) a measure of interoperability performance, which is primarily related to assessing the performance of interoperability in terms of costs, time (duration) of exchange, quality, and compliance of the exchanged information. The 'a priori' evaluation allows companies to prepare for interoperability and thus avoid potential problems when they need to collaborate mutually.

Interoperability maturity models, such as the NC3TA Reference Model for Interoperability - NMI (Andreas & MUGUIRA 2003), OIM (Clark & Jones, 1999), LCIM (Andreas & Muguira, 2003), and EIMM, despite their relevance and wide application across various fields, predominantly focus on the 'a posteriori' assessment of interoperability. These models, significant in NATO and other contexts, will not be explored in this study.

5 Final Considerations

This study aimed to elucidate, through an extensive systematic literature review, the fundamental characteristics related to process management, university management, and interoperability in Higher Education Institutions (HEIs). To achieve this purpose, a careful analysis of publications was conducted using databases such as Redalyc, Oasis, Scielo, EbscoHost, Scopus, Web of Science, and the CAPES Catalog of Theses and Dissertations.

The results of the SLR revealed that it was not possible to identify a significant number of works on business process management in Higher Education Institutions. However, it was possible to discern that the main topics revolve around methodologies for implementing process management, competitiveness in HEIs, academic information systems, organizational culture, knowledge management, BPM (Business Process Management) methodology, including BPM evaluation tools, and models for producing educational materials.

Furthermore, the research identified concepts regarding what exactly constitutes a process, as, despite being a recurrent term in the literature, a variety of meanings were found. For higher education institutions, a process represents the key activities for managing their necessary routines aimed at rationalization, efficiency, and productivity.

Regarding the results from the catalogs of theses and dissertations on process management and university management, the number of works is significantly larger than the number of articles, with many of these theses and dissertations dealing with process mapping and modeling, and on BPM methodology.

In this investigation, a specific search focused on interoperability, emerging as the segment with the most substantial findings. The analysis revealed a diversity of perspectives on the concept of interoperability, encompassing its classifications into technical, syntactic, semantic, and organizational. Detailed discussions addressed specific concerns, existing barriers, and the various approaches related to organizational interoperability. Furthermore, eight distinct views on the topic were identified, as well as various frameworks and metrics for assessing organizational interoperability, highlighting the complexity and richness of the existing theoretical contributions to this important aspect of management.

Lastly, as this research is the result of an analysis based on findings about the three defined terms, undoubtedly, there remain gaps that could stimulate the pursuit of new discoveries by other researchers from different perspectives. In this regard, future studies are suggested that seek to delve deeper into issues of process management in higher education institutions and their impacts on data accuracy and interoperability..

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