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Research paper

Critical success factors for business intelligence implementation in public universities

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ABSTRACT

Introduction / Objective: this study examines the adoption of Business Intelligence systems in public universities in Bogotá, Colombia, emphasizing their role in improving decision-making processes and institutional adaptability during the COVID-19 pandemic. The primary objective is to identify the critical success factors that underpin the effective implementation of Business Intelligence in higher education institutions.

Methodology: the research adopts a qualitative approach, combining a comprehensive literature review with semi-structured interviews. Participants include academic leaders and information technology professionals from a case study public university in Bogotá. The study analyzes their experiences and perspectives on Business Intelligence systems, classifying the critical success factors into three key dimensions: technology, people, and processes.

Results: the findings highlight several essential success factors for the adoption of Business Intelligence, such as high data quality and content, strategic alignment of Business Intelligence initiatives with institutional objectives, robust governance frameworks, and interoperability of university systems. These factors were benchmarked against existing literature, offering a nuanced understanding of their critical role in the successful implementation of Business Intelligence systems.

Conclusions: this research provides actionable insights for public universities aiming to implement Business Intelligence systems. The critical success factors identified serve as a practical framework for enhancing Business Intelligence initiatives, fostering improved decision-making and institutional resilience during crises. Additionally, the study contributes to the broader academic discourse on Business Intelligence integration in the public sector, underscoring the importance of a strategic approach to technology adoption in higher education.

Factores críticos de éxito para la implementación de sistemas de inteligencia empresarial en universidades públicas

Palabras clave:
Inteligencia empresarial, factores críticos de éxito, educación superior, análisis de datos, transformación organizacional, gestión del sector público.

RESUMEN

Introducción / Objetivo: este artículo examina la adopción de sistemas de inteligencia empresarial en universidades públicas de Bogotá, Colombia, destacando su papel en la mejora de los procesos de toma de decisiones y la adaptabilidad institucional durante la pandemia de COVID-19. El objetivo principal es identificar los factores críticos de éxito que sustentan la implementación efectiva de la inteligencia empresarial en instituciones de educación superior.

Metodología: la investigación adopta un enfoque cualitativo, combinando una revisión exhaustiva de la literatura con entrevistas semiestructuradas para la recopilación de datos. Los participantes incluyen líderes académicos y profesionales de tecnología de la información de varias universidades públicas de Bogotá. El estudio analiza sus experiencias y perspectivas sobre los sistemas de inteligencia empresarial, clasificando los factores críticos de éxito en tres dimensiones clave: tecnología, personas y procesos.

Resultados: los hallazgos destacan varios factores esenciales para la adopción de la inteligencia empresarial, como la alta calidad y contenido de los datos, la alineación estratégica de las iniciativas de inteligencia empresarial con los objetivos institucionales, marcos de gobernanza robustos y la interoperabilidad de los sistemas universitarios. Estos factores se compararon con la literatura existente, ofreciendo una comprensión detallada de su papel crítico en la implementación exitosa de sistemas de inteligencia empresarial.

Conclusiones: esta investigación proporciona ideas prácticas para las universidades públicas que buscan implementar sistemas de inteligencia empresarial. Los factores críticos de éxito identificados sirven como un marco práctico para mejorar las iniciativas de inteligencia empresarial, fomentando una toma de decisiones más efectiva y la resiliencia institucional durante crisis. Además, el estudio contribuye al discurso académico más amplio sobre la integración de la inteligencia empresarial en el sector público, subrayando la importancia de un enfoque estratégico para la adopción de tecnología en la educación superior.

Introduction

Business Intelligence and Analytics (BI&A) has become essential for professionals and researchers due to the considerable scale and impact of data-related challenges faced by contemporary organizations (Chen et al., 2012). Similarly, governments and their agencies have embraced technologies and information systems (IS) to enhance performance. The Covid-19 pandemic underscored the urgent need for governments to accelerate this adoption, enabling them to make expedite decision-making and respond more effectively (Reale, 2021). The education sector is expected to prioritize this necessity, leading to a notable increase in the implementation of Business Intelligence Systems (BIS) in the post-pandemic period. While BI&A holds transformative potential for public institutions, its adoption has not been uniform across different sectors and regions, particularly in public universities and higher education institutions around the world (Figure 1).

The goal of this article is to identify critical success factors (CSF) regarding BI&A in public universities. This research employs an in-depth case study in Colombia regarding their daily use of data and information for decision-making. The present work is structured as follows. The second section presents a literature review regarding BI&A, maturity, critical success factors, and research on the education sector. Section 3 explains the methodology of the case study. Section 4 presents the results and main factors regarding the implementation of BI strategies in public universities. Sections 5 to 7 state the limitations, conclusions, and main contributions of this research.

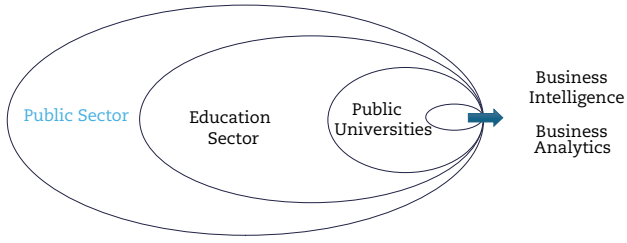

Figure 1. Gap in research
Source: Own elaboration.

Theoretical framework

Business intelligence and analytics

The terms "Business Intelligence" and "Business Analytics" (BA) became popular in organizations and IT communities in the late 1990s (Chen et al., 2012). Due to unpredictable changes and an increasingly complex environment (Pawar & Sharda, 1997), organizations began collecting internal and external data to make informed decisions (Pawar & Sharda, 1997; Siegel, 2000).

BI&A is defined in different ways across the literature. These definitions can be categorized into different types based on their focus: 1) *Conceptual and Methodological* (Dresner, 1989 as cited by Power, 2007; Watson et al., 2004; 2) *Process and Technological Scope* (Davenport, 2006; Golfarelli et al., 2004), Kasabian, 2007 as cited by Rajterič, 2010; 3) *Organizational and Capability-Based* (Gangadharan & Swami, 2004), Wells, 2008 as cited by Popovič et al., 2012; Rajterič, 2010; and 4) *Knowledge and Decision-Making Focused* (Popovič et al., 2012; Power et al., 2018; Chen et al., 2012; Wixom & Watson, 2010; Azvine et al., 2006; Lönnqvist & Pirttimäki, 2006). For the purposes of this research, BI&A is understood as an organization's capability to turn data into information and then into knowledge to improve decision-making.

Different authors began to approach BI&A from a broader scope than its technological aspect. The purpose of BI is to add more scientific and data-based decisions for businesses, (Watson & Wixom, 2007), but now from a yet broader perspective. Non-technical factors, such as organization and process, are more influential and important than technological and data-related factors (Yeoh & Koronios, 2010).

BI literature has evolved in different stages. During the early 70's to 90's, the literature shows the origin of the concepts and the need for companies to start implementing BI due to the uncertainties in the environment. This period structures the discipline and establishes the differences between the concepts as well (Cleland & King, 1975; Ghosbal & Kim, 1986; Gilad & Gilad, 1985; Pawar & Sharda, 1997; Siegel, 2000). The second stage is between 2000 and 2010. This period begins with the explosion of the internet as a new source of information and the creation of new types of information that can be used by companies. Researchers still focused on implementation of BI but in a more structured way, complementing existing information technologies in companies. By the end of the decade, researchers and practitioners were interested in the benefits of implementing BI and how they could be measured (Baars & Kemper, 2008; Elbashir et al., 2008; Golfarelli et al., 2004; Jourdan et al., 2008; Kohavi et al., 2002; Lönnqvist & Puhakka, 2009; Sahay & Ranjan, 2008; Trkman et al., 2010; Vercellis, 2008; H. Watson & Wixom, 2007). The third stage runs from 2010 to 2019 and is characterized by the diversification of BI research. New perspectives emerge as industries adopt BI technologies and innovations in data analytics and related technologies become prominent. Researchers explore the impact of these advancements on BI practices and the growing importance of Business Analytics as a complementary field. The literature reflects a broader range of industries and applications, highlighting the evolution of BI tools and methodologies (Chau & Xu, 2012; S. Chaudhuri et al., 2011; Chen et al., 2012; Işik et al., 2013; D. Larson & Chang, 2016; Popovič et al., 2012; Sharma et al., 2014; Vidgen et al., 2017; Yeoh & Koronios, 2010). The most recent stage, though relatively brief, is marked by a surge in research output. This period sees a substantial increase in published studies, reflecting the rapid advancements in BI technologies and their applications, such as artificial intelligence, data mining, and data analytics in many fields. Current research lays the groundwork for future exploration (Atwadkar & Patil, 2025; Bhambri & Khang, 2024), addressing emerging trends and setting directions for ongoing development in BI. This stage is crucial for understanding contemporary challenges and opportunities in the field and for shaping future research agendas.

BI&A maturity and critical success factors

BI&A maturity is based on the relationship between the solution, the application, and the temporal view of *critical success factors* (Hawking & Sellitto, 2010). Factors that were previously critical may not have the same relevance after a company has improved its BI&A capabilities (Hawking & Sellitto, 2010). Some organizations leverage these capabilities better than others, allowing them to respond to more complex questions and analysis regarding the environment. Over a hundred (Becker et al., 2009) maturity models have been developed within the IS field. BI&A maturity models include technology and data (Chen et al., 2012; Geiger, 2009) as an essential part of their analysis, but organizational processes and workforce capabilities (Ariyachandra & Frolick, 2008; Brooks et al., 2015; S. Williams & Williams, 2004; Yeoh & Koronios, 2010) must also be considered when measuring organizations' maturity levels. However, most maturity models are generic and focus on technical aspects applicable in any domain (Brooks et al., 2015). Furthermore, there is limited research on how BI&A capability matures and on the obstacles that impede or restrict this advancement (Mikalef et al., 2020).

BI&A implementation

BI refers to the set of processes that allow for the collection and analysis of information to improve decision-making with criteria of quality, reliability, and relevance (I. Magaireah et al., 2019). Essentially, BI seeks to integrate a range of methodologies and processes aimed at transforming data into information and subsequently into strategic knowledge. The implementation of BI systems facilitates the collection of large volumes of real-time information in a data structure that supports its subsequent use and analysis (Hartley & Seymour, 2015; I. Magaireah et al., 2019). Implementation refers to the process of deploying and integrating BI systems and tools within an organization to improve decision-making, data management, and overall business performance (Loshin, 2013).

As a result of this implementation, improvements are achieved in productivity, budget adjustments, better resource allocation, real-time report and document gener-

ation, project management, and data regulation and governance (Drake & Walz, 2018; Murti & Mulyani, 2022). Therefore, BI systems enhance data analysis, streamline processes, and increase the visibility of operations, among other benefits (El-Adaileh & Foster, 2019).

Implementing BI means setting up tools and processes to use data more successfully for decision-making. It involves careful planning and development, plus ongoing checks to ensure that the BI system meets the organization's needs and provides real value.

Given the strong connection between the concept of maturity and CSF, this research consists of an in-depth case study of an organization that has already implemented BI strategies and is progressing towards higher maturity levels (Figure 2). By examining a case where BI systems are actively in use and the organization is striving for advanced digital transformation, this study aims to uncover how these CSF influence the journey toward achieving a comprehensive global digital transformation. This approach allows for a detailed exploration of how evolving maturity impacts BI effectiveness and the overall transformation process, providing valuable insights into the challenges and successes encountered along the way.

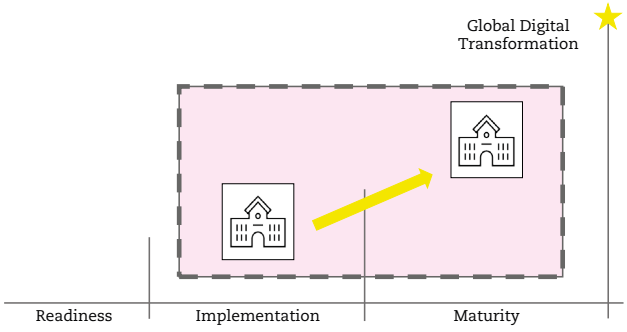

Figure 2. Scope of research

Source: Own elaboration.

BI&A in public universities

BI&A in public universities involve the use of data analysis tools and techniques (Boulila et al., 2023; Weber et al., 2021) to support decision-making (Haryono & Mansur, 2024a; Maaitah, 2023; Prayogo et al., 2023), improve operational efficiency (Sorour & Atkins, 2024), and enhance academic and administrative functions (Bichsel & Benefits, 2012; Drake & Walz, 2018; Hanandeh et al., 2024; Munawar et al., 2024; Sorour et al., 2020). In the context of public universities, BI helps in making informed decisions based on data analysis, improving strategic planning, and managing institutional performance (Colmenares Garzón et al., 2024; Drake & Walz, 2018; El-khalili et al., 2024; Sorour et al., 2020). Despite the advantages offered by BI implementation (Sequeira et al., 2024), a review of its application in public institutions reveals low participation associated with various barriers that may obstruct its use (Gasbarri et al., 2024; Yahaya et al., 2019). Faculty and staff frequently hesitate to embrace these technologies because they are accustomed to conventional teaching methods (Matar et al., 2024).

Given the changes faced by higher education institutions in Colombia, related to new accreditation systems, open data policies, and management and results reports, it is necessary to explore these barriers and propose actionable pathways for BI implementation, which is the aim of this project.

Methodology

The methodological approach for this project is grounded in the interpretative paradigm, following a qualitative methodology and exploratory case study strategy. The study relies on in-depth interviews for data collection.

Methodological choice: Qualitative

In line with the interpretative paradigm of phenomenology, the researchers chose a qualitative methodology for the study. This methodology is used to profoundly explore and investigate a phenomenon to gain a deeper understanding about people's interactions, situations, and social life matters (Leavy, 2014, 2017), (Gupta & Awasthy, 2015).

This research focused on understanding and explaining a particular phenomenon by participating in everyday activities within the organization, rather than implementing changes (Kelemen & Rumens, 2008; Saunder et al., 2019). Specifically, BI and BA research conducted by practitioners and academics has included and validated qualitative research as an important approach for achieving an in-depth understanding of organizations, establishing a diverse range of relevant dimensions in approaching organizations that should be considered during BI&A research, such as technology, people, and processes (Elbashir et al., 2008; Hawking & Sellitto, 2010; Yeoh & Koronios, 2010). In consequence, there has been an increase in the application of qualitative methods (Myers, 1997), and exploratory research is playing a significant role in building new theories about BI (Jourdan et al., 2008).

The exploratory case study approach aims to "develop pertinent hypotheses and propositions for further inquiry" (Saunder et al., 2019, p. 6). This approach involves immersion in the organization's daily activities to understand and explain its operations rather than make changes (Kelemen & Rumens, 2008; Saunder et al., 2019). As Yin (2013) notes, case studies are "valuable for enhancing our understanding of various phenomena, including individual, group, organizational, and social aspects" (p. 1).

Research strategy: Case study

The research strategy implemented in this investigation was the case study. Of the different definitions of case study as a method and research strategy, this research project adopted the definition proposed by Simons (2009):

> Case study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, or systems in a 'real-life' context. (p. 21)

As a research strategy, case studies are routinely employed in business, medicine, and law (Gupta & Awasthy, 2015), and are carried out to richly contribute to the under-

standing of an individual, a group, an organization, an event, a program, a phenomenon, among others (Simons, 2014; R. K. Yin, 2003). The importance of case studies derives from the need to understand complex social phenomena (R. K. Yin, 2003). Therefore, case studies as a qualitative methodological choice allow researchers to thoroughly investigate complex theoretical descriptions from participants and how they experience the research context (Gupta & Awasthy, 2015), and lead researchers to a holistic and meaningful understanding of the phenomena (R. K. Yin, 2003). This research focuses on a specific group of public sector officials in middle or senior management roles at a higher education institution. Their unique perspectives on decision-making and technological understanding are crucial for analyzing BI&A implementation.

Methodological phases

Phase 1: Literature review

A review was conducted of the literature on BI, BA, and IS maturity models by practitioners and researchers. Based on this review, the authors first established the theoretical framework for the research, which revealed the research needs and gaps that support the development of this study. Second, a list was made of 72 initial critical success factors present in several maturity models. After work sessions with the authors of this research project as well as the research group, the list was reduced to 42 factors to triangulate the information and avoid bias on the part of a single researcher (Table 1). The factors were selected and classified into four BI&A aspects: people, process, technology, and data. This classification was consistent with the literature review and served for the codification process (phase 3). Third, the literature review described different methodologies and designs implemented in BI and BA research, which helped in selecting the methodological design for this research (Figure 3).

Phase 2: Data collection

The information was collected from in-depth interviews related to the BI&A strategy implemented in a public university in Bogota, Colombia. This research focused on one type of participant: the administrators/leaders of the implementation of BI&A strategies and the leaders of the current BI&A projects. The interview questions were open-ended, allowing the researchers to profile the status quo of information systems at the organization and identify the BI&A maturity levels without bias from users' perspectives. The length of the interviews was expected to be between 60 and 90 minutes. The interviews were voice recorded and conducted mainly online on Zoom, due to the availability of the participants. Due to the choice of study methodology, and to guarantee rigor in the research, the interviews were conducted until data saturation was achieved.

Phase 3: Data analysis

The analysis of the information collected during phase 2 was done using NVivo software, an important qualitative tool, to code the transcripts and visualize the findings regarding the key factors of BI&A implementation from the population established as the object of study.

Figure 3. Methodological Phases

Source: Own elaboration.

Table 1. List of critical success factors categorized by people, process, technology, and data

Factor Reduction**	Factors*	References	People	Process	Technology	Data
Data-driven culture	Process of business culture improvement		X	X		
Partnership between business units and IT	Partnership between business units and IT		X	X		
Data-driven culture	Information and analysis of usage culture	(C. Williams, 2007)	X	X		
Analytical capabilities	Technical readiness BI/Data Warehouse (DA)				X	
BI strategic position	BI portfolio management		X			
Data-driven culture	Process of establishing decision culture		X			
BI strategic position	BI strategic position		X			

(*Continued*)

Factor Reduction**	Factors*	References	People	Process	Technology	Data
Investment in BI	Scope		X	X		
BI strategic position	Sponsorship		X			
Investment in BI	Funding		X			
BI strategic position	Value		X	X		
Architecture of the systems	Architecture	(Eckerson, 2004)		X	X	X
Quality and integration of data	Data					X
Architecture of the systems	Development					
Usage of the information and automatization	Delivery			X		
Users involved (suppliers, business partners, customers)	Users involved (suppliers, business partners, customers)		X			
Data-driven culture	Data-driven culture	(Burton-Jones & Gallivan, 2007)	X	X		X
Business strategy	Business strategy		X	X	X	
Investment in BI	Investment in BI		X		X	
BI strategic position	Identification of the importance of BI		X			
Usage of the information and automatization	Usage of the information and automatization			X	X	
Data-driven culture	Importance of data		X			
Partnership between business units and IT	Linked departments	(Gartner Research, 2006)	X	X		
Defined operational and financial metrics	Defined operational and financial metrics			X		
Agile response to changes in the market	Agile response to changes in the market		X			
Quality and integration of data	Integrated, clean, and high quality data	(Khaleefeh Mohammad et al., 2011)			X	
Data-driven culture	Usage of the information		X	X	X	
Sound, timely, and efficient decision	Sound, timely, and efficient decision		X			
Quality and integration of data	Data integration	(Popovič et al., 2012)		X	X	
Content of information	Content of information			X		
Accessibility of information	Accessibility of information				X	
Data-driven culture	Use of information in business processes			X		
Analytical capabilities	Analytical capabilities		X	X	X	
Quality and integration of data	BI systems need to be integrated effectively into management and operational processes	(Elbashir et al., 2008)	X	X	X	
Improvement of organizational and business processes	Improving the efficiency and effectiveness of organizational structure and business processes, i.e. the "internal strategy"	(Lönnqvist & Pirttimäki, 2006)	X	X		
Competitive advantage	Outperforming other organizations in the industry, i.e. the "competitive strategy".	(Bakos & Treacy, 1986; Lönnqvist & Pirttimäki, 2006)	X			
Quality and integration of data	Quality and purpose of the data	((S. Larson, 2010)	X		X	X
Sharing of knowledge	Sharing of knowledge		X	X		
Existence of data warehouse	Existence of DW				X	X
Constant evaluation of information and user feedback	Constant evaluation of information and user feedback	(Larson & Chang, 2016)		X		
Quality and integration of data	Quality of communication between systems	(Işik et al., 2013)			X	
Flexibility and robust functionality of the systems	Flexibility and robust functionality	(Isik et al., 2013)		X	X	
Quality and integration of data	Correct, valid, integrated, and timely data	(Popovič et al., 2012)	X	X	X	X
Quality and integration of data	Integration of large amounts of data from disparate heterogeneous sources within BIS	(Elbashir et al., 2008; Popovič et al., 2012)			X	X

(*Continued*)

Factor Reduction**	Factors*	References	People	Process	Technology	Data
Analytical capabilities	Analytical capabilities	(Popovič et al., 2012; Trkman et al., 2010)	X		X	
Ease of use, learning, and access of the system	Ease of use		X		X	
Ease of use, learning, and access of the system	Ease of learning		X		X	
Ease of use, learning, and access of the system	Ease of access		X		X	
Frequency of use	Frequency of use		X	X		
Direct or indirect use	Direct or indirect use		X	X		
Type of use (voluntary or mandatory)	Type of use (voluntary or mandatory)		X	X		
Type of information access (strategic or operative)	Type of information access (strategic or operative)			X		
Satisfaction of the information needed and received	Satisfaction of the information needed and received		X			
Overall system satisfaction	Overall system satisfaction		X			
Satisfactory experience	Satisfactory experience		X			
Improvement of decision-making	Satisfaction for making decisions					
Improvement of individual productivity	Improvement of individual productivity	(Delone & McLean, 2003)	X	X		
Improvement of decision-making	Support in carrying out tasks		X	X		
Time taken to complete tasks	Time taken to complete tasks		X	X		
Time taken to make decision	Time taken to make decision		X	X		
Greater understanding of the context	Greater understanding of the context		X	X		
Improvement of decision-making	Participation in decision-making		X	X		
Reduction of costs/operation times	Reduction of costs/operation times			X		
Improved resource management	Improved resource management			X		
Improved overall productivity	Improved overall productivity			X		
Increase in sales, benefits, actions	Increase in sales, benefits, actions		X			
New products, services, and models	New products, services, and models		X	X		
Improved relationships with customers and suppliers	Improved relationships with customers and suppliers		X	X		
Improvement of decision-making	Improved decision making		X	X		
Competitive advantage	Competitive advantage		X	X		
Job creation	Job creation		X			
Economic development	Economic development		X			

Source: Own elaboration from the literature review (several authors).

Results

The research project on critical success factors regarding BI implementation in public universities reveals several key findings. During the interviews, the directors and leaders involved in the ongoing BI strategies highlighted that the main challenges and constraints are related to resistance to change and technology adoption, data silos and integration issues, data quality, and the lack of analytical capabilities. Additionally, the main factors influencing successful BI implementation fall predominantly into the categories of *people/organization* and *processes*.

Figure 4 provides a summary of the key factors associated with each category as mentioned by the participants. The dotted lines indicate that these factors may span multiple categories, reflecting their interconnected nature. Critical success factors are not confined to a single category but rather form a network of interrelated elements. Consequently, no single factor can independently ensure the success of BI&A implementation. Nonetheless, this research has identified the primary factors crucial for implementing BI&A strategies within the higher education sector.

Data

The analysis of the data category in the research on BI implementation in public universities reveals that two primary factors—data quality and data content—are crucial for advancing BI capabilities.

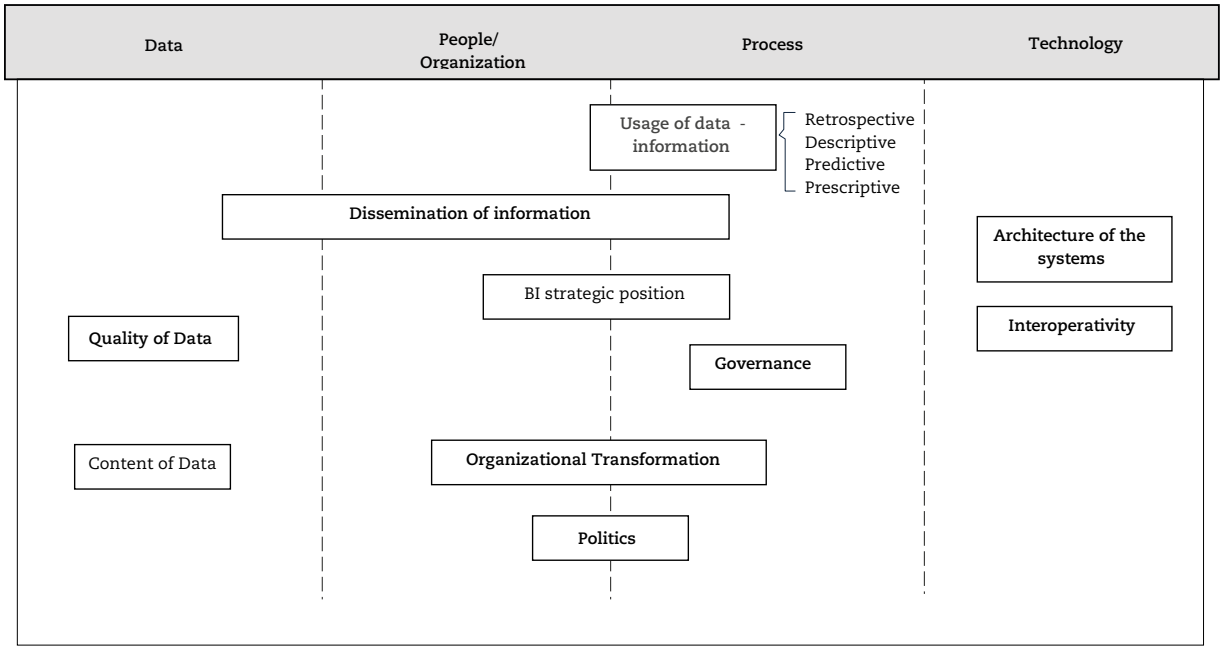

Figure 4. Main factors associated by categories

Source: Own elaboration.

On one hand, ensuring high data quality emerged as a critical factor in the interviews. Leaders stressed that accurate, complete, and reliable data is foundational for effective BI. High data quality not only enhances the credibility of the insights generated but also supports informed decision-making by minimizing errors and inconsistencies. On the other hand, the relevance and comprehensiveness of the data content were also mentioned as significant. The leaders emphasized that having rich, relevant data that aligns with organizational goals and decision-making needs is essential for moving beyond basic reporting. Despite the wealth of data available across different areas of the universities, it has not yet been effectively incorporated into their decision-making processes (Haryono & Mansur, 2024). There has been limited use of BI in higher education institutions for data-based decision making.

The relationship between data quality and data content is integral to achieving higher levels of BI usage. By improving these aspects, universities can transition from retrospective analysis, which focuses on historical data, to more advanced prescriptive analysis, which provides actionable recommendations and insights for future decision-making. This progression enhances the strategic value of BI and supports more proactive and informed decision-making processes.

People/Organization

The interviews emphasized that organizational culture, leadership support, and staff expertise are crucial for BI success. The leaders noted that a strong commitment from senior management and a culture that embraces data-driven decision-making are essential. Additionally, having skilled personnel who are trained in BI tools and methodologies significantly impacts the effectiveness of BI strategies. The success of data-driven decision-making depends not only on the data itself, but also on the techniques employed for collecting and analyzing that data (Shamim et al., 2019). A data-driven culture within an organization can influence innovation strategy and lead to changes in organizational processes (Chaudhuri et al., 2024).

Process

The research also highlighted several critical process-related factors. These factors relate to how data is handled, analyzed, and utilized within the organization, and they highlight the importance of well-defined processes, governance structures, and the alignment of BI objectives within higher education settings. Once the BI objectives are clear, universities must ensure that BI systems are not just technical tools but strategic enablers of institutional improvement. Effective BI implementation depends on streamlined processes that ensure data accuracy and support timely decision-making. Universities must establish clear processes for integrating data from various departments and systems to create a unified data repository or DW. This could be challenging, due to resistance from their workers to the implementation of new technologies and systems (Matar et al., 2024). Additionally, governance factors (Jamiu et al., 2020)—such as laws and regulations governing data use, the overall framework, and organizational transformation—are crucial components of the process category. Participants mentioned the need for data management practices, including data cleaning, data validation, and regular updates, to ensure that data reflects current conditions. Without proper data management, BI systems may be relying on faulty or outdated data, producing inaccurate insights, which in turn leads to distrust by the worker and affects the adoption of

data to facilitate decision-making (Medeiros et al., 2020). These elements collectively influence how BI processes are structured and executed, reinforcing their role in achieving successful BI outcomes.

Technology

Despite significant advancements in technology, this category does not emerge as a prominent one compared to the other three. The main factors highlighted by participants include system architecture and interoperability. In the context of universities, data comes from a variety of sources, such as student information systems, learning management systems, faculty performance data, financial systems, and research databases. One of the primary challenges for universities is integrating these diverse data sets into a coherent, accessible, and usable format. Ensuring the right technology is in place, aligned with user needs, and that systems are well-integrated can enhance information dissemination, facilitate organizational transformation, and strategically position BI from the user's perspective, not just from that of the project leaders.

The interconnected nature of these factors and categories indicates that successful BI implementation requires a holistic approach that considers multiple interrelated elements. For example, effective leadership (a "people/organization" factor) is often essential for establishing clear processes (a "process" factor), and well-structured processes are necessary for the successful adoption of BI tools by the people in the organization. Overall, these findings underscore the importance of focusing on organizational culture and process optimization to achieve successful BI implementation in public universities.

Conclusions

BI&A has transformative potential for public institutions. However, its adoption has been uneven across various sectors and regions, especially within public universities and higher education institutions globally. The research reveals that successful BI&A implementation in public universities hinges on several critical factors across four categories: data, people/organization, process, and technology.

High data quality—accurate, complete, and reliable—is essential for credible insights and informed decision-making. Additionally, having relevant and comprehensive data that aligns with the institution's strategic goals is crucial for moving beyond basic reporting and enabling more sophisticated, data-driven decision processes across academic, administrative, and financial functions. People/organization factors emphasize the importance of organizational culture, leadership support, and staff expertise in driving BI&A success. The research emphasizes the critical role of process-related factors in the successful implementation of BI in universities. Key factors identified include effective data integration and management, well-defined BI objectives, standardized procedures for data analysis and reporting, robust governance frameworks, and the capacity for timely decision-making. These elements ensure that BI systems are not only technically proficient but also strategically aligned with the university's overarching goals and objectives.

The research identified several critical process-related factors in BI implementation within universities. These include the need for well-defined processes, governance structures, and alignment of BI objectives with institutional goals. Effective BI implementation requires clear data integration processes, ensuring data accuracy and supporting timely decision-making. However, challenges arise from resistance to new technologies and systems (Matar et al., 2024). Governance factors, including data use regulations and organizational frameworks, are also essential. Additionally, proper data management practices—such as data cleaning, validation, and regular updates—are crucial to avoid relying on outdated or inaccurate data, which can undermine BI effectiveness and hinder adoption (Medeiros et al., 2020). These factors collectively shape how BI processes are structured, influencing successful outcomes.To foster best practices and enhance quality, university administration should support this transition by establishing specific regulations, recognizing employees' digital contributions through rankings and incentives, and offering focused training aimed at practical solutions (Matar et al., 2024).

Each category presents essential factors; the interview results show that no single factor can ensure the success of a BI&A strategy on its own. Instead, the interplay between these factors is crucial for universities. Achieving higher levels of BI&A maturity and success requires a cohesive approach wherein the relationships among data quality, organizational support, process efficiency, and technological capabilities are effectively managed. It also requires the involvement of several actors to achieve the alignment between the BI goals and the universities' objectives. This interconnectedness underscores the complexity of BI&A implementation and the need for a holistic strategy to realize its full potential.

Limitations

This qualitative research has several limitations due to the fact that it focused solely on high-level executives at a single public university. While the insights from senior management are valuable for understanding strategic decision-making, they may not fully reflect the operational challenges or day-to-day realities encountered by staff at other levels of the organization. As a result, the findings may not provide a comprehensive understanding of the full scope of BI implementation, particularly at the operational or tactical levels. The perspectives of mid-level managers, faculty, and administrative staff, who play a critical role in the execution and adoption of BI initiatives, were not included. Therefore, the research may overlook key barriers, concerns, and opportunities that arise during the practical implementation of BI systems at various organizational levels. This limited scope may affect the generalizability of the findings to the broader university population and the diverse challenges faced in BI implementation across different departments and functions.

Contributions

Despite these limitations, the research offers valuable contributions. It outlines the main factors by category that universities and leaders of these institutions should focus on to achieve the correct implementation of BI and obtain higher levels of maturity. The conclusions from this study share significant insights into BI implementation and maturity and their impact on digital transformation, particularly for high-level decision-makers. Expanding future research with more public universities as well as including multiple organizational levels and users from universities—students, workers, professors, among others—would strengthen the analysis and offer a broader understanding of the subject matter, benefiting both academics and practitioners.

This work not only contributes to academic literature on BI&A maturity but is also beneficial for BI&A practices in public universities in Colombia. This research represents an opportunity for public management, IS, technology and innovation researchers and practitioners to improve their BI&A capabilities.

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Conflict of interest

The authors have no conflict of interest to declare regarding the publication of this paper. All views expressed in this study are solely those of the authors and do not represent the views of any affiliated institutions.

Authors' contribution

Katherine Maldonado-Romero: Conceptualization, formal analysis, research, methodology, software, writing (original draft); Claudia Alexandra Garzón Santos: Conceptualization, formal analysis, fundraising, methodology, project management, resources, supervision, writing -revision and editing.

References

Ariyachandra, T. R., & Frolick, M. N. (2008). Critical success factors in business performance management - Striving for success. *Information Systems Management*, *25*(2), 113-120. https://doi.org/10.1080/10580530801941504

Atwadkar, S. A., & Patil, U. P. (2025). *Business analytics: Prospectivness and opportunities* (pp. 467–472). https://doi.org/10.1007/978-981-97-8031-0_49

Azvine, B., Cui, Z., Nauck, D. D., & Majeed, B. (2006). Real time Business Intelligence for the adaptive enterprise. *The 8th IEEE International Conference on E-Commerce Technology and The 3rd IEEE International Conference on Enterprise Computing, E-Commerce, and E-Services (CEC/EEE'06)*, 29-29. https://doi.org/10.1109/CEC-EEE.2006.73

Baars, H., & Kemper, H. G. (2008). Management support with structured and unstructured data - An integrated Business Intelligence framework. *Information Systems Management*, *25*(2), 132-148. https://doi.org/10.1080/10580530801941058

Bakos, J., & Treacy, M. (1986). Information technology and corporate strategy: A research perspective. *MIS Quarterly*, 107-119.

Becker, J., Knackstedt, R., & Pöppelbuß, J. (2009). Developing maturity models for IT management. *Business & Information Systems Engineering*, *1*(3), 213-222. https://doi.org/10.1007/s12599-009-0044-5

Bhambri, P., & Khang, A. (2024). *Challenges and future directions on Business Intelligence* (pp. 117-146). https://doi.org/10.4018/979-8-3693-3498-0.ch006

Bichsel, J., & Benefits, R. (2012). *Analytics in higher education*. https://doi.org/10.13140/RG.2.1.1064.6244

Boulila, W., Al-kmali, M., Farid, M., & Mugahed, H. (2023). A Business Intelligence based solution to support academic affairs: Case of Taibah University. *Wireless Networks*, *29*(3), 1051-1058. https://doi.org/10.1007/s11276-018-1880-3

Brooks, P., El-Gayar, O., & Sarnikar, S. (2015). A framework for developing a domain specific Business Intelligence maturity model: Application to healthcare. *International Journal of Information Management*, *35*(3), 337-345. https://doi.org/10.1016/j.ijinfomgt.2015.01.011

Burton-Jones, & Gallivan. (2007). Toward a deeper understanding of system usage in organizations: A multilevel perspective. *MIS Quarterly*, *31*(4), 657. https://doi.org/10.2307/25148815

Chau, M., & Xu, J. (2012). Special issue: Business Intelligence research business intelligence in blogs: Understanding consumer interactions and communities 1. *MIS Quarterly*, *36*(4), 1189-1216.

Chaudhuri, R., Chatterjee, S., Vrontis, D., & Thrassou, A. (2024). Adoption of robust business analytics for product innovation and organizational performance: The mediating role of organizational data-driven culture. *Annals of Operations Research*, *339*(3), 1757-1791. https://doi.org/10.1007/s10479-021-04407-3

Chaudhuri, S., Dayal, U., & Narasayya, V. (2011). An overview of Business Intelligence technology. *Communications of the ACM*, *54*(8), 88-98. https://doi.org/10.1145/1978542.1978562

Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business Intelligence and analytics: From big data to big impact. *MIS Quarterly: Management Information Systems*, *36*(4), 1165-1188. https://doi.org/10.2307/41703503

Cleland, D. I., & King, W. R. (1975). Competitive Business Intelligence systems. *Business Horizons*, *18*(6), 19-28.

Colmenares Garzón, Y. A., Guina Escobar, E. D., & Cardona-Román, D. M. (2024). Business Intelligence dashboard as a technological innovation for analysis on digital transformation in education. *Sustainable Engineering for a Diverse, Equitable, and Inclusive Future at the Service of Education, Research, and Industry for a Society 5.0*. https://doi.org/10.18687/LACCEI2024.1.1.1725

Davenport, T. H. (2006). Competing on analytics. *Harvard Business Review*, *84*(1), 98–107. www.hbr.orgorcall800-988-0886.www.hbr.org

Delone, W., & McLean, E. (2003). The DeLone and McLean model of Information systems success: A ten-year update. *Journal of Management Information Systems*, *19*(4), 9-30. https://doi.org/10.1080/07421222.2003.11045748

Drake, B. M., & Walz, A. (2018). Evolving Business Intelligence and data analytics in higher education. *New Directions for Institutional Research*, *2018*(178), 39–52. https://doi.org/10.1002/ir.20266

Eckerson, W. (2004). *Best practices in business performance management: Business and technical strategies*. www.dw-institute.com

El-Adaileh, N. A., & Foster, S. (2019). Successful Business Intelligence implementation: A systematic literature review. *Journal of Work-Applied Management*, *11*(2), 121-132. https://doi.org/10.1108/JWAM-09-2019-0027

Elbashir, M. Z., Collier, P. A., & Davern, M. J. (2008). Measuring the effects of business intelligence systems: The relationship

between business process and organizational performance. *International Journal of Accounting Information Systems*, *9*(3), 135-153. https://doi.org/10.1016/j.accinf.2008.03.001

El-khalili, N., Abu Arqoub, M., Hasan, M. A., Banna, A. A., & Arafah, M. (2024). Empowering learning analytics with business intelligence. *2024 2nd International Conference on Cyber Resilience (ICCR)*, 1-6. https://doi.org/10.1109/ICCR61006.2024.10533111

Gangadharan, G. R., & Swami, S. N. (2004). Business intelligence systems: Design and implementation strategies. *26th International Conference on Information Technology Interfaces*.

Gasbarri, P., Accardo, D., Cacciaguerra, E., Meschini, S., & Tagliabue, L. C. (2024). Supporting asset management with GIS and business intelligence technologies: The case study of the University of Turin. *ISPRS International Journal of Geo-Information*, *13*(3), 65. https://doi.org/10.3390/ijgi13030065

Geiger, J. (2009). How to start a business intelligence program. *Information Management*, *19*(6).

Ghosbal, S., & Kim, S. K. (1986). Building effective intelligence systems for competitive advantage. *Sloan Management Review*, *27*, 49-58.

Gilad, B., & Gilad, T. (1985). A system approach to Business Intelligence. *Business Horizons*, *28*(6), 65-70.

Golfarelli, M., Rizzi, S., & Cella, I. (2004). Beyond data warehousing. *Proceedings of the 7th ACM International Workshop on Data Warehousing and OLAP*, 1-6. https://doi.org/10.1145/1031763.1031765

Gupta, R., & Awasthy, R. (2015). *Qualitative research in management: Methods and experiences*. (R. Gupta & R. Awasthy, Eds.). Sage.

Hanandeh, A., Qudah, M. A. Al, Mansour, A., Al-Qudah, S., Abualfalayeh, G., Kilani, Q., & Khasawneh, M. A. S. (2024). The achievement of digital leadership sustainability and business performance through the implementation of business intelligence, artificial intelligence, and quality learning in private universities in Jordan. *Uncertain Supply Chain Management*, *12*(4), 2581-2586. https://doi.org/10.5267/j.uscm.2024.5.012

Hartley, M. K., & Seymour, L. F. (2015). Key success factors for implementing Business Intelligence in South African public sector organisations. *Proceedings of the 9th IDIA conference, IDIA2015*.

Haryono, K., & Mansur, A. (2024). Systematic literature mapping: Finding potential novelty for Business Intelligence in higher education institution. *2024 6th International Conference on Management Science and Industrial Engineering*, 267–272. https://doi.org/10.1145/3664968.3665004

Hawking, P., & Sellitto, C. (2010). *Business Intelligence (BI) critical success factors* (Vol. 4). http://aisel.aisnet.org/acis2010/4

I. Magaireah, A., HidayahSulaiman, H., & Ali, N. (2019). Identifying the most critical factors to Business Intelligence implementation success in the public sector organizations. *The Journal of Social Sciences Research*, *52*, 450-462. https://doi.org/10.32861/jssr.52.450.462

Işik, Ö., Jones, M. C., & Sidorova, A. (2013). Business Intelligence success: The roles of BI capabilities and decision environments. *Information and Management*, *50*(1), 13-23. https://doi.org/10.1016/j.im.2012.12.001

Jamiu, S. M., Abdullah, N. S., Miskon, S., & Ali, N. M. (2020). *Data governance support for Business Intelligence in higher education: A systematic literature review* (pp. 35-44). https://doi.org/10.1007/978-3-030-33582-3_4

Jourdan, Z., Rainer, R. K., & Marshall, T. E. (2008). Business Intelligence: An analysis of the literature. *Information Systems Management*, *25*(2), 121-131. https://doi.org/10.1080/10580530801941512

Kelemen, M. L., & Rumens, N. (2008). *An introduction to critical management research*. Sage.

Khaleefeh M., Muflih, Y. T., & T. Jawarneh. (2011). An examination of ICT skills possession and adoption amongst faculty members at Jordan University of Science and Technology (JUST) in relation to Rogers' diffusion of innovation model background for the study. *International Journal for Research in Education*, *30*, 29-59.

Kohavi, R., Rothleder, N. J., & Simoudis, E. (2002). Emerging trends in business analytics. *Communications of the ACM*, *45*(8), 45-48.

Larson, D., & Chang, V. (2016). A review and future direction of agile, Business Intelligence, analytics and data science. *International Journal of Information Management*, *36*(5), 700-710. https://doi.org/10.1016/j.ijinfomgt.2016.04.013

Larson, S. (2010). Information systems and strategic decisions: A literature review. *SAIS 2009 Proceedings*.

Leavy, P. (2014). *The Oxford Handbook of Qualitative Research*. Oxford University Press.

Leavy, P. (2017). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches*. The Guilford Press.

Lönnqvist, A., & Pirttimäki, V. (2006). The measurement of Business Intelligence. *Information Systems Management*, *23*(1), 32-40. https://doi.org/10.1201/1078.10580530/45769.23.1.2006 1201/91770.4

Lönnqvist, A., & Puhakka, V. (2009). The measurement of Business Intelligence. *EDPACS*, *40*(3), 1-14. https://doi.org/10.1080/07366980903446611

Loshin, D. (2013). *Business Intelligence: The Savvy Manager's Guide* (1st edition). Morgan Kaufmann.

Maaitah, T. (2023). The role of Business Intelligence tools in the decision making process and performance. *Journal of Intelligence Studies in Business*, *13*(1), 43–52. https://doi.org/10.37380/jisib.v13i1.990

Matar, N., Al-Jaber, A., & Matar, W. (2024). Unlocking Business Intelligence and data analytics adoption patterns: Insights from Jordanian higher education Institutions. *Engineering, Technology & Applied Science Research*, *14*(5), 16198–16206. https://doi.org/10.48084/etasr.8013

Medeiros, M. M. de, Hoppen, N., & Maçada, A. C. G. (2020). Data science for business: Benefits, challenges and opportunities. *The Bottom Line*, *33*(2), 149-163. https://doi.org/10.1108/BL-12-2019-0132

Mikalef, P., Pappas, I. O., Krogstie, J., & Pavlou, P. A. (2020). Big data and business analytics: A research agenda for realizing business value. In *Information and Management* (Vol. 57, Issue 1). Elsevier B.V. https://doi.org/10.1016/j.im.2019.103237

Munawar, G., Arsyad, Z., & Hodijah, A. (2024). *The development of Business Intelligence dashboard to measure the KPI of the study program (Case study: LAM Infokom instrument)*. 120004. https://doi.org/10.1063/5.0211908

Murti, G. T., & Mulyani, S. (2022). The determinant of Business Intelligence systems quality on Indonesian higher education information center. *Linguistics and Culture Review*, *6*, 581-595. https://doi.org/10.21744/lingcure.v6nS1.2104

Myers, M. (1997). Qualitative research in information systems. *MISQ Discovery*, 1-19.

Pawar, B. S., & Sharda, R. (1997). Obtaining Business Intelligence on the Internet. *Long Range Planning*, *30*(1), 110-121. https://doi.org/10.1016/S0024-6301(96)00100-8

Popoviş, A., Hackney, R., Coelho, P. S., & Jakliş, J. (2012). Towards Business Intelligence systems success: Effects of maturity and culture on analytical decision making. *Decision Support Systems*, *54*(1), 729-739. https://doi.org/10.1016/j.dss.2012.08.017

Power, D. J. (2007). *A brief history of decision support systems* (pp. 1-10). http://DSSResources.COM/history/dsshistory.html

Power, D. J., Heavin, C., McDermott, J., & Daly, M. (2018). Defining business analytics: An empirical approach. *Journal of Business Analytics*, *1*(1), 40-53. https://doi.org/10.1080/2573234X.2018.1507605

Prayogo, S., Hidayanto, M. B., & Lubis, M. (2023). Business Intelligence in e-learning for Higher Education. *Proceedings of the 2023 11th International Conference on Computer and Communications Management*, 215–220. https://doi.org/10.1145/3617733.3617768

Rajteriş, I. H. (2010). *Overview of Business Intelligence maturity models*. *Management*, *15*(1), 47-67. https://hrcak.srce.hr/file/81745

Reale, F. (2021). Mission-oriented innovation policy and the challenge of urgency: Lessons from Covid-19 and beyond. *Technovation*, *107*, 102306. https://doi.org/10.1016/j.technovation.2021.102306

Sahay, B. S., & Ranjan, J. (2008). Real time Business Intelligence in supply chain analytics. *Information Management and Computer Security*, *16*(1), 28-48. https://doi.org/10.1108/09685220810862733

Saunder, M. N. K., Lewis, P., & Thornhill, A. (2019). *Research methods for business students* (8th Edition). Pearson.

Sequeira, R., Reis, A., Alves, P., & Branco, F. (2024). Roadmap for implementing Business Intelligence systems in higher education institutions: Systematic literature review. *Information*, *15*(4), 208. https://doi.org/10.3390/info15040208

Shamim, S., Zeng, J., Shariq, S. M., & Khan, Z. (2019). Role of big data management in enhancing big data decision-making capability and quality among Chinese firms: A dynamic capabilities view. *Information & Management*, *56*(6), 103135. https://doi.org/10.1016/j.im.2018.12.003

Sharma, R., Mithas, S., & Kankanhalli, A. (2014). Transforming decision-making processes: A research agenda for understanding the impact of business analytics on organisations. In *European Journal of Information Systems* (Vol. 23, Issue 4, pp. 433-441). Palgrave Macmillan Ltd. https://doi.org/10.1057/ejis.2014.17

Siegel, C. F. (2000). Introducing marketing students to Business Intelligence using project-based learning on the world wide web. *Journal of Marketing Education*, *22*(2), 90-98.

Simons, H. (2009). *Case study research in practice*. Sage.

Simons, H. (2014). Case study research: In-Depth understanding in contex. In P. Leavy (Ed.), *The Oxford Handbook of Qualitative Research* (pp. 1-756). Oxford University Press.

Sorour, A., & Atkins, A. S. (2024). *Integrating Artificial Intelligence Transformers With Business Intelligence Systems for Monitoring Learning Outcomes in Higher Education Institutions* (pp. 36-54). https://doi.org/10.4018/979-8-3693-1198-1.ch003

Sorour, A., Atkins, A. S., Stanier, C. F., & Alharbi, F. D. (2020). The role of Business Intelligence and analytics in higher education quality: A proposed architecture. . *International Conference on Advances in the Emerging Computing Technologies (AECT)*. Al Madinah Al Munawwarah, Saudi Arabia. https://doi.org/10.1109/AECT47998.2020.9194157

Trkman, P., McCormack, K., De Oliveira, M. P. V., & Ladeira, M. B. (2010). The impact of business analytics on supply chain performance. *Decision Support Systems*, *49*(3), 318-327. https://doi.org/10.1016/j.dss.2010.03.007

Vercellis, Carlo. (2008). *Business Intelligence: Data mining and optimization for decision making*. Wiley.

Vidgen, R., Shaw, S., & Grant, D. B. (2017). Management challenges in creating value from business analytics. *European Journal of Operational Research*, *261*(2), 626–639. https://doi.org/10.1016/j.ejor.2017.02.023

Watson, H. J., Abraham, D. L., Chen, D. Q., Preston, D. S., & Thomas, D. (2004). Data warehousing ROI: Justifying and assessing a data warehouse. *Business Intelligence Journal*, 6-17.

Watson, H., & Wixom, B. (2007). The current state of Business Intelligence. *Computer*, *40*(9), 96-99. https://doi.org/10.1109/MC.2007.331

Weber, K., DaSilva, A. F., Dault, J. T., Eber, R., Huner, K., Jones, D., Kornman, K., Ramaswamy, V., Snyder, M., Ward, B. B., & Nalliah, R. P. (2021). Using Business Intelligence and data visualization to understand the characteristics of failed appointments in dental school clinics. *Journal of Dental Education*, *85*(4), 521–530. https://doi.org/10.1002/jdd.12538

Williams, C. (2007). Research methods. *Journal of Business & Economic Research*, 5, 65-72.

Williams, S., & Williams, N. (2004). Assessing BI Readiness: The key to BI ROI. *Business Intelligence Journal*, 9(3), 1-11.

Wixom, B., & Watson, H. (2010). The BI-Based organization. *International Journal of Business Intelligence Research*, *1*(1), 13-28. https://doi.org/10.4018/jbir.2010071702

Yahaya, J., Hani, N., Deraman, A., & Yah, Y. (2019). The implementation of Business Intelligence and analytics integration for organizational performance management: A case study in public sector. *International Journal of Advanced Computer Science and Applications*, *10*(11). https://doi.org/10.14569/IJACSA.2019.0101140

Yeoh, W., & Koronios, A. (2010). Critical success factors for Business Intelligence systems. *Journal of computer information systems* (Vol. 50, Issue 3). http://hdl.handle.net/10536/DRO/DU:30033043

Yin, R. (2013). *Case study research: Design and methods* (3rd Ed., Vol. 5). Sage.