



SMART CAMPUS IN PUBLIC HIGHER EDUCATION: ADAPTING A PLANNING MODEL TO THE BRAZILIAN CONTEXT

SMART CAMPUS NO ENSINO SUPERIOR PÚBLICO: ADAPTAÇÃO DE UM MODELO DE PLANEJAMENTO À REALIDADE BRASILEIRA

SMART CAMPUS EN LA EDUCACIÓN SUPERIOR PÚBLICA: ADAPTACIÓN DE UN MODELO DE PLANIFICACIÓN A LA REALIDAD BRASILEÑA

ABSTRACT

Objective: to analyze the planning process for implementing a smart campus at the Instituto Federal do Ceará (IFCE) Sobral campus, based on the framework by Pagliaro et al. (2016). The study discusses how the scarcity of resources, institutional dynamics, and co-creation influence the applicability of international frameworks in public contexts.

Methodology: a qualitative, exploratory, and descriptive case study was conducted at the IFCE Sobral Campus. Data were collected through semi-structured interviews with managers and document analysis. Content analysis and data triangulation were used to enhance the robustness of the findings.

Results: The findings indicate that the case partially adheres to the six phases proposed by Pagliaro et al. (2016), which were developed in an emergent and non-formalized manner. The framework proved useful but requires adjustments related to fundraising, governance, and institutional coordination.

Limitations: Limited formal documentation and the small number of key informants with first-hand knowledge of the project.

Practical implications: provides support for public managers in structuring smart campus projects that are more aligned with the financial, operational, and institutional conditions of the public sector, promoting efficiency and sustainability.

Social implications: highlights the potential of smart campuses to improve teaching, local innovation and optimize public resources for the benefit of the community.

Theoretical implications: contributes to studies on the framework of Pagliaro et al. (2016) and proposes a framework adapted to the context of Brazilian public institutions.

Originality: the study provides a contextual extension of the framework proposed by Pagliaro et al. (2016), incorporating institutional and financial conditions relevant to smart campus planning in public higher education institutions subject to budgetary and operational constraints.

Keywords: **Smart campus.** Public higher education institutions. Public management. Sustainable cities and communities. Planning and implementation.

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RESUMO

Objetivo: analisar o processo de planejamento para implementação de um smart campus no Instituto Federal do Ceará (IFCE) Campus Sobral, sob a luz do framework de Pagliaro et al. (2016). Discute-se como a escassez de recursos, as dinâmicas institucionais e a cocriação influenciam a aplicabilidade de frameworks internacionais em contextos públicos.

Metodologia: adotou-se uma abordagem qualitativa e exploratória, com caráter descritivo, configurando um estudo de caso no IFCE, Campus Sobral. A coleta de dados inclui entrevistas semiestruturadas com gestores e pesquisa documental. A análise do conteúdo, com triangulação de dados, garantiu a robustez dos achados.

Resultados: os achados indicam aderência parcial do caso às seis fases propostas por Pagliaro et al. (2016), desenvolvidas de forma emergente e não formalizada. O modelo estudado demonstrou utilidade, mas requer ajustes relacionados à captação de recursos, governança e articulação institucional.

Limitações: reduzida documentação formal sistematizada e número limitado de servidores com informações primárias.

Implicações práticas: oferece subsídios para gestores públicos na formulação de estratégias de inovação em contextos de escassez, promovendo eficiência e sustentabilidade.

Implicações sociais: evidencia o potencial do smart campus para aprimorar o ensino, inovação local e otimizar recursos públicos em benefício da comunidade.

Implicações teóricas: contribuição para os estudos sobre o framework de Pagliaro et al. (2016) e propõe modelo adaptado à realidade de instituições públicas brasileiras.

Originalidade: o estudo oferece uma ampliação contextual do modelo de Pagliaro et al. (2016), incorporando condições institucionais e financeiras relevantes para o planejamento de smart campus em instituições públicas de ensino superior submetidas a restrições orçamentárias e operacionais.

Palavras-chave: Smart campus. Gestão

pública. Cidades e comunidades sustentáveis. Planejamento e implementação.

RESUMEN

Objetivo: analizar el proceso de planificación para la implementación de un campus inteligente en el Instituto Federal del Ceará (IFCE), campus Sobral, con base en el framework de Pagliaro et al. (2016) a la realidad brasileña. El estudio analiza cómo la escasez de recursos, la dinámica institucional y la cocreación influyen en la aplicabilidad de los marcos internacionales en contextos públicos.

Metodología: se adoptó un enfoque cualitativo y exploratorio, de carácter descriptivo, configurando un estudio de caso en el IFCE, campus Sobral. La recopilación de datos incluyó entrevistas semiestruturadas con directivos e investigación documental. El análisis de contenido, con triangulación de datos, garantizó la robustez de los hallazgos.

Resultados: los hallazgos indican una adhesión parcial del caso a las seis fases propuestas por Pagliaro et al. (2016), desarrolladas de manera emergente y no formalizada. El modelo estudiado demostró ser útil, pero requiere ajustes relacionados con la captación de recursos, la gobernanza y la articulación institucional.

Limitaciones: reducida documentación formal sistematizada y número limitado de empleados con información primaria.

Implicaciones prácticas: ofrece apoyo a los gestores públicos en la estructuración de proyectos de smart campus más adecuados a las condiciones financieras, operativas e institucionales del sector público en contextos de escasez, promoviendo eficiencia y sostenibilidad.

Implicaciones sociales: destaca el potencial de los campus inteligentes para mejorar la docencia, la innovación local y optimizar los recursos públicos en beneficio de la comunidad.

Implicaciones teóricas: contribuye a los estudios sobre el marco de Pagliaro et al. (2016) y propone un modelo adaptado a la realidad de las instituciones públicas brasileñas.

Originalidad: el estudio ofrece una ampliación contextual del modelo propuesto por Pagliaro et al. (2016), incorporando condiciones institucionales y financieras relevantes para la planificación de



campus inteligentes en instituciones públicas de educación superior sujetas a restricciones presupuestarias y operativas.

Palabras clave: Campus inteligentes. Instituciones de educación superior. Gestión pública. Ciudades y comunidades sostenibles. Planificación e implementación.

INTRODUCTION

The advancement of digital technologies, coupled with urbanization and the scarcity of natural resources, has driven a significant transformation in the way cities and institutions address their operational and social challenges (Carvalho, Coelho & Moura, 2025). This movement also encompasses higher education institutions (HEIs), which, inspired by the concept of smart cities, apply similar principles on a smaller scale and within a more controlled environment focused on education (Li, 2021).

The concept of a smart campus encompasses technological solutions applied to the educational context, grounded in the use and evolution of information technologies (Sui & Xie, 2023). In this regard, HEIs constitute environments conducive to innovation, functioning as spaces for experimentation aligned with contemporary challenges, which makes them ideal for the application of smart campus solutions, whose outcomes can be extrapolated to urban contexts (Jesus et al., 2018).

Despite the growth of scientific research on smart campuses, the literature still presents areas that remain insufficiently consolidated regarding the definition of the concept, the assessment of campus smartness, the centrality of users, and the empirical analysis of the planning and implementation processes of such initiatives (Freire et al., 2025; Polin et al., 2023; Polin et al., 2024; Zhang et al., 2022). Some studies focus on the proposal of models, technologies, and expected benefits, while the institutional, organizational, and contextual conditions that influence the application of these models in specific settings remain less explored, particularly in public institutions and developing countries (Polin, 2026).

The literature presents planning models

for smart campuses, among which the framework proposed by Pagliaro et al. (2016) stands out. However, some of these models were developed in institutional contexts in which the prior availability of financial and operational resources for the transition from a traditional campus to a smart campus is assumed. This assumption limits their direct applicability to contexts experienced by Brazilian public HEIs, which are characterized by budgetary constraints, administrative bureaucracy, dependence on partnerships, and the need to secure funding to enable innovation projects (Conif, 2023; Hoppe, 2021), making resource mobilization a crucial dimension.

This discussion is particularly relevant considering that a large proportion of the universities adopting the smart campus concept in Brazil belong to the public sector (Bandeira & Neto, 2020). In these settings, implementation depends not only on the incorporation of smart technologies but also on the institutional capacity to articulate financial sustainability, participation of the academic community, interinstitutional collaboration, and innovation strategies compatible with material and organizational constraints, reinforcing the importance of investigations that address the specific characteristics of this institutional segment.

In this context, the following research question arises: How can the planning process for implementing a smart campus in a Brazilian public institution be characterized in light of the contextual and structural challenges faced during the initial stages of the project? From this perspective, the objective of this study was to analyze the planning process for implementing a smart campus at the Federal Institute of Education, Science and Technology of Ceará (IFCE), Sobral Campus, in light of the framework proposed by Pagliaro et al. (2016), considering the institutional, operational, and contextual specificities of a Brazilian public institution during the initial stages of the project.

This study adopted a qualitative, exploratory, and descriptive approach, configured as a case study at the IFCE Sobral Campus. Data collection involved semi-structured interviews with the three staff members responsible for the



project, as well as document analysis. Data analysis followed content analysis procedures, using data triangulation to ensure greater robustness of the findings.

The implementation of smart campuses in HEIs faces obstacles such as inadequate planning, insufficiently prepared specialists, limited infrastructure, and the unavailability of initial resources (Hidayat & Saputra, 2020). Therefore, the theoretical contribution of this article lies in discussing the applicability of an international smart campus planning framework to a Brazilian public institution, demonstrating how the institutional, financial, and operational conditions of the context investigated influence the planning process. As a practical contribution, the study provides support for public managers seeking to structure smart campus initiatives in resource-constrained contexts, highlighting dimensions such as institutional mobilization, partnerships, resource mobilization, governance, and academic community participation.

The results demonstrate that the model proposed by Pagliaro et al. (2016) has analytical utility for understanding smart campus planning at the IFCE Sobral Campus. However, the case analysis reveals specific characteristics of the Brazilian public-sector context that require consideration when applying international planning models, particularly with regard to institutional mobilization, benchmarking, resource mobilization, partnership development, and public governance.

The remainder of the article presents the theoretical framework, followed by the methods, discussion of the results, final conclusion, and references.

LITERATURE REVIEW

Smart Campus: Concepts, Dimensions, and Implementation Models

Although cities and universities have distinct purposes, they often share similar socioeconomic, environmental, and geographical contexts, as well as infrastructure, services, and communication channels (Sospedra et al., 2015).

In this regard, the concept of a smart campus emerges as an adaptation of the smart city paradigm to educational institutions, which, like cities, face complex challenges related to mobility, energy management, security, sustainability, and innovation (Dong et al., 2020; Zhang et al., 2022).

This transposition has driven an expanding field of research, particularly since 2010, stimulated by advances in digital technologies and the pursuit of greater efficiency in academic and institutional management (Dong et al., 2020; Imbar et al., 2020). Over the past five years, the topic has gained increasing prominence, with an emphasis on technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), big data, and cloud computing (Neis et al., 2023).

Scientific research on smart campuses has advanced through systematic reviews addressing definitions, technologies, and conceptual perspectives (Freire et al., 2025; Giuriatti et al., 2023; Jesus & Camelo, 2024; Madyatmadja et al., 2021; Zhang et al., 2022), while empirical studies have explored digitalization strategies and institutional transformation (Budiono & Budiarto, 2024; Chagnon-Lessard et al., 2021; Gasperina et al., 2022; Sui & Xie, 2023). These studies can be organized into four domains: technological infrastructure; sustainability and energy efficiency; university governance and management; and user-centeredness (Awuzie et al., 2021; Zhang et al., 2022). While China, Spain, Finland, and South Africa lead smart campus implementation, with a focus on smart mobility, energy efficiency, and digital learning environments (Madyatmadja et al., 2021), advances in Brazil remain fragmented, concentrated on isolated technological infrastructure initiatives, without articulation with public policies or long-term institutional plans, thereby compromising the sustainability and replicability of such initiatives (Carvalho, Coelho, & Moura, 2025; Vasconcelos & Scaico, 2023).

Despite the growing interest, studies that empirically measure the impacts of smart campus initiatives on teaching quality, academic performance, and institutional efficiency remain scarce (Freire et al., 2025). In addition, there is a gap in the understanding of the initial stages of implementation, particularly in Brazilian

public institutions, which account for most of these experiences in the country (Bandeira & Neto, 2020; Carvalho, Coelho, & Moura, 2025; Francisco, 2019; Jesus & Camelo, 2024; Santos et al., 2025), highlighting the need to expand research into smart campus implementation processes within public management contexts and under budgetary constraints.

The definition of smart campus varies across studies according to the contexts and objectives of each investigation (Alexandre & Alexandria, 2024; Chagnon-Lessard et al., 2021; Jesus & Camelo, 2024). Schenatz (2019) structures the concept into eight interconnected dimensions: education, social, health, security, buildings, energy, mobility, and technology, whereas Dong et al. (2020) define the smart campus as an ecosystem based on the integrated application of Information and Communication Technology (ICT), aimed at improving operational efficiency, the educational experience, and sustainability, proposing five pillars that encompass this perspective: education, environment, people, processes, and technology.

Imbar et al. (2020) complement this perspective by considering the smart campus as a conceptual extension of smart cities, structured to integrate technologies across different institutional domains. Zhang et al. (2022), in turn, present a human-centered perspective, arguing that a smart campus should be designed based on the needs of its users, promoting inclusion, security, accessibility, and innovation.

From a contemporary perspective, the smart campus is characterized as a collaborative and digitally connected environment that integrates technologies such as IoT, cloud computing, and data analytics to optimize institutional management. Freire et al. (2025) highlight the benefits for institutions and users, while Carvalho, Coelho, and Moura (2025) emphasize the importance of shared governance, sustainability, and strategic decision-making. These definitions demonstrate the convergence of multiple conceptual categories, as systematized in Table 1.

Table 1
Conceptual dimensions of the smart campus

Conceptual Dimension	Main Emphasis	Authors
Technological Infrastructure	Use of ICT, IoT, wireless networks, cloud computing, and data analytics to support academic and administrative processes.	Alexandre e Alexandria (2024); Carvalho, Coelho e Moura (2025)
Management and Decision-Making	Strategic use of information to optimize institutional resources, services, and processes.	Freire et al. (2025); Dong <i>et al.</i> (2020)
Sustainability and Efficiency	Reduction of energy consumption, environmental improvement, and efficient use of campus resources.	Kou & Park (2022); Lobato <i>et al.</i> (2021)
User Experience	Improvement of learning, safety, accessibility, interaction, and quality of life for the academic community.	Zhang et al. (2022); Imbar <i>et al.</i> (2020)
Integration with smart cities	Transposition of the smart city paradigm to the university context.	Bandeira e Neto (2020); Imbar <i>et al.</i> (2020)

Source: Elaborated by the author (2025).

Based on Table 1, it is possible to observe that the smart campus concept integrates technological, managerial, environmental, and human dimensions. Accordingly, its implementation is not confined to the adoption of digital devices; rather, it entails the articulation

of infrastructure, governance, sustainability, data management, and user engagement. This perspective broadens the debate beyond technology alone, enabling the analysis of the smart campus as a strategy for institutional transformation.



The benefits of a smart campus encompass administrative, pedagogical, operational, and social gains. The literature highlights efficiency in resource management, improvements in teaching and learning, transparency, safety, enhanced ties with the academic community, and sustainability (Bernal et al., 2024; Santana, Dornelas, & Silva, 2024). Studies also point to the monitoring of workflows, traffic, risks, energy consumption, and asset inventory, thereby fostering data-driven decision-making (Cață, 2015; Sánchez-Torres et al., 2018). In the educational domain, it fosters collaboration, communication, personalized learning, open education, and efficient data management (Alexandre & Alexandria, 2024; Ng, 2010; Vasconcelos & Scaico, 2023).

Despite these benefits, implementing a smart campus presents organizational, financial, technical, and regulatory barriers. In a systematic review, Carvalho, Coelho, and Moura (2025) highlight resistance to change, budgetary constraints, legacy systems, inadequate infrastructure, data protection requirements, lack of training, and fragmented governance as key factors that hinder the adoption and maintenance of such initiatives.

The literature offers various frameworks that support the conceptualization, implementation, and evaluation of smart campuses. Conceptual models structure the smart campus into core dimensions or axes, such as technology, sustainability, mobility, governance, education, and user experience (Bernal et al., 2024; Dong et al., 2020; Ng, 2010; Nóbrega et al., 2022; Polin et al., 2023; Zhang et al., 2022). In turn, implementation models provide pathways to operationalize these initiatives—whether through processual planning stages, as in Pagliaro et al. (2016); through a digital architecture and operational model, as in Jurva et al. (2020); or through a strategic framework driven by IoT and cloud computing, as in Abualnaaj et al. (2020). Meanwhile, evaluation models focus on measuring the campus's level

of smartness, as seen in Polin et al. (2024) and Samancioglu and Nuere (2023).

Considering this classification, implementation models stand out by offering clear pathways for operationalizing these initiatives. Although Abualnaaj et al. (2020) propose a strategic framework and Jurva et al. (2020) emphasize digital and operational architecture, the model by Pagliaro et al. (2016) proves most aligned with the objective of this study by proposing a processual sequence for planning and implementation. Unlike models predominantly focused on digital infrastructure or smartness assessment, this model enables the analysis of the early transition phases from a traditional campus to a smart campus - the central focus of the investigation conducted at IFCE Sobral Campus.

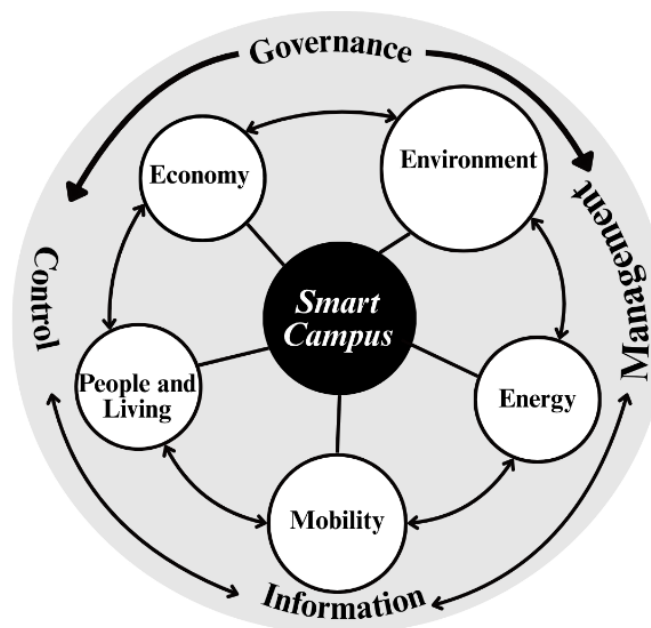
Smart Campus Framework at La Sapienza University

The methodological framework proposed by Pagliaro et al. (2016), conceived in the context of Università La Sapienza, constitutes a structured model to guide the transition from a traditional university campus to a smart campus. Developed by a multidisciplinary team, the model is based on the premise that the campus can be understood as an intelligent and experimental ecosystem capable of promoting sustainable, technological, and collaborative solutions.

The methodology proposed by Pagliaro et al. (2016) is structured into six sequential stages, beginning with preliminary planning that encompasses the diagnosis and mapping of the institutional context. Based on this diagnosis, strategic fields of action are defined, as presented in Figure 1, which highlights the transversal nature of governance across the different strategic dimensions of the smart campus.



Figure 1
Strategic Fields of Action

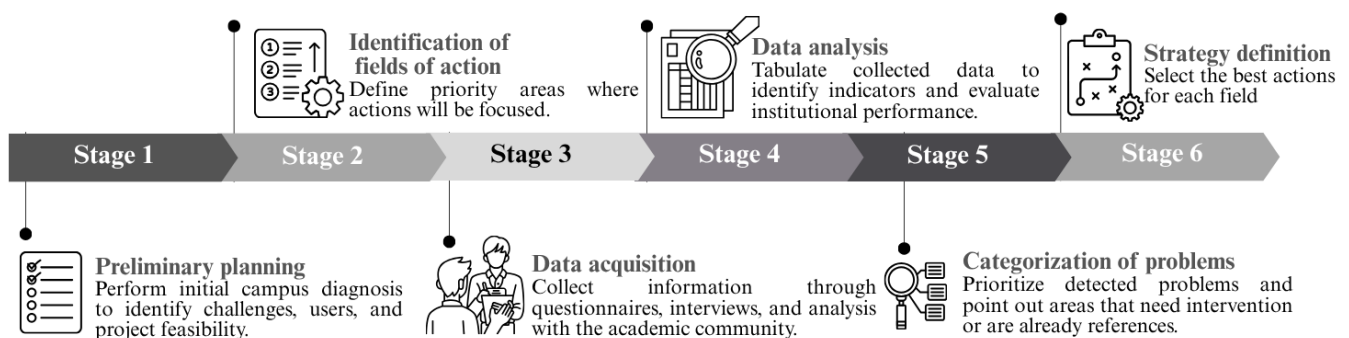


Source: adapted from Pagliaro et al. (2016).

Next, the problems are categorized to identify deficiencies and potentialities within the fields of action, culminating in the strategic definition of priority actions for the intervention plan. Figure 2 illustrates the stages for implementing the smart campus proposed by

Pagliaro et al. (2016), which emphasizes the active participation of the community, the flexibility of solutions, and the integration of physical and digital systems, positioning the campus as a living lab focused on innovation and sustainability.

Figure 2
Stages for the Implementation of the Smart Campus



Source: Author's own elaboration based on Pagliaro et al. (2016)

Since its proposal, the Sapienza framework has been subject to evaluations and adaptations. Studies such as Polin et al. (2024), which validated its indicators in different university contexts, demonstrate the robustness of the model, while Chagnon-Lessard et al. (2021) expanded the debate by incorporating emerging issues such as ethics and interoperability. In Brazil, Jesus and

Camelo (2024) point to its relevance for national projects, suggesting stages of adaptation to the reality of public higher education institutions, corroborating studies that emphasize the need for a sociotechnical and integrated approach that takes into account the cultural, organizational, and participatory aspects of institutions (Matos, 2021; Nóbrega et al., 2022; Siqueira, 2023).

This need for adaptation becomes even more evident when models developed at universities in the Global North are applied to Global South contexts, which are characterized by disparities in funding, infrastructure, and operational capacity (Polin, 2026). In such scenarios, the literature on organizational bricolage and frugal innovation contributes to understanding how institutions innovate under conditions of scarcity by recombining available resources and developing functional, accessible solutions that are suited to their constraints (Baker & Nelson, 2005; Radjou & Prabhu, 2015; Weyrauch & Herstatt, 2017).

Despite its conceptual breadth and adaptability, the framework proposed by Pagliaro et al. (2016) was developed in an institutional context with greater availability of financial, operational, and technological resources to support the transition. This condition limits its direct application in Brazilian public institutions, which face persistent budgetary constraints (Conif, 2023; Hoppe, 2021). In this context, resource mobilization, partnership development, and the recombination of available means become essential dimensions for enabling smart campus projects

METHODS

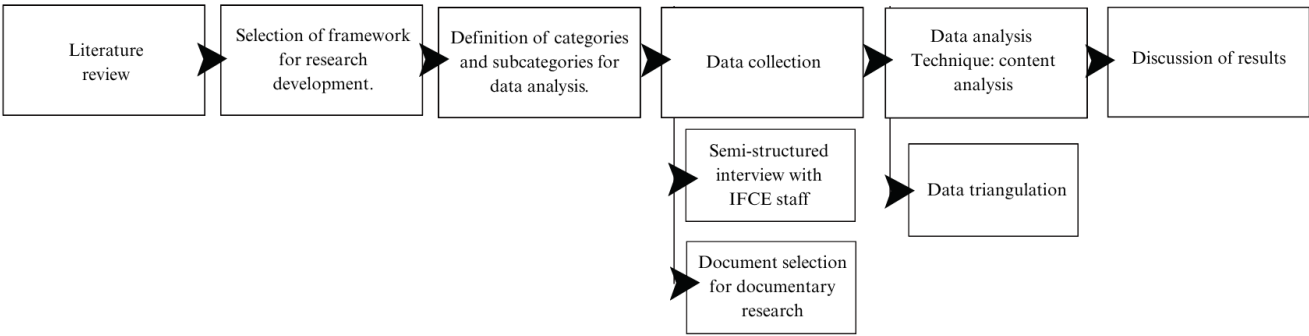
To achieve the research objective, a qualitative approach was adopted, grounded in description and subjectivity (Flick et al., 2004). According to Yin (2016), this methodological strategy is characterized by an in-depth and detailed analysis of the facts under investigation, enabling a broad and thorough understanding of the reality and phenomena under examination,

thereby facilitating the correlation between Pagliaro et al.'s (2016) smart campus model and the process experienced at IFCE Sobral.

Regarding its nature, this is an exploratory and descriptive study, as its purpose was to analyze the planning and implementation process of the smart campus at IFCE Campus Sobral. The choice of the Federal Institute of Ceará (IFCE) Campus Sobral as the object of study is justified by its strategic role within the Federal Network and its structural complexity, encompassing 17 programs (technical, undergraduate, and graduate) distributed across more than 50 academic facilities, including laboratories and pilot plants. This dynamic context poses significant management and infrastructure challenges, prompting the institution to take its first formal steps toward the transition to a Smart Campus (2026). Analyzing this planning process through the lens of the framework proposed by Pagliaro et al. (2016) is particularly appropriate, as the dimensions proposed by the authors help elucidate how a public institution of technical and higher education can align technology, governance, and sustainability within a complex educational ecosystem.

Finally, from the perspective of technical procedures, this research is characterized as an instrumental case study, since the selected case enables the understanding of a broader phenomenon: the adaptation of smart campus models to Brazilian public institutions (Stake, 2010). The methodological process followed the stages presented in Figure 3, which are detailed below:

Figure 3
Research Development Structure



Source: author's own elaboration (2025).



To ensure greater robustness and validity of the research findings, data triangulation was adopted by combining different sources and methods of data collection and analysis: bibliographic research, semi-structured interviews, and document analysis. The documentary research encompassed institutional and media sources published between 2021 and 2024: (1) a parliamentary portfolio containing investment demands for the project; (2) two reports published on the official IFCE Sobral website; and (3) an article published in Revista IFCE Sobral em Destaque. These documents provided complementary evidence regarding strategic decisions, prioritized fields of action, and institutional perceptions.

The interviews were conducted between October and November 2024 with the three staff members directly involved in the project. The participants were selected because they were the only staff members involved in the project’s planning and, consequently, could be considered key informants due to their phenomenological knowledge, following the guidance of Akhter (2022) (Table 2). The interviews were conducted in person, recorded, and fully transcribed upon the signing of the Informed Consent Form. To preserve the participants’ identities, the codes E1, E2, and E3 were used.

Table 2
Characterization of the Research Participants

Interviewee	Position	Interview Date	Duration
E1	Faculty member	10/17/2024	01:23
E2	Electrical Engineering Technician	11/12/2024	00:57
E3	Administrative Assistant	11/22/2024	01:11

Source: author’s own elaboration (2025).

A semi-structured interview guide comprising five open-ended questions was used as the data collection instrument, addressing the origins of the proposal, the planning process, the partnerships established, the expected and perceived outcomes, and the challenges encountered. The questions made it possible to capture elements related to planning, governance, priority setting, resource mobilization, and

implementation barriers (Table 3). The semi-structured nature of the interviews allowed for the formulation of additional questions as elements related to the stages of the framework emerged in the participants’ responses. The names of the stages were not presented to the participants in order to minimize the potential influence on their responses.

Table 3
Semi-structured interview questions and analysis categories

Question	Category Analyzed	Theoretical Framework
Q1. How did the idea of implementing a smart campus at IFCE Sobral emerge?	Contextualization of the smart campus initiative	Bandeira e Neto (2020); Imbar <i>et al.</i> (2020); Santana, Dornelas e Silva, 2024; Stuckrath <i>et al.</i> (2025).
Q2. What results are expected following its implementation?	<i>Benefits of the smart campus</i>	Bernal <i>et al.</i> (2024); Ng (2010); Vasconcelos e Scaico (2023).
Q3. What stages are planned for the project?	Planning stages and fields of action	Pagliaro <i>et al.</i> (2016).
Q4. What actions have been carried out so far?	Implementação	Pagliaro <i>et al.</i> (2016).
Q5. What are the initial challenges involved in transitioning from a traditional campus to a smart campus?	Barriers and adaptation to the public-sector context	Bernal <i>et al.</i> (2024); Carvalho, Coelho e Moura (2025); Sánchez-Torres <i>et al.</i> (2018); Soares (2023).

Fonte: autoria própria (2025).

Data analysis was conducted using categorical content analysis, following Bardin (2016), and was carried out in three stages. During the pre-analysis stage, the corpus, consisting of the interviews and institutional documents, was organized through a preliminary reading of the material and preparation of the data for analysis. During the material exploration stage, the recording units extracted from the interviews and documents were manually organized in

a spreadsheet. These units were linked to the categories previously defined in Table 3 and grouped according to thematic recurrence. The six stages of the framework proposed by Pagliaro et al. (2016) were adopted as deductive analytical categories and operationalized through descriptions that guided the coding process. Table 4 presents the categories, their analytical descriptions, the related interview questions, and the sources of evidence used.

Table 4
Analytical Categories Derived from Framework proposed by Pagliaro et al. (2016)

Analytical Category	Analytical Description	Questions	Sources
Preliminary planning	Delimitation of the intervention, identification of stakeholders and partners, and feasibility assessment.	Q1; Q3; Q4; Q5	Interviews; Institutional Development Plan (PDI); portfolio; news reports
Identification of fields of action	Definition of strategic areas of intervention.	Q2; Q3; Q4	Interviews; portfolio; news reports
Data acquisition	Collection of information about the campus, users, infrastructure, and needs.	Q3; Q4	Interviews
Data analysis	Identification of deficiencies, potentialities, and conditions of the campus.	Q3; Q4	Interviews
Problem categorization	Organization and prioritization of the identified demands.	Q3; Q4; Q5	Interviews; portfolio
Strategic definition	Selection of actions, responsibilities, resources, and implementation methods.	Q2; Q3; Q4; Q5	Interviews; Institutional Development Plan (PDI); portfolio; news reports

Source: Author’s own elaboration (2025).

The responses were analyzed in an integrated manner, allowing the same recording unit to be associated with more than one category. Emerging categories not originally included in the framework were also considered when identified through thematic recurrence, such as institutional mobilization, benchmarking, partnerships, and resource mobilization. Finally, in the stage of processing, inference, and interpretation of the results, the findings were synthesized and integrated with the framework proposed by Pagliaro et al. (2016) and the literature on smart campus, with the aim of identifying areas of alignment, limitations, and the need to adapt the model to the context of the IFCE Sobral. The following section presents the results obtained from this process.

RESULTS AND DISCUSSION

Contextualization of the Smart Campus Initiative at IFCE

IFCE operates in professional training, research, and innovation across various regions of Ceará. The institution comprises a Rectorate,

an Innovation Hub, and 33 campuses distributed across six intermediate geographic regions of the state. Established in 2007 as part of the expansion plan of the federal education network, IFCE Sobral Campus offers technical and technological programs across four areas: industrial control and processes, food production, natural resources, and environment and health (IFCE, 2024). The smart campus initiative began in 2021, aligned with the institution’s mission of fostering regional scientific and technological development. The project seeks to incorporate smart city practices into the daily operations of IFCE through technological solutions aimed at both the academic community and the broader community, as detailed in the following subsections (research data, 2024).

Motivation for Implementation

The conception of the smart campus project at IFCE Sobral Campus is driven by three main motivations:

Alignment with its organizational identity: IFCE’s organizational identity, which prioritizes technology, innovation, and



sustainability, is aligned with its mission of producing, disseminating, and applying scientific and technological knowledge for citizenship education, as well as with its vision of pursuing excellence in teaching, research, outreach, and innovation for social transformation and regional development. However, a discrepancy was perceived between this stated identity and the practices observed, as expressed by Interviewee 1:

In 2018, I started participating in many conferences and things like that, and I began to realize that it was a trend. It's a trend! And we are a technology institute. And I was puzzled by how we could be a technology institute without having technology implemented on our own campus, right? (E1).

Interviewee 1's account highlights the gap between IFCE's institutional mission of fostering technological innovation and the practical obstacles encountered, indicating that the smart campus proposal serves as a mechanism for aligning the organization's identity with the consolidation of an innovation culture on the campus.

Co-creation and living lab: The managers envision the campus as a "living laboratory" for experimentation. The intention is for the development of the smart campus to actively involve students from different areas in co-creating innovative solutions:

The idea is that the smart campus should be built together with the students on the campus, across the different internal areas of the campus: Irrigation and Drainage [technological program] in the automation and control of the garden; the [technical program in] Environmental Studies students in selective waste collection [...] we want to automate and better control the campus's selective waste collection; the Industrial [technological area] students collaborating in the development of equipment and systems. So, the idea is that the smart campus should be built with all the students on the campus, producing and developing the entire system (E3).

This perspective converges with the concept of living labs, in which the campus serves as an environment for experimentation and co-creation (Stuckrath et al., 2025). The project is expected to foster a culture of innovation, encouraging students to develop technologies to address problems in their communities and to validate technological products. One example is the development of an application for waste management with student participation, as reported by Interviewee 1:

This selective waste collection area needs to weigh [the waste], and we have already thought about creating some smart scales as well. This scale can already measure density, it can measure everything. It is even underground. The collection bin itself, as you put things into it, already provides the information. And there will be a device with this application. Since the application communicates with the scale, the collection agent will receive a message saying that it can already be collected. And the app is being developed by students (E1).

Student participation is regarded as beneficial to teaching and learning and to alignment with labor market demands, as reported in a news article:

We need our students to graduate with the qualifications to compete in the market, with socio-environmental responsibility, with an understanding of Industry 4.0, the use of the Internet of Things, and Artificial Intelligence. And all of this will be incorporated into the dynamics of the campus. Students will be able to see all of this in practice, in a giant laboratory—the entire campus—in an integrated, transdisciplinary way. Students will leave here much more qualified, keeping pace with actual technological developments in the world" (Braga, 2021).

The teaching and learning benefits associated with the smart campus are corroborated by Imbar et al. (2020), who highlight the use of users' knowledge to improve institutional operations.

Operational efficiency and sustainability: The discussion surrounding the smart campus is also related to resource optimization, given the budgetary constraints faced by public institutions and cuts in federal funding. The integration of technology and management is viewed as a solution for controlling consumption and optimizing resources, thereby aligning the campus with the Sustainable Development Goals, as reported in a news article:

It is a trend; there is a need to look toward the smart campus and toward some educational institutions in Brazil that are already trying to implement smart campuses, especially in terms of energy efficiency. Here, however, we want to increase energy efficiency and efficiency in other sectors as well, but always with sustainability as the underlying principle in every step we take (Braga, 2021).

According to Santana, Dornelas, and Silva (2024), concern for environmental issues and the transformation of the university into a space for

innovation and development are fundamental to promoting the Sustainable Development Goals. Interviewee 2 emphasizes resource management and optimization:

The idea of the smart campus would be to make the campus more modern, with innovative technologies that could optimize the Institution’s resources, such as water, energy, and human resources as well [...] We would have greater control over these variables, right? And with this monitoring, we would reduce costs and have a sustainable institution as well (E2).

Operational efficiency also aims to improve the quality of services provided to students, including process automation and enhanced security.

Table 5 summarizes the first categories analyzed, showing that the smart campus initiative combines institutional alignment, co-creation, and the pursuit of efficiency within a context of budgetary constraints.

Table 5
Summary of Findings on the Origins and Motivations of the Smart Campus

Category	Central Finding	Interpretation
Institutional alignment	The project emerged from the perception of a gap between IFCE’s technological identity and the campus infrastructure.	The smart campus seeks to bring together the institution’s mission, innovation, and organizational practices.
Co-creation and living lab	Students participate in the development of solutions to real problems on the campus.	The campus is understood as a space for experimentation, applied learning, and innovation.
Efficiency and sustainability	The actions aim to reduce costs, automate processes, and improve the use of water, energy, and services.	Technology emerges as a response to budgetary constraints and the need for efficient management.

Source: Research data (2025).

These findings indicate that the project’s initial motivations combine innovation, efficiency, and sustainability, but also reveal that its implementation depends on the institutional, operational, and financial conditions of the campus. This aspect is further explored in the analysis of the implementation stages.

Implementation Stages of the Smart Campus at IFCE

The analysis of documents and interviews reveals that the implementation of the smart campus at IFCE Sobral did not follow a structured

plan organized into formal stages. Instead, it developed through an emergent and adaptive process shaped by institutional opportunities, resource availability, and the establishment of partnerships. Although this characteristic provides flexibility, it also represents a limitation in terms of the project’s predictability and long-term management, potentially affecting the robustness of its outcomes. Nevertheless, it was possible to identify phases analogous to those proposed by Pagliaro et al. (2016), although these phases were neither intentionally nor formally established. Interviewee 1 illustrates this approach:

We started with very small dreams, right? For example, issuing our ID badges. Why doesn't this badge come with RFID, which is already a smart technology? [...] Then we started thinking: why can't we make this more advanced, with facial recognition? So, we are already moving forward with the procurement of smart turnstiles as well. All of this is aimed at generating efficiency. [...] Shall we create an innovation office? We created an innovation office.(E1)

Despite the absence of detailed planning, actions and priority areas were mapped, including monitoring through an Excel spreadsheet and a schedule included in the Parliamentary Portfolio (Figure 4). The managers' accounts also revealed the development of emerging strategies to address budgetary constraints and other challenges arising during the implementation of the proposal.

Figure 4
Schedule for the Implementation of the Smart Campus

	1	2	3	4	5	6	7	8	9	10	11	12
Technical Project Definition												
Procurement												
Implementation												
Operational Pilot												

Note: Prospective schedule prepared for the Parliamentary Portfolio (2021), organized over a twelve-month period, which does not necessarily correspond to the actual period of implementation of the actions.

When questioned about the initial stage of the project, Interviewee 1 revealed that the maturing of the smart campus idea included benchmarking conducted through visits to higher education institutions that adopt smart campus principles, such as the State University of Campinas (Unicamp) and its Sustainable Campus Project, focused on electricity savings using IoT since 2017. Furthermore, managers deepened their understanding of the topic by participating in courses on energy sustainability and specific events.

This finding shows that, in the case of IFCE Campus Campus, preliminary planning did not begin directly with the technical diagnosis of the intervention area, as provided for in the framework by Pagliaro et al. (2016). Before that, there was a stage of institutional learning, management awareness, and a search for external references. This evidence supports the need to insert, into the adapted model, a preparatory phase of institutional mobilization and benchmarking,

especially in public institutions where technical knowledge about smart campuses is still consolidating.

From then on, management mapped out existing areas for improvement on campus alongside those responsible for the project. Issues such as energy waste and inefficient manual processes were identified, in addition to aspects that would impact project continuity, particularly the financial constraints. There was also a survey of potential collaborative initiatives, where establishing partnerships was considered a key differentiator for executing the proposal:

But another thing that also draws attention to the project is the issue of collaboration, because you end up attracting other partners to do the work, and so, regarding these sustainability strategies, one of the important points is the issue of collaboration, of articulation, right? What they call orchestration (E1).



The campus's first partnership was established with Unicamp through visits to its facilities, which built a channel for future consultations regarding project implementation: "Unicamp today is a partner. When I wonder: 'Man, what's on the cutting edge out there?', they talk" (E1).

It is also possible to identify that, despite not following a standard methodology, managers recognize establishing partnerships as an integral part of the first planning phase, according to an excerpt from the news article: "the project will be executed gradually and long-term. Currently, it is in the planning phase, seeking partnerships for the technologies to be used in the systems" (Braga, 2021). The collected data suggests that making the smart campus project feasible depends on forming institutional partnerships. This practice is predominant in consolidated smart campus projects in Brazil, often developed by research centers or institutes within the universities themselves (Vasconcelos & Scaico, 2023).

After preliminary planning, the model by Pagliaro et al. (2016) provides for the identification of fields of action. In the case of IFCE Sobral Campus, initiatives related to the model's five strategic fields were identified: people and living, economy, energy, environment, and mobility. Evidence was extracted from the Parliamentary Portfolio, news articles, and interviews. This correspondence indicates partial alignment to the framework, as the case encompasses the fields predicted by the model. However, the way these fields were defined and prioritized reveals contextual adaptation: actions were selected not only by technical criteria, but also by perceived urgency, operational feasibility, and the possibility of obtaining external resources.

This diversity of initiatives, aimed at modernizing and increasing campus efficiency, aligns with the main motivations for smart campus implementation discussed in the previous section.

Following the identification of fields, the model by Pagliaro et al. (2016) predicts the data

acquisition phase, which involves collecting primary and secondary data to support an in-depth diagnosis of the defined fields of action. In the studied context, this stage was marked by campus management meetings with representatives from various sectors, document analysis, and the monitoring of resources such as internet, energy, and water that presented urgent problems aligned with the previously defined fields of action. Reports indicated operational bottlenecks related to energy waste, manual opening of rooms, irrigation, asset inventory, and access to the cafeteria. These issues guided the definition of actions aimed at process automation, resource rationalization, and service improvement:

This dedicated one-gigabit internet, we realized it was above what we needed [...] We monitored how much internet we consumed. We realized the peak query demand was around 360 megabits. So, we contracted now—and it's already working—400 megabits of dedicated internet (E1).

This finding demonstrates partial alignment to the framework of Pagliaro et al. (2016), as it shows the use of data to inform management decisions. However, the analysis also reveals a limitation of the initial implementation: the collected data has not yet been converted into systematic indicators to monitor the performance of the fields of action, as envisioned in the original model. After the data acquisition stage, the methodology of Pagliaro et al. (2016) directs information analysis toward building thematic indicators. In the IFCE context, data consolidation—obtained via the Parliamentary Portfolio and compared against interviews and news articles—made it possible to identify planned actions and technologies associated with smart campus planning. Table 6 shows that the project encompasses the five fields outlined by Pagliaro et al. (2016), but also reveals that action execution depends on institutional and financial conditions not sufficiently detailed in the original model.

Table 6
Summary of smart campus project actions by field of action

Field of action	Actions identified at IFCE Sobral Campus	Analytical summary
People and living	Self-service apps and chatbots; Online services; Data bus / Data lake / Machine learning; Automated inventory; Wi-Fi 6 network; Network Operation Center and LoRaWAN telecommunications infrastructure; Back-end ICT infrastructure; Maker Space / Maker Lab; Video editing studio; Student involvement in project implementation; Campus monitoring and surveillance; Beacons; Video analytics; Smartphone access control; and License plate recognition.	Concentrates the largest number of actions, indicating that enhancing the experience of the academic community and internal management is a central axis of the project.
Economy	Partnerships for equipment acquisition and establishment of the Innovation and Technology Center (CIT).	Highlights that financial and institutional viability depends on external articulation, an aspect lightly detailed in the original model.
Energy	Solar energy generation.	Relates the project to energy efficiency and operational cost reduction.
Environment	Water and energy consumption management; Automation of lighting and climate control in classrooms; and Waste management apps.	Associates sustainability with resource rationalization and waste reduction.
Mobility	Smart turnstiles at the University Restaurant and campus navigation system.	Indicates initial actions aimed at improving flows and access to services.

Source: research data (2024).

Pagliaro et al. (2016) emphasize the need to use indicators to evaluate the relative performance of each field of action. However, although IFCE defined actions based on meetings, documents, and operational demands, the creation of systematic indicators to monitor these fields was not identified during the studied period. This absence constitutes an important limitation of the initial implementation. Without indicators, it becomes more difficult to assess project evolution, compare fields of action, measure results, and justify investment priorities. At the same time, this finding reinforces the need to adapt the framework to the reality of Brazilian public institutions by incorporating gradual monitoring mechanisms compatible with available technical and operational capacity.

Based on the analysis, the categorization of problems organizes and prioritizes identified situations by severity, scope, and impact. When carried out at different times, this stage makes

it possible to build campus evolution scenarios (Pagliaro et al., 2016). Such categorization highlights areas requiring immediate intervention and those that already serve as best practices. The document analysis did not reveal a formal ranking of problem or field-of-action prioritization. Actions considered priorities were inferred from those already initiated or underway, combining interviews, institutional documents, and news articles. This finding highlights a departure from the Pagliaro et al. (2016) model: in the case studied, prioritization did not stem from a formal matrix of impact or feasibility, but rather from a combination of perceived urgency, resource availability, ease of execution, and the potential to secure external funding.

It is possible that an action defined as a priority during the proposal’s planning phase may not be implemented due to budget constraints, as reported by Interviewee 2 when asked about the existence of an activity schedule:



We will do whatever is easiest, depending on the available resources. For example, this classroom thing to raise funds would offer the best cost-benefit ratio—let's say we were going to spend very little to get started, so we could approach a politician. 'Oh, great, let's invest in this Institution here, let me get you some funding (E2).

The interviewee exemplifies that actions with lower initial costs could be used to demonstrate the project's feasibility and attract political and financial support. Thus, budget constraints condition the definition of strategies, bringing implementation closer to an adaptive logic in which actions are prioritized according to available resources and external support opportunities. This finding aligns with Hoppe (2021), highlighting that successive federal budget cuts have generated significant impacts on scientific advancement and the administration of public assets. Therefore, enabling improvements and maintaining public spaces, such as migrating to a smart campus, will require commitment from public authorities and support from civil society for efficient and sustainable management.

Based on the consolidated diagnosis and problem categorization, Pagliaro et al. (2016) indicate that the strategic definition stage should guide the choice of actions for each thematic field, considering technical, financial, and social feasibility criteria, which can be represented in impact matrices to facilitate prioritization. The goal is to select high-value-added interventions, allocating resources efficiently and ensuring alignment with institutional goals of innovation, sustainability, and quality of life on campus.

In the case of IFCE Sobral Campus, however, the adoption of tools such as matrices or formal models to establish strategies was not identified. The document that comes closest to the procedure proposed by Pagliaro et al. (2016) for this stage—which focuses on outlining action strategies based on feasibility and prioritization criteria—is the Parliamentary Portfolio (Portfólio Parlamentar), which gathers actions to be carried out, expected benefits, and the required budget, but lacks an explicit ranking of priority actions.

This absence highlights a limitation of the initial implementation: although the project shows adherence to the framework by Pagliaro et al. (2016) regarding the definition of fields and actions, the choice of priorities appears to have been conditioned by financial viability, fundraising opportunities, and available operational capacity. Thus, strategic definition took on a more adaptive than formal character, reinforcing the need to adjust the model to the reality of Brazilian public institutions.

The 2020 Parliamentary Portfolio (Portfólio Parlamentar 2020 Smart campus) highlights strategies for infrastructure modernization (logical and electrical networks), procurement of furniture and equipment for innovation labs, and the implementation of smart monitoring systems and sustainable energy generation. The document reinforces the intention to generate data to inform decision-making and optimize resources, consolidating the campus as an innovative, digitally structured, and environmentally responsible space.

Documentary analysis also indicates alignment between the Parliamentary Portfolio (2021) and the IFCE Institutional Development Plan (Plano de Desenvolvimento Institucional - PDI) 2024–2028, particularly regarding objectives related to process improvement, fundraising, innovation, sustainability, infrastructure, and revenue diversification (IFCE, 2024). This alignment shows that the smart campus is not an isolated initiative, but a strategy connected to medium-term institutional goals. At the same time, it reveals that its execution depends on technical cooperation, staff training, external partnerships, and the recombination of available resources.

Proposed Adaptations to the Model by Pagliaro et al. (2016)

The analysis of the actions carried out in planning the smart campus at IFCE Sobral Campus highlights dimensions that are lightly detailed in the original model by Pagliaro et al. (2016) when applied to the early phases of projects in Brazilian public institutions.



Empirical data show that, prior to preliminary planning, managers engaged in institutional learning activities and sought support through benchmarking and visits to universities with smart campus initiatives, which fostered the identification of training needs and tools to support initial planning. This movement preceded the technical diagnosis and contributed to maturing the understanding of the smart campus concept, identifying external references, and guiding the project's first decisions.

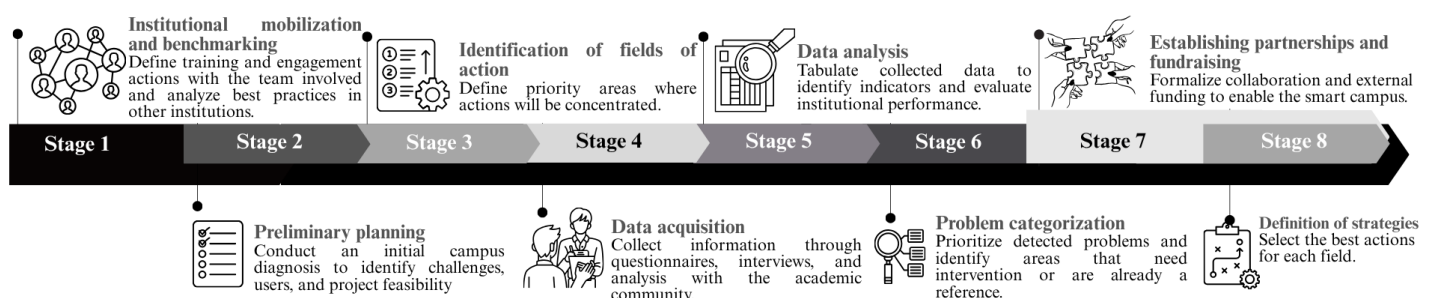
Given this, the inclusion of an "Institutional mobilization and benchmarking" stage prior to the framework's preliminary planning is proposed. This preparatory phase, essential in contexts with limited knowledge about smart campuses, encompasses management awareness, initial technical training for the team, participation in events and courses, and the search for references in previously implemented experiences. In the case analyzed, this stage proved necessary because the project did not stem from a previously consolidated technical structure, but rather from a gradual process of conceptual and institutional appropriation. Thus, empirical evidence supports including this preparatory phase in the adapted model.

Furthermore, the findings indicate that making the project feasible was contingent on forming partnerships and securing external resources. Unlike the origin context of the Pagliaro et al. (2016) model, Brazilian public institutions face recurring budget constraints and rely

mostly on parliamentary amendments, funding agencies, or contributions from companies and technical cooperation to implement innovation projects (Conif, 2023; Hoppe, 2021; Silva et al., 2024). The IFCE experience demonstrated that forming strategic partnerships with private companies, universities, and foundations can overcome technical and operational limitations. A private foundation provided funds to purchase equipment for the pilot project, while private companies were mentioned as potential technology providers and operational support. The relationship with Unicamp, in turn, provided benchmarking references and established a dialogue channel on energy sustainability, complemented by managers' participation in courses on the topic. This inter-institutional orchestration expanded the possibilities for project development, showing that networking and fundraising acted not merely as complementary support, but as a condition for implementation feasibility. Therefore, it is suggested to include an "Establishing partnerships and fundraising" stage positioned before strategic definition, but operating cross-cuttingly throughout the project, aimed at mobilizing strategic efforts for the project's financial and technical sustainability. This stage encompasses the prospecting and formalization of support networks with public and private entities, active participation in funding calls, the search for investments, and political and institutional articulation to guarantee the viability and expansion of smart campus initiatives (Figure 5).

Figure 5

Stages for the Implementation of a Smart Campus in the Brazilian Public Sector Context



Note: Adapted from the model proposed by Pagliaro et al. (2016), with additional phases proposed.



The suggested stages give the planning a less linear and more adaptive nature. The institutional mobilization and benchmarking stage would occur simultaneously with the later stages, while the evaluation and continuous improvement stage would remain active until the end of the project. This continuous and flexible approach is essential, as it allows for dynamic adjustment to the budget, technical, and institutional context of the campus (Polin, 2026), bringing implementation closer to a logic of frugal innovation and organizational bricolage, in that it involves the recombination of available resources and the pursuit of functional, accessible solutions suited to contextual constraints (Baker & Nelson, 2005; Weyrauch & Herstatt, 2017).

In summary, the proposed adaptations broaden the applicability of the framework by Pagliaro et al. (2016), incorporating the specificities of Brazilian public environments. They recognize that, in institutions with budgetary constraints and reliance on external support, implementing a smart campus requires not only technical planning, but also institutional mobilization, network building, fundraising, and the recombination of available means. Thus, the adapted model becomes more responsive to the institutional, operational, and contextual specificities of the initial implementation stages in Brazilian public institutions.

CONCLUSION

This study aimed to analyze the planning process for implementing the smart campus at IFCE Sobral Campus in light of the framework by Pagliaro et al. (2016), considering the institutional, operational, and contextual specificities of a Brazilian public institution in the initial stages of the project.

The results indicate partial adherence of the smart campus implementation process at IFCE Sobral Campus to the stages of Pagliaro et al. (2016). Although elements of preliminary planning, definition of fields of action, data acquisition and analysis, problem categorization, and strategic definition were identified, these stages occurred in an emergent and adaptive manner, conditioned by budgetary constraints, external partnerships, resource availability, and

the campus's operational capacity.

The application of the framework made it possible to identify two relevant dimensions for the reality of Brazilian public institutions. The first refers to the need for a prior stage of institutional mobilization and benchmarking, as evidenced by awareness actions, institutional learning, participation in events, and the search for external references. The second concerns establishing partnerships and fundraising, a dimension that proved central to enabling the actions planned in the project, especially given the reliance on external support, grant calls, engagement with policymakers, and technical cooperation. These findings highlight the need for contextual adaptation of the model, prioritizing feasible interventions in light of budgetary constraints and using the campus as a living lab, corroborating studies aligned with Bernal et al. (2024), Sánchez-Torres et al. (2018), and Soares (2023).

Thus, the article contributes to smart campus implementation studies by showing that the framework by Pagliaro et al. (2016), while useful for analyzing smart campus planning, requires adjustments to reflect the reality of Brazilian public HEIs. The theoretical contribution consists of proposing the contextual expansion of the model, incorporating dimensions related to network formation, co-creation, fundraising, the recombination of available means, and the flexibility to overcome challenges and handle contextual limitations. The research contributes to the field of administration by demonstrating, through a case study, how public institutions articulate strategic vision, collective participation, and emerging technologies to build innovative solutions, even under budgetary and structural constraints, paving the way for future investigations.

As a practical contribution, the findings have the potential to support public managers in structuring projects that better align with the financial, operational, and institutional conditions of the public sector, combining technical planning, partnerships, and a gradual definition of priorities. Furthermore, the social value of a smart campus in public institutions is highlighted, enhancing education, fostering local innovation, and optimizing resource management, directly



benefiting the academic community and society.

The study's limitations relate primarily to the research context, including the absence of structured formal documentation—which hindered the objective identification of all methodological stages—and the small number of staff members directly involved in the project. To mitigate these issues, future research with multiple institutional actors is suggested to broaden the understanding of implementation dynamics in diverse public contexts.

For future research, it is also proposed to apply the suggested adaptations to the framework by Pagliaro et al. (2016) to other campuses and public institutions, including different institutional actors—such as students, staff, faculty, external partners, and service users—to empirically validate its applicability. Additionally, proposing specific smart campus frameworks that account for emergent dynamics, low-cost strategies, and collaborative arrangements in similar contexts is recommended. Longitudinal monitoring of the smart campus implementation is also advised to verify how the stages evolve over time, which indicators are adopted, and the extent to which the proposed adaptations to the framework by Pagliaro et al. (2016) prove applicable in other Brazilian public contexts.

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