FEDERAL UNIVERSITY OF CAMPINA GRANDE
FACULTY OF MANAGEMENT AND ACCOUNTING
POSTGRADUATE PROGRAM IN MANAGEMENT

SMART CAMPUS: INDICATORS FOR THE SMARTIZATION PROCESS AT UNIVERSITIES

MASTER THESIS

PEDRO IVO SILVA DA NÓBREGA

CAMPINA GRANDE – PB, 2021

POSTGRADUATE PROGRAM IN MANAGEMENT

PEDRO IVO SILVA DA NÓBREGA

SMART CAMPUS: INDICATORS FOR THE SMARTIZATION PROCESS AT UNIVERSITIES

Advisor: Prof. Dra. Adriana Fumi Chim Miki

Co-advisor: Prof. Dra. Marysol Castillo Palacio

Master thesis presented as a requirement to obtaining the Master of Management certificate from the Postgraduate program of the Federal University of Campina Grande.

CAMPINA GRANDE – PB 2021

N754e Nóbrega, Pedro Ivo Silva da.
Smart campus: indicators for the smartization process at universities / Pedro Ivo Silva da Nóbrega. – Campina Grande, 2021.
121 f. : il. color.

Dissertação (Mestrado em Administração) – Universidade Federal de Campina Grande, Centro de Humanidades, 2021.
"Orientação: Profa. Dra. Adriana Fumi Chim Miki, Prof. Dra. Marysol Castillo Palacio".
Referências.

1. *Smart Campus*. 2. Sustainable Development. 3. Smartization Process. 4. Latin American Perspective. 5. *Smart Campus* Monitor. I. Miki, Adriana Fumi Chim. II. Palacio, Marysol Castillo. III. Título.

CDU 378.4:004.8:502.131.1(043)

FICHA CATALOGRÁFICA ELABORADA PELA BIBLIOTECÁRIA SEVERINA SUELI DA SILVA OLIVEIRA CRB-15/225

PEDRO IVO SILVA DA NÓBREGA

Master Thesis presented to the Postgraduate Program in Management of the Federal University of Campina Grande as a requirement to obtaining the Master of Management Certificate. Concentration area: Social and environmental management. Approved on December 20, 2021.

Examining commission:

_____

President: Prof. Dra. Adriana Fumi Chim Miki – PPGA/UFCG
Advisor

_____

Prof. Dra. Marysol Castillo Palacio – Pontífica Universidad Javeriana
Co-advisor

_____

1st evaluator: Prof. Dr. Camilo Allyson Simões de Farias- CCTA/UFCG
External evaluator

_____

2nd evaluator: Prof. Dr. Vinicius Farias Moreira – PPGA/UFCG
Internal evaluator

Campina Grande, December 2021.

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DE CAMPINA GRANDE
POS-GRADUACAO EM ADMINISTRACAO
Rua Aprigio Veloso, 882, - Bairro Universitario, Campina Grande/PB, CEP 58429-900

FOLHA DE ASSINATURA PARA TESES E DISSERTAÇÕES

PEDRO IVO SILVA DA NÓBREGA

"SMART CAMPUS: INDICATORS FOR THE SMARTIZATION PROCESS AT UNIVERSITIES"

Dissertação apresentada ao Programa de Pós-Graduação em Administração (PPGA-UFCG) como pré-requisito para obtenção do título de Mestre em Administração.

Aprovado em: 20/12/2021

Profa. Dra. Adriana Fumi Chim Miki - PPGA/UFCG
Orientadora Principal

Prof. Dr. Vinicius Farias Moreira - PPGA/UFCG
Examinador Interno

Prof. Dr. Camilo Allyson Simões de Farias - CCTA/UFCG
Examinador Externo

Campina-Grande-PB, 2021

Documento assinado eletronicamente por **ADRIANA FUMI CHIM MIKI**, **PROFESSOR DO MAGISTERIO SUPERIOR**, em 22/12/2021, às 09:10, conforme horário oficial de Brasília, com fundamento no art. 8º, caput, da Portaria SEI nº 002, de 25 de outubro de 2018.

Documento assinado eletronicamente por **VINICIUS FARIAS MOREIRA**, **PROFESSOR DO MAGISTERIO SUPERIOR**, em 23/12/2021, às 08:48, conforme horário oficial de Brasília, com fundamento no art. 8º, caput, da Portaria SEI nº 002, de 25 de outubro de 2018.

Documento assinado eletronicamente por **CAMILO ALLYSON SIMOES DE FARIAS**, **PROFESSOR DO MAGISTERIO SUPERIOR**, em 23/12/2021, às 13:09, conforme horário oficial de Brasília, com fundamento no art. 8º, caput, da Portaria SEI nº 002, de 25 de outubro de 2018.

A autenticidade deste documento pode ser conferida no site https://sei.ufcg.edu.br/autenticidade, informando o código verificador **2036960** e o código CRC **B1A3B41B**.

Referência: Processo nº 23096.076123/2021-38 SEI nº 2036960

SMART CAMPUS: INDICATORS FOR THE SMARTIZATION PROCESS AT UNIVERSITIES

ABSTRACT

Smart campuses transform the university through a range of technological, sustainable, and social actions. This thesis proposes a general framework for Smart Campus and recommends indicators to monitor the smartization process for the Latin American context based on technology, connectivity, and the Sustainable Development Goals pillars (SDGs). The thesis is structured by three papers that used both qualitative and quantitative methodologies. Firstly, the study performed a Systematic Literature Review based on PRISMA and SPIDER methods to identify the state-of-the-art and propose a smart campus framework, indicating its concept, main theoretical, and empirical perspectives. The second paper validated the previous framework through a Focus Group Method with a Latin American expert panel to create the Latin American school perspective. The third paper applied the framework in a Brazilian University to identify its importance and the priorities to decision-makers toward smartization processes of universities. The research method was an HJ-BIPLOT methodology based on Importance-Performance Analysis (IPA). The results have twofold contributions. Theoretically, it consolidated a smart campus concept and model; at the same time, opened the Latin American perspective of smart campuses. Empirically, the thesis provided a tool for academic managers to implement and control the smartization process in universities. Thesis Results also offered an integrative framework for the smart campus based upon the SDGs as an integrated and indivisible universal agenda that seeks to balance the three dimensions of sustainable development: economic, environmental, and social. Also, the research provides a Smart Campus Model with eight dimensions and 38 indicators validated by Latin American scholars as a Framework to the field. In the end, this thesis gathered all findings in a management tool such as a monitor of smart campus.

Keywords: Smart campus. Sustainable Development. Smartization process. Latin American Perspective. Smart Campus Monitor.

SMART CAMPUS: INDICADORES DO PROCESSO DE SMARTIZATION EM UNIVERSIDADES

RESUMO

Smart Campuses transformam a universidade por meio de uma série de ações tecnológicas, sustentáveis e sociais. Esta dissertação propõe um framework geral para Smart Campus e recomenda indicadores para monitorar o processo de smartization para o contexto latino-americano com base na tecnologia, conectividade e nos pilares dos Objetivos de Desenvolvimento Sustentável (ODS). A dissertação está estruturada em três artigos que utilizaram metodologias qualitativas e quantitativas. Primeiramente, o estudo realizou uma Revisão Sistemática da Literatura com base nos métodos PRISMA e SPIDER para identificar o estado da arte e propor um framework de *Smart Campus*, indicando seu conceito, principais perspectivas teóricas e empíricas. O segundo artigo validou a estrutura anterior por meio de um Método de *Focus Group* com um painel de especialistas latino-americanos para criar a perspectiva da escola latino-americana. O terceiro artigo aplicou o framework em uma universidade brasileira para identificar sua importância e as prioridades para os tomadores de decisão em relação aos processos de *smartization* das universidades. O método de pesquisa foi uma metodologia HJ-BIPLOT baseada na Análise de Desempenho-Importância (IPA). Os resultados têm contribuições duplas. Teoricamente, consolidou um conceito e modelo de *smart campus*; ao mesmo tempo, abriu a perspectiva latino-americana de *smart campus*. Empiricamente, a dissertação forneceu uma ferramenta para gestores acadêmicos implementarem e controlarem o processo de *smartization* nas universidades. Os resultados da dissertação também ofereceram uma estrutura integrativa para o de *smart campus* com base nos ODS como uma agenda universal integrada e indivisível que busca equilibrar as três dimensões do desenvolvimento sustentável: econômica, ambiental e social. Além disso, a pesquisa fornece um modelo de *Smart Campus* com oito dimensões e 38 indicadores validados por acadêmicos latino-americanos como uma estrutura para o campo. Ao final, esta dissertação reuniu todas as descobertas em uma ferramenta de gestão como um monitor de campus inteligente.

Palavras-chave: Smart Campus. Desenvolvimento Sustentável. Processo de *Smartization*. Perspectiva latino-americana. Monitor de *Smart Campus*.

ACKNOWLEDGEMENTS

The Master course was a challenge from the selection until the last minute. So, first of all, I still cannot believe I'm writing my master thesis acknowledgments because this makes it all real. I am speechless to express how much I've grown in the last two years, but I want to take this moment to thank all the people who helped me in this process:

"God, thank you for loving me so generously"! I read this phrase today and it just makes so much sense at this moment. It expresses my feelings right now and when I remember all of what I've gone through in these last two years. All the happiness, sadness, craziness, and other "nesses" moments that I was held by His peaceful and comforting arms. Thank you, Jesus!

To my family, Ivo (painho), Ronaide (mainha), Anna Rebeca (irmã), thank you guys for believing, encouraging, worrying, stressing, and celebrating with me at all times! You are my foundation doesn't matter the situation. A paragraph cannot reflect all my love for you, but still: I LOVE YOU WITH ALL MY HEART (read this part as a scream)! Also, my aunts, uncles, and cousins that even when they don't understand a single thing of what I did, still managed to always ask and encourage me. So, thank you, guys! Love you all!

To my advisor, professor Adriana, a big and special THANK YOU. I don't have enough words (because I used them all "aperriando" you since day 1 or even before, haha) to express how grateful I am. You know that you're way more than a professor, you're my professional inspiration and mentor. Also, my co-advisor professor Marysol. Thank you so much for all your time, help, encouragement, and quick answers! Muchas gracias también por su ayuda con el español. Thanks to all my PPGA professors, this thesis has a small part from each of you. Especially, the evaluators for all contributions and recommendations.

To all my friends that were also by my side (sometimes literally), supporting me from the highest happiness until the eye of the storm. So, writing a summarized list here: Ramon, Amanda, Yuri, Barack (Matheus), Sharon, and Rebeca, you guys are wonderful; Tárcila (a special shout out to you my study partner, thank you for everything), Natália, and Pablo, you're a gift UFCG gave me; but also from UFCG, Jaiany, Lúcia, my colleagues from Class 3, Juliana, Rodrigo, and Manoela, thanks! A special thank you to Emanuel who helped me a lot! And, of course, my friends and leaders from celebrart, agrupe, and ACEV, thank you for all your prayers and help, love you all!

At last, thanks to all experts from the Focus Group, all UFCG students that answered my questionnaire, and the CAPES foundation for the funding.

LIST OF FIGURES

CHAPTER 1

CHAPTER 2

CHAPTER 3

LIST OF TABLES

INTRODUCTION

CHAPTER 2

CHAPTER 3

CHAPTER 4

TABLE OF CONTENTS

1 Introduction

The Sustainable Development Goals (SDG), proposed by the United Nations, offers an agenda of 17 goals distributed in indicators to implement Sustainable Development initiatives on countries, cities, regions, companies, and individuals (United Nations, 2015, 2020). It encompasses initiatives to make the world more sustainable and often promotes a wide range of technological, social, environmental, and economic changes.

In this line, the smart city concept emerged in the 1990s to improve the citizen quality of life through smartization processes that comprehend intelligent solutions, smart combinations of endowments and activities from aware citizens, sustainable development, governance, and multi-stakeholder partnerships (E. Ahmed, Yaqoob, Gani, Imran, & Guizani, 2016; Gubbi, Buyya, Marusic, & Palaniswami, 2013; Hussain & Jain, 2020).

A smart city must be well-performing in a forward-looking way by smart dimensions, such as economy, mobility, people, governance, environment, and living. Those must be provided by integrated and multidimensional systems to form a more intelligent, interconnected, and efficient infrastructure of components and services, such as education and healthcare (Fernandez-Anez, Fernández-Güell, & Giffinger, 2018; Giffinger et al., 2007; Washburn et al., 2010).

The smartization is also replacing classical education with smart education. The process is led by industry 4.0 and technical innovations influenced by the socio-economic challenges of the post-industrial era, changing the education paradigm of the XXI century (Elsakova, Kuzmina, & Kochkina, 2019; Tikhonova, 2019). Technology is a fundamental tool in this process, promoting context-sensitive, ubiquitous learning, e-learning, and other improvements; but technology is not the ultimate goal to pursue a smart education, which needs to introduce modern policies, new learning criteria, and methodologies to adapt learning to every student individual needs and requirements (Durán-Sánchez, Álvarez-García, Del Río-Rama, & Sarango-Lalangui, 2018; Elsakova et al., 2019; Segredo, Miranda, & Leon, 2017).

From an overlap with smart city and smart education, emerged the smart campus approach. It aims to implement a set of smart services with a wide range of technologies to build or improve a university into an interactive, adaptive, and digital learning ecosystem to cope with novel and emerging needs from both modern society and the labor market in a sustainable, social, and technological way (Atif, Mathew, & Lakas, 2015; Caballero, García-Valverde, Pereñíguez, & Botía, 2016; Y. Chen, Zhang, & Zhang, 2012; Coccoli, Maresca, &

Stanganelli, 2017; Khamayseh, Mardini, Aljawarneh, & Yassein, 2015; Villegas-Ch, Arias-Navarrete, & Palacios-Pacheco, 2020).

However, the smart campus is still at the exploratory stage, also it is a broad concept without a unified and common definition (Chiu, Chang, Lee, Chen, & Lee, 2020; Min-Allah & Alrashed, 2020; Prandi, Monti, Ceccarini, & Salomoni, 2020). Nevertheless, smart campus interventions are growing in various universities worldwide, which highlights the need to pursue more studies in this matter.

Thus, this Master thesis questions: **How to monitor the implementation of a Smart Campus according to an integrative concept and model toward smartization processes for Latin American universities?** Based on this research problem, the main and specific goals follow.

1.1 Objective of the master's thesis

The main research objective is to propose a Smart Campus framework adapted to the context of Latin-American universities and recommend indicators to monitor the smartization process for the Brazilian context based on technology, connectivity, and the Sustainable Development Goals (SDG).

1.1.2 Specific Objectives

- Identify the state-of-the-art and propose a smart campus framework.
- Formulate and validate a Smart Campus model with indicators to monitor the smartization process in the Latin American Context.
- Identify the essential elements and the most significant deficiencies in the Smart Campus dimensions and its variables from the user point of view to offer a list of priorities to decision-makers.

1.2 Justification

The smart campus has not a consensual definition, dimensions, and components among authors; as well it has a low number of interventions in Latin America. The need to gather the literature about the matter and propose a framework adapted to Latin American universities justifies this research. Another gap on smart campus is the lack of indicators to monitor the smartization process and support the decision-maker in universities.

The novelty of this study is twofold: First, it provides a review of the smart campus literature and builds a theoretical framework; secondly, it creates and validates a Latin American perspective and a set of indicators to monitor the smartization process of universities with both experts and users. The results have double contributions: on the one side, theoretical contribution to the model of smart campus; on the other, it provides insights and tools to decision-makers of universities seeking to implement smart campus' projects.

1.3 Thesis Modality

This Master's thesis will adopt the structure of Scientific Papers Modality as foreseen in the regulations of the Postgraduate Program of Management of the Federal University of Campina Grande. It will be conducted as shown in Table 1.

Table 1. Thesis structure

PROBLEM: How to monitor the implementation of a Smart Campus according to an integrative concept and model toward smartizatio				
MAIN GOAL: To propose a framework to Smart University adapted to the context of the Latin-American campus and recommend in Brazilian context based on the technology, connectivity, and SDGs (Sustainable Development Goals).				
SPECIFICS GOALS	**CORREPONDING ARTICLE**	**SUBMISSION**	DATABASE	**MET** ANALY
1. Identify the state-of-the-art and propose a smart campus framework.	1st article: *Status of knowledge on Smart Campus: Implications for educational institutions and sustainability.*	Submitted to the journal Review of Educational Research.	Bibliographic: Scopus and Web of Science databases.	Qualitati Systematic Li Review
2. Formulate and validate a Smart Campus model with indicators to monitor the smartization process in the Latin American Context	2nd article: *Smart Campus Monitor: A method to support decision-making from Latin American universities.*	Submitted to the journal Technology in Society.	Interviews with Latin American management experts and researchers	Qualitati Focus Gr
3. Identify the essential elements and the most significant deficiencies in the Smart Campus dimensions and its variables from the user point of view to offer a list of priorities to decision-makers.	3rd article: *Prioritizing decision-making: Indicators to the Smartization process of universities.*	Submitted to the journal Management Decision.	5-point Likert scale survey to UFCG students.	Quantitat Importan Performance (IPA matr

.

Source: Elaborated by the authors

Besides this introduction, the thesis project follows this structure:

- **Chapter 1 – "**Status of knowledge on Smart Campus: Implications for educational institutions and sustainability" is the first article of this thesis. It gathers information about the smart campus from 178 articles through a systematic literature review in both Web of Science and Scopus databases. Thereby, we identified smart campus definitions, dimensions, interventions, advancements, and future research. By those means, we proposed a smart campus definition and framework.
- **Chapter 2 –** "Smart Campus Monitor: A method to support decision-making from Latin American universities" is the second article of this thesis. It focused on the methodological procedures to formulate and validate smart campus' indicators with experts through a focus group. Thus, it results in an evolution of the previous model for the smart campus, according to a Latin American perspective.
- **Chapter 3 –** "Prioritizing decision-making: Indicators to the Smartization process of universities" is the third article of this thesis. We conducted an Importance-Performance Analysis to identify the most important and the greatest deficiencies on the smart campus concept from students at a Brazilian university. Thus, we validated the final model built from both previous articles with campus end-users, i.e., the students.
- **Chapter 4 –** At last, we draw our conclusions. It comprises a summary of main findings from all chapters and how they interrelate to compose this thesis outcome. Furthermore, we present limitations and suggest future studies in the area.

We also highlight that each article follows the same structure, citation format, reference list, figures and tables listing, as well appendix inclusion, according to the respective submitted journals, following the PPGA/UFCG guidelines.

CHAPTER 1

STATUS OF KNOWLEDGE ON SMART CAMPUS: IMPLICATIONS FOR EDUCATIONAL INSTITUTIONS AND SUSTAINABILITY

STATUS OF KNOWLEDGE ON SMART CAMPUS: IMPLICATIONS FOR EDUCATIONAL INSTITUTIONS AND SUSTAINABILITY

Pedro Ivo Silva da Nóbrega
Postgraduate Program of Management
Federal University of Campina Grande, Brazil

Adriana Fumi Chim Miki
Federal University of Campina Grande, Brazil

Marysol Castillo Palacio
Pontífica Universidad Javeriana – Cali, Colombia

Abstract

The Smart Campus is a trending transformative initiative for universities, mostly improving processes, livability, and learning through Information and Communication Technologies (ICT) and sustainability; although, there is not a standard definition or dimensions among scholars. Thus, our research goal is to identify the state-of-the-art and a framework of the Smart Campus through a Systematic Literature Review to identify definitions, dimensions, interventions, advancements, and future research suggestions on 178 articles. To improve reliability in the search process, we followed PRISMA and SPIDER methods. We found 70 definitions for smart campus and related terms, but overall, the smart campus concept relates to technology innovations, sustainability, learning strategies, and stakeholders' participation to promote changes in educational paradigms and livability on universities. We categorized the smart campus characteristics and components into nine dimensions according to its resemblance, which were mainly related to ICT. Besides a broad concept that includes more than technology, most smart campus initiatives and future research agenda relates to the informatization of universities. At last, we conclude that a Smart Campus is a higher education ecosystem that uses technology to achieve the tripod of sustainability (economy, environmental, and social aspects) in a model of governance, collaborative, and adaptive learning to promote better livability for its stakeholders. It has an integrative framework composed by smart dimensions linked to the Sustainable Development Goals, namely Economy, Education, Environment, Living, Mobility, Management, Security, and Technology, which is a transversal component to all others.

Keywords: Smart Campus. Information and Communication Technologies. Sustainability. Sustainable Development Goals. Systematic Literature Review.

1 Introduction

The Smart Campus concept is an approach to improve traditional universities through technology, sustainability, livability, and other implementations, seeking a better quality of life on campus, as well as working and learning processes to its stakeholders. The Smart Campus definitions have three main approaches: one acknowledges mostly the informatization of universities, one relates to the smart city concept, while another understands it based on the organizational development.

The first approach focuses on the university informatization mainly through Internet of Things (IoT) and Information Communication Technologies (ITC) implementations (Liang & Chen, 2018; H. I. Wang, 2014; Xia et al., 2018; A. M. Yang et al., 2018). Also, cloud computing and data fusion to integrate independent business systems and resources of schools into an organic whole (X. Liu, 2017) in which school managers, teachers, students, and parents interact with campus resources (Qiu, Lei, & Zhang, 2018).

The second approach of the smart campus is based on the smart city approach as it transforms the traditional university through a systemic view using more than just technology (Uskov et al., 2016). It includes improvements on architecture, learning processes, social services, community relationship, resources, favorable places for learning, and shared knowledge between all university stakeholders in a seamless way (Atif et al., 2015; Coccoli, Guercio, Maresca, & Stanganelli, 2014; Coccoli et al., 2017; Villegas-Ch, Palacios-Pacheco, & Luján-Mora, 2019).

Thus, the smart campus concept connects with the goal of a smart city to become smarter through even more connected and ubiquitous devices, apps, and wearables, but also developing better social resources, services, and products, such as democracy, education, and health (Caragliu, del Bo, & Nijkamp, 2011; Giffinger et al., 2007).

The third approach of smart campus connects with services provision using technology enhancement to lead the services improvement. The ultimate purpose of smart campus services is to improve the efficiency of campus management, which is based on organizational development and competitive advantage (G. Guo, 2018; Nan, Suo, Jia, Wu, & Shan, 2018).

Beyond these three approaches, the Smart Campus knowledge field still needs more research on its concept, components, and dimensions, due to its novelty in the academic universe and lack of consensus from authors (Min-Allah & Alrashed, 2020; Prandi, Monti, Ceccarini, & Salomoni, 2020). Thus, our research goal is to identify the state-of-the-art and theoretical

framework of Smart Campus. We performed a systematic literature review to comprise the best information about smart campus and a content analysis to extract and synthesize data concerning definitions, dimensions, interventions, advancements, and future research on the field.

Systematic reviews are essential tools to summarize evidence accurately and reliably, providing information about theories and practice to any discipline as well as to afford information of a research agenda, therefore, it is an adequate research objective for scholars (Liberati et al., 2009; Tranfield, Denyer, & Smart, 2003). This study contributes to the development of the Smart Campus approach providing an integrative overview and framework of the Smart Campus concept, highlighting gaps, and offering future research insights to the field.

2 Smartization: from city to campus

Technologies to enhance living are increasing around the world through smart devices and services that automate everyday tasks, at the same time that optimize the use of resources based on Sustainable Development providing a livable environment (Boni, Xu, Chen, & Baddoo, 2020; Cesconetto et al., 2020). A smart environment is a connected world by sensor-enabled devices that work collaboratively with Information and Communication Technologies, the Internet of Things, computational and information exchanging devices that can perceive the people state and actions on the environment to facilitate their lives (Boni et al., 2020; Cesconetto et al., 2020; Gubbi et al., 2013; Hussain & Jain, 2020; Rashidi, Cook, Holder, & Schmitter-Edgecombe, 2011; Streitz et al., 2005).

The term “smart” relates to the ability to autonomously obtain and apply knowledge, while “environment” refers to the surroundings. Thus, the smart environment is capable of acquiring knowledge and using it according to its inhabitants’ needs contributing in the analog to the digital transition of humankind (E. Ahmed et al., 2016; Boni et al., 2020).

Smart environments have unique properties, such as ubiquity, invisibility, sensing, and memory amplification that aim to facilitate human life in several ways and support positive societal changes (Cesconetto et al., 2020; Hussain & Jain, 2020). There is a wide range of applications related to smart environments, such as smart health, smart homes, smart offices, smart retail, smart agriculture/forest, smart water, smart mobility/transportation, and smart cities (E. Ahmed et al., 2016; Gubbi et al., 2013; Hussain & Jain, 2020).

The Smart City concept began in the 1990s with a "Technopolis" perspective and became an icon of innovation (de Wijs, Witte, de Klerk, & Geertman, 2017; L. Mora, Bolici, & Deakin, 2017). However, smart cities go beyond technology, aiming to improve the citizens quality of life through smartization processes that comprehend the identification of intelligent solutions, a smart combination of endowments, citizens awareness, sustainable development, participatory governance, and multi-stakeholder partnership (Caragliu, del Bo, & Nijkamp, 2011; Fernandez-Anez et al., 2018; Giffinger et al., 2007; Ismagilova, Hughes, Dwivedi, & Raman, 2019; Nesti, 2020).

A smart city is a well-performing city in a forward-looking way on several dimensions, such as economy, mobility, people, governance, environment, and living integrated with multidimensional systems that can make the infrastructure of components and services of a city, for instance, education, healthcare, and utilities, more intelligent, interconnected, and efficient (Fernandez-Anez et al., 2018; Giffinger et al., 2007; Washburn et al., 2010).

Although the smart city concept has two different conceptual lines (Angelidou, 2015; L. Mora et al., 2017), its goal reflects a bottom-up citizen-centered approach driven by stakeholders to achieve urban development, public-private partnerships, and a better quality of life (Caragliu & Del Bo, 2016; De Guimarães, Severo, Felix Júnior, Da Costa, & Salmoria, 2020; Fernandez-Anez et al., 2018).

Smart environments are also a driver for smart campuses, which is a refinement of the term and idea (Prandi et al., 2020). The smart campus is a smart environment of teaching, learning, and living based on IoT and application services, supporting its development with a wide range of technologies, becoming a new form of campus information (Y. Huang et al., 2016; Xing, Yuan, Yang, Lai, & Zhang, 2014). Besides, the smart campus could be part of the smart city and share a similar base installation, communication network, and traffic network (Janssen & Prasetiyowati, 2018; Ren, Zhang, & Duan, 2018). Usually, smart campus projects scale up smart city initiatives

(Alvarez-Campana, López, Vázquez, Villagrá, & Berrocal, 2017; Moreno et al., 2017; Ramos, Trilles, Torres-Sospedra, & Perales, 2018; Vasileva et al., 2018; Wu et al., 2020).

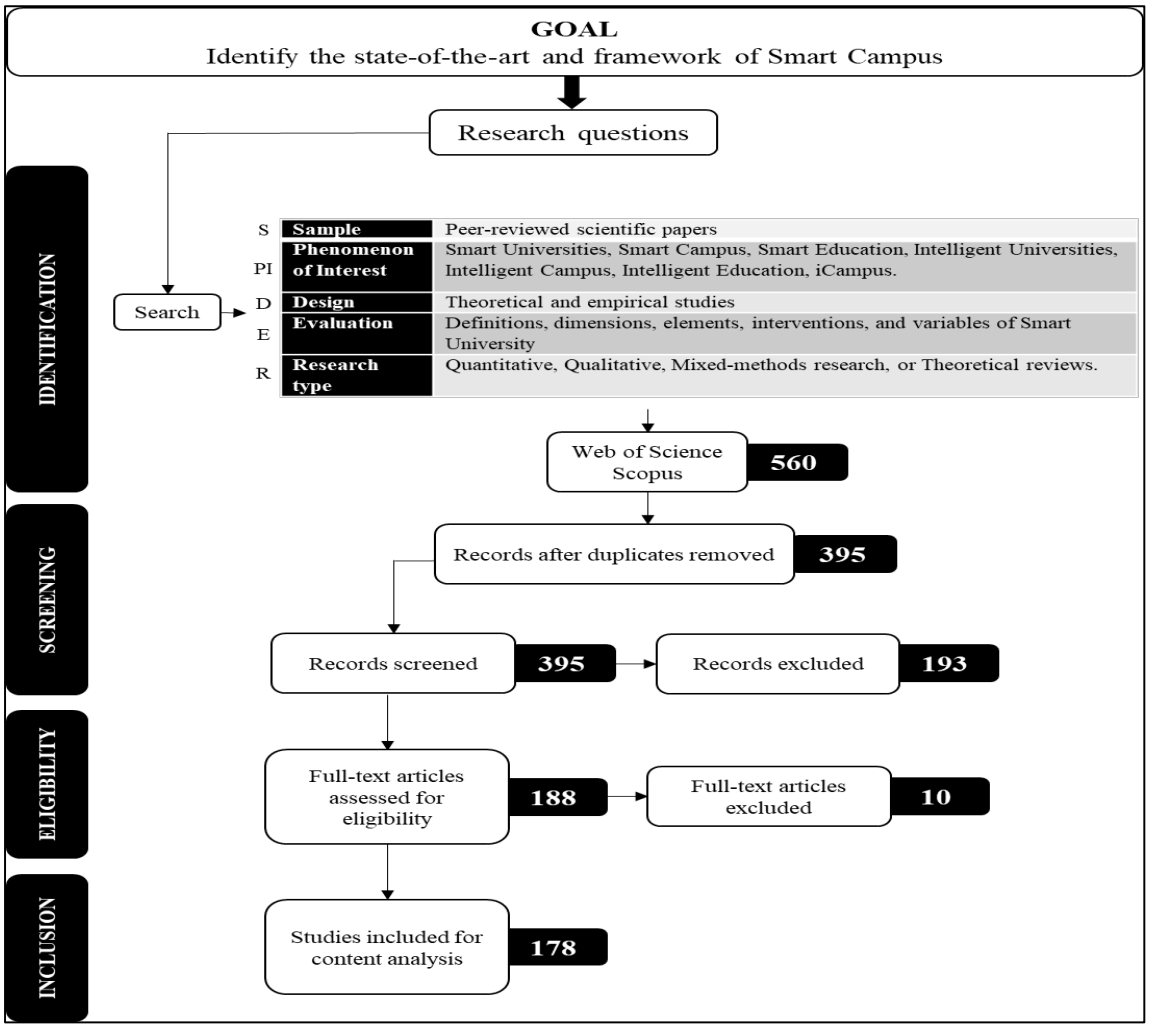
There is not yet a common concept of a smart campus. It is a broad and fragmented research area with many issues to be addressed (Y. Chen et al., 2012; Chiu et al., 2020; Min-Allah & Alrashed, 2020; Prandi et al., 2020; Vasileva et al., 2018) In this sense, this research intends to contribute on deepening the theoretical review and define the state-of-the-art of Smart Campus scientific perspective.

3 Methods

This study conducts a literature review on smart campus as indicated by Tranfield, Denyer, & Smart (2003), which is systematic, transparent, and reproducible. The search process followed both PRISMA and SPIDER techniques to improve reability. PRISMA guides authors to conduct systematic reviews and meta-analysis; although the method was created to health interventions, it is relevant to any systematic review (Moher et al., 2009). We were also guided by Alexander (2020) suggestions to enhance the quality of the review process and improve our findings.

The SPIDER method is a search strategy tool more appropriate for qualitative and mixed methods research. The process comprises Sample, Phenomenon of Interest, Design, Evaluation, and Research type (Cooke, Smith, & Booth, 2012). Figure 1.1 shows the methodological design merging SPIDER technique inside the PRISMA identification process.

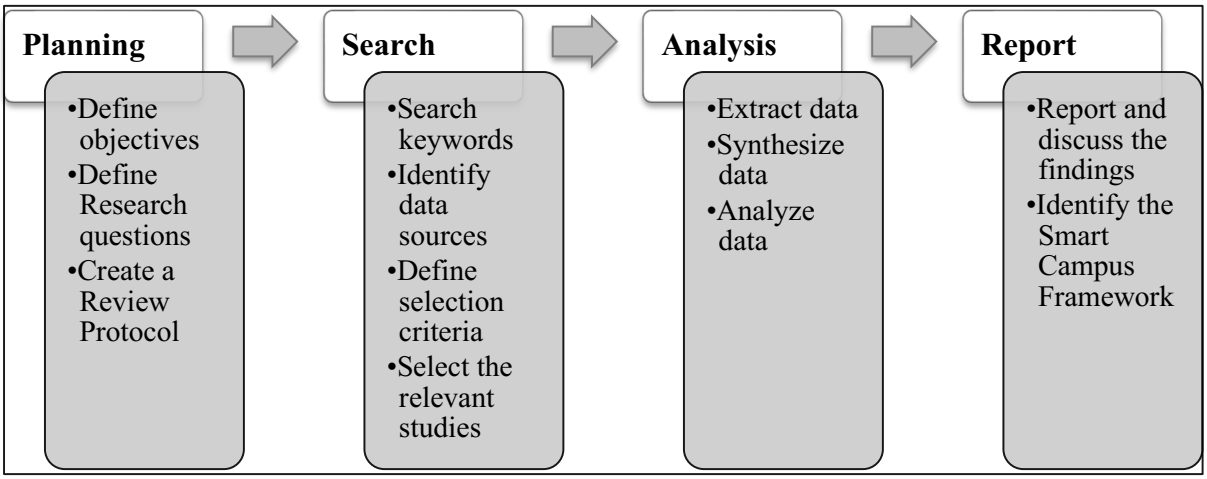
Figure 1.1 Methodological design based on PRISMA and SPIDER techniques



Source: Elaborated by the authors based on Cooke et al. (2012) and Moher et al. (2009).

To systematically review the Smart Campus concept, we used a four-staged method based on Kitchenham (2004) and Iwasaki (2020). Figure 1.2 presents the stages and their procedures.

Figure 1.2. Four-stage method for the systematic review procedure

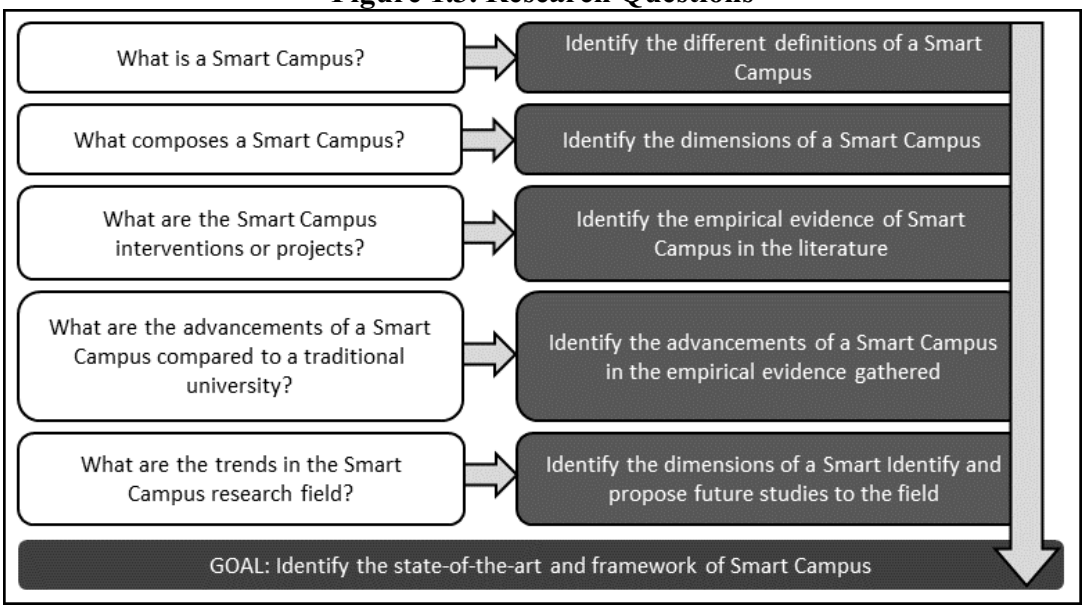


Source: Elaborated by the authors.

3.1 Planning

The planning stage defines a set of research questions to guide the primary goal of the study that is to identify the state-of-the-art and a theoretical framework of the Smart Campus approach. Thus, we defined five questions and its rationale (Figure 1.3) offering a concise and informative overview of what has been established and what remains to be explored (Alexander, 2020).

Figure 1.3. Research Questions



Source: Elaborated by the authors.

3.2 Search

In September 2020, we searched in the Web of Science, Scopus, and Google Scholar databases to identify relevant papers about smart campus to determine better keywords and optimal search terms. By these initial searches, we defined “iCampus” (as an abbreviation for Intelligent Campus) and combined both adjectives “Smart” and “Intelligent” with “Universit*”, “Campus”, and “Education”. Thus, seven quest terms with the “OR” Boolean operator guided the search in both Web of Science and Scopus databases. As criteria, the words should be in Title, abstract, keyword, and topic of the paper.

We did not set any language restriction during the selection process, so scientific articles published in a language other than English, or Spanish were translated to assess their eligibility. The limiters restricted the search to only peer-reviewed journals and reviews, following Ordanini et al. (2008) indications. Thus, we excluded proceeding papers, editorial revisions, books, data papers, and early access papers. There were no lower publication time limits, and the upper limit was the time of completing the search, that means, studies published until September 2020.

We collected 560 papers from the databases; then we used Mendeley software to manage references from both Web of Science and Scopus databases that allowed us to remove duplicates resulting in a sample of 410 papers. Then, we conducted the screening process based on title, abstract, and keywords according to the following exclusion criteria: (1) papers focused on education institutions other than universities, colleges, or faculties, and (2) papers without definition or intervention of a Smart Campus feature or project.

To ensure a higher degree of confidence and reliability in the screening process, two researchers evaluated all papers independently to define the pertinence to the final sample. The differences of choice were discussed and solved by consensus, resulting in 188 eligible pieces that fit both focus and scope. After the reading of full-text versions of the eligible studies, we excluded 10 papers based on the exclusion criteria. The final sample was composed by 178 papers selected for content analysis (Figure 1.1).

3.3 Analysis

The qualitative content analysis aims to describe a phenomenon, being appropriate to theory or literature on a limited phenomenon, allowing the categories to flow from the data (Hsieh

& Shannon, 2005). We chose the content analysis direct approach to extend conceptually a theoretical framework that is a deductive application to identify and categorize all instances of a phenomenon on a structured and reasoned manner (Hsieh & Shannon, 2005). We read the full-text versions and used a Microsoft Excel spreadsheet to synthesize data following the rationale exposed in Figure 1.3: definitions, dimensions, interventions, advancements, and future research.

3.4 Report

We reported and discussed the results following the same rationale from Figure 1.3, exposing a timeline from the most cited authors and its approaches, the different dimensions proposed, and interventions conducted on the field, as well the advancements related with future research. Then, we identify a Smart Campus framework based on the results found from the data.

4 Results

From the data analysis, the phenomenon named "Smart Campus" have different understandings among scholars, therefore it still has a vague concept and components. The literature review showed eight names given to the phenomenon (Figure 1.4). Four variations are interchangeable terms since they are synonyms referring to the same circumstance. According to Cambridge Dictionary (2020), smart is an adjective that means "intelligent, or able to 'think quickly or intelligently in difficult situations"; while intelligent means "showing intelligence, or able to learn and understand things easily".

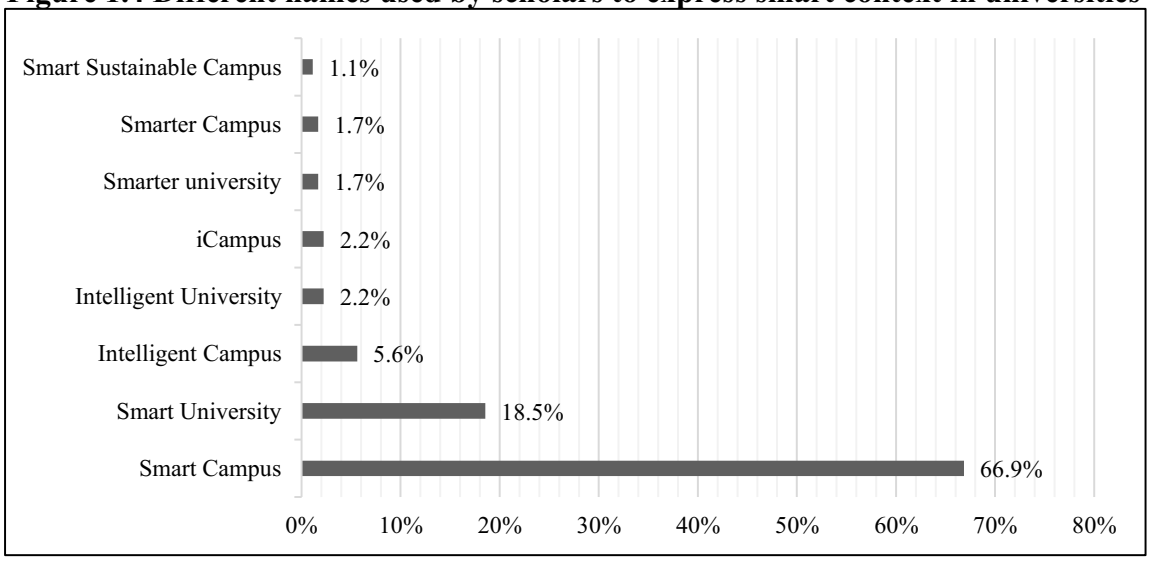
The smart campus is also understood as any entity that uses technology and infrastructure to improve its processes. At the same time, the smart university focus on improving the infrastructure of universities through technology to enhance the quality of the education provided by institutions. Thus, the smart university approach derived from the smart campus concept (Sanchez-Torres, Alberto Rodriguez-Rodriguez, Willmer Rico-Bautista, & Guerrero, 2018). In this matter, the term "campus" relates to any entity, but according to the Cambridge Dictionary (2020), it is "the buildings of a college or university and the land that surrounds them".

There are no significant differences among the approaches of Smart University and Smart Campus. The smart university is a dynamic and innovative place that implements technologies and new education methods to replace "classical education" with smart education to improve experiences to its stakeholders with open learning systems, education customization, mobile free

access to educational content, and smart organizational systems (Elsakova, Kuzmina, & Kochkina, 2019; Khamayseh, Mardini, Aljawarneh, & Yassein, 2015; Rico-Bautista, Maestre-Góngora, & Guerrero, 2020; Tikhonova, 2019; Zapata-Ros, 2018). The same ideas are presented in the Smart Campus approach.

Similar results showed the comparison with the term intelligent campus. It is a multi-agent system providing ambient intelligence as a new paradigm for supporting and integrating all the academic activities that take place at universities. Intelligent Campus is an effort to enrich the end-to-end learning lifecycle of a knowledge ecosystem, including several areas of intelligence for the university life (Bromuri et al., 2010; Bureš, Tučník, Mikulecký, Mls, Blecha, et al., 2016; Caballero, Munoz, Soto, & Botía, 2014).

Figure 1.4 Different names used by scholars to express smart context in universities



Source: Elaborated by the authors.

4.1 Definition

From 178 papers, we found 70 definitions of smart campus or similar terms. To synthesize this finding, we chose the most cited articles of each year and created a timeline of the smart campus concept to present its evolution (Figure 1.5). There is a lack of definitions in some years – 2009, 2011, and 2013, for instance – also some of the most cited papers did not offer a concept, so we chose the next most cited article with a smart campus definition. Kaneko, Sugino, Suzuki and Ishijima (2000) coined the term smart campus to represent a web-based environment built in

cooperation between university and industry with video-conferencing facilities and technologies mostly related to internet and networking system (Min-Allah & Alrashed, 2020).

Although the concept of Smart Campus emerged from technologies, the oldest paper of our sample focused on creative learning as the driver for a sustainable smart campus (Clark II & Eisenberg, 2008). In the sequence, another concept is toward inclusion and accessibility as an iCampus (Bromuri, Urovi, & Stathis, 2010). Despite the diverging focuses, both concepts indicated an experimental phase towards the universities smartization.

However, in 2012 the tech context is highlighted by the smart campus representing informatization, high-tech and modern architecture (Y. Chen et al., 2012). The 2012 concept evolved from the multi-agent system proposed by the earlier years; however, it expressed a focus on a convenient daily life based on technology, therefore, being beyond inclusion.

The Smart Campus in 2014 retrieved the idea from creative learning of 2008 but highlighted shared knowledge among stakeholders. The concept of Coccoli et al. (2014) did not use the term technology, although it is the base to promote shared knowledge. In 2015 the presented idea of smart campus gathers some previous approaches on stakeholders, learning spaces, social services, and emphasizes that technology is the way to augmented physical resources efficiency (Atif et al., 2015). Thus, the concept of the smart campus started a broader view. In the same line, in 2016 was presented a systemic view but highlighted the use of IoT and application services in the smart campus (Y. Huang et al., 2016).

Since 2017, the concept of smart campus pointed out a two-pillar structure – social and sustainable – mediated through technology tools to the future university (Coccoli et al., 2017). However, in 2018 emerged worries about cybersecurity issues. Tian et al. (2018) highlighted that technology became the foundation of all university processes; thus, technology also represents a weak point or risk.

In 2019, the smart campus concept returned to its origin, i.e., the smart city approach. It rethought the university as a small city, based on innovation and emphasized the importance of management (Fortes et al., 2019). Nowadays, in 2020, the smart campus definition encompasses all previous approaches to create an intelligent ecosystem to meet stakeholders needs. It includes the university community, society, and environment, using ICT as a mediator (Villegas-Ch, Arias-Navarrete, et al., 2020). Technology assumes the place of the mediator or the way to the smartization process (Figure 1.5).

Figure 1.5. Timeline of smart campus concepts

	DEFINITION	CORE ELEMENTS	AUTHOR
2008	Any sustainable smart campus is a vibrant, ''experiential'' applied educational model that should catalyze creative learning.	Sustainability Educational model Creative learning	(Clark II & Eisenberg, 2008)
2010	iCampus is a prototype multi-agent system providing the ambient intelligence required for an inclusive and accessible campus.	Multi-agent system Inclusiveness Accessibility	(Bromuri, Urovi, & Stathis, 2010)
2012	The smart campus is an advanced stage in the construction of campus informatization, which can make the daily life in a campus more convenient. Intelligent campus is a unique combination of high-tech and modern architecture.	Informatization High-tech Modern architecture	(Chen, Zhang, & Zhang, 2012)
2014	By "smarter university" we mean a place where knowledge is shared between employees ,teachers, students, and all stakeholders in a seamless way.	Smarter university Knowledge Stakeholders	(Coccoli, Guercio, Maresca, & Stanganelli, 2014)
2015	The smart campus approach is presented as a composition of ambient learning spaces, which are environments where physical learning resources are augmented with digital and social services.	Ambient learning Digital and social services	(Atif, Mathew, & Lakas, 2015)
2016	Smart Campus is an intelligent and smart environment of teaching, learning and living, which is based on the IoT and application services.	Smart environment IoT Application services	(Huang et al., 2016)
2017	The presented vision of a smarter university is the vision of the future university, which responds to the students' needs in a sustainable, social and technological way.	Smarter university Future university Sustainability	(Coccoli, Maresca, & Stanganelli, 2017)
2018	Smart campus is an exciting, new, and emerging research area that uses technology and infrastructure to support and improve its processes in campus services, teaching, learning, and research, especially, the explosive growth in knowledge makes the role of cybersecurity of smart campus become increasingly important.	Emerging research área Technology Processes Knowledge Cybersecurity	(Tian et al., 2018)
2019	The goal is to transform university campuses into "small" smart cities able to support efficient management of their area as well as innovative educational and research activities, which would be key factors to the proper development of the smart-cities of the future.	Smart city Management Innovative education and research	(Fortes et al., 2019)
2020	Smart campuses are conductive environments where ICT and campus members interact with each other to create an ecosystem where all campus resources are focused on meeting the needs of members.	Conductive environment ICT Ecosystem	(Villegas-Ch, Arias-Navarrete, & Palacios-Pacheco, 2020)

Source: Elaborated by the authors

Most definitions link some technology implementation, for instance, cutting-edge technologies such as the Internet of Things (IoT) and Information Communication Technologies (ITC) to enhance the informatization level in colleges and universities (Celdran et al., 2020; Luo, 2018; Rico-Bautista, Medina-Cárdenas, et al., 2020; Rico-Bautista, Maestre-Góngora, et al., 2020; Tian et al., 2018; Xu et al., 2019; Xu, Wang, & Yu, 2018). Interconnection of physical and virtual systems become a crucial point to a smart campus. Some authors characterize the smart campus as an advanced digital campus pattern (Y. Chen et al., 2012; Janssen & Prasetiyowati, 2018; Nan et al., 2018; Yange, Xiaopin, Zhili, & Liang, 2016). That is an integration platform that combines various systems to provide information management service (Y. Chen et al., 2012).

The smart campus is also understood as an open, innovative, collaborative, and integrated information service platform in which the technology is a key to ensure the service system to run efficiently and continuously in daily life. Its purpose is to achieve the intelligent management and service on campus, offering sophisticated services and individual information to its stakeholders (Jurva, Matinmikko-Blue, Niemelä, & Nenonen, 2020; A. M. Yang et al., 2018). The smart campus utilizes and integrates physical and digital spaces to establish responsive, intelligent, and improved services to create a productive, creative, and sustainable environment (Min-Allah & Alrashed, 2020).

The Organizational perspective highlights a new set of intelligent services into campus to replace old manual services to integrate new service concepts, management service, and information sharing mechanisms to optimize processes (Khamayseh et al., 2015; G. Guo, 2018; Nan et al., 2018). It is necessary to focus on processes and organizational systems, motivate people to workgroups connected to decision processes, new knowledge creation, and organizational learning (Staškevičiute & Neverauskas, 2008). Then, intelligent management is another key-point to a smart campus.

Besides, a smart campus adequately manages resources within the university and provides a better coexistence between the university population and its surroundings (Villegas-Ch, Palacios-Pacheco, et al., 2019). Segredo, Miranda, & Leon (2017) encouraged the development of computing thinking as a driver in the transformation process to smartization. They highlighted that technology should not be the goal if the university pursues smart education, instead it should focus on a Sensitive, Manageable, Adaptable, Responsive and Timely (SMART) education.

Thus, “being smart” should not be confused with “being digital”. Instead, the smart campus is a composition of learning spaces in which physical learning resources are augmented through digital and social services. It should focus on shared knowledge between stakeholders to enrich the learning ecosystem to prepare them to novel and emerging needs of both the modern society and the labor market in a sustainable, social, and technological way (Atif et al., 2015; Caballero, García-Valverde, Pereñíguez, & Botía, 2016; Coccoli, Maresca, & Stanganelli, 2017; Coccoli, Maresca, Stanganelli, & Guercio, 2015; Coccoli, Guercio, Maresca, & Stanganelli, 2014).

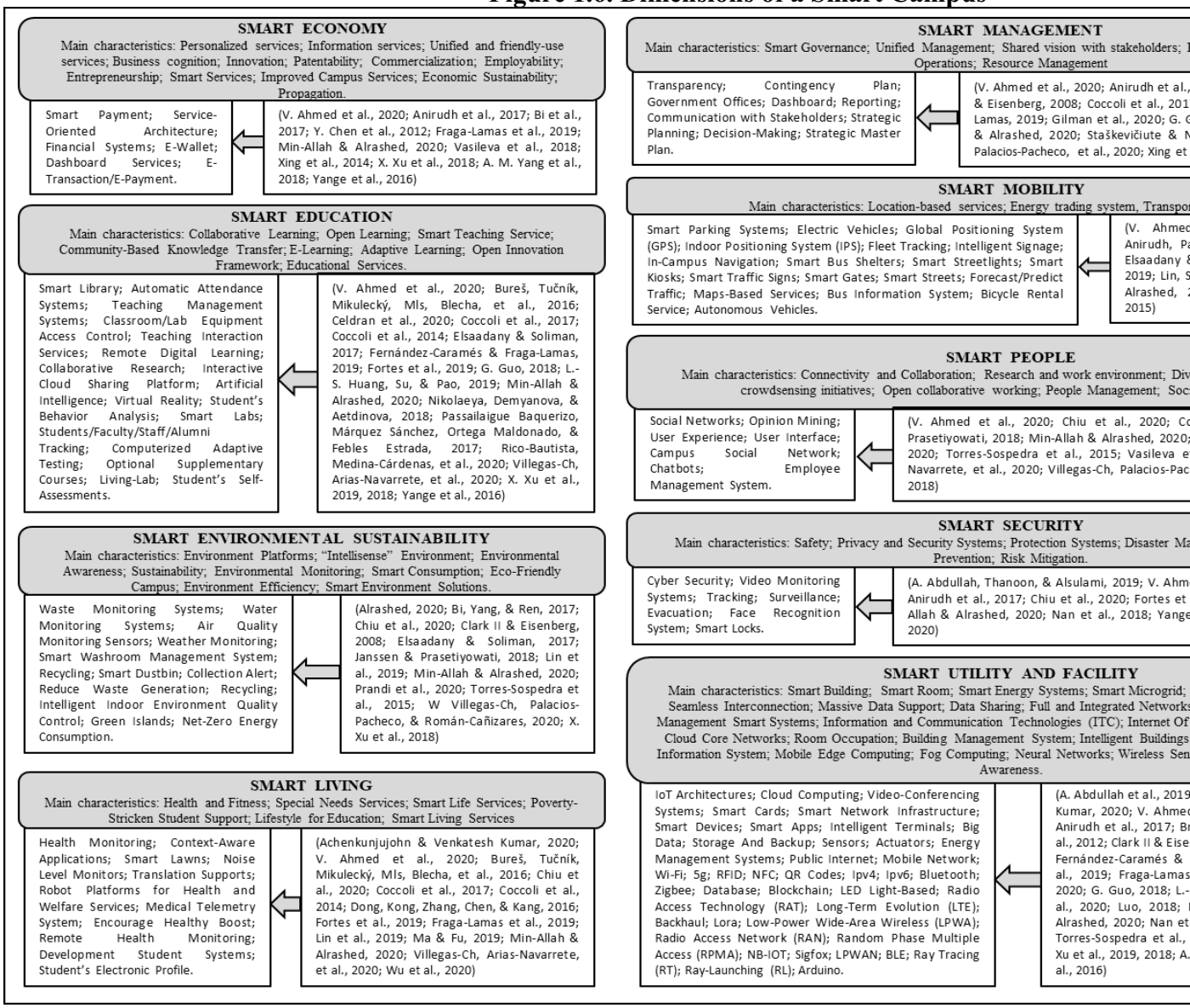
The smart city concept is linked to smart campus approach (Fraga-Lamas et al., 2019; Janssen & Prasetiyowati, 2018; Ren et al., 2018; Wu et al., 2020), which integrates economic, environmental, and social dimensions with technologies to offer a better quality of life to its inhabitants (Caragliu et al., 2011; Giffinger et al., 2007; Nesti, 2020).

The broad view of the Smart Campus concept generates many points of view. However, the definitions can be categorized in three approaches, as categorized as: (a) technology-driven, (b) smart city concept adoption, and (c) based on the development of an organization or business process (Gilman et al., 2020; Prandi et al., 2020). To sum up, the smart campus is a refinement of the umbrella term smart environment. It is a broad concept with no unified definition, and it still is at the exploratory stage (Y. Chen et al., 2012; Chiu et al., 2020; Min-Allah & Alrashed, 2020; Prandi et al., 2020).

4.2 Dimensions

The dimensions, characteristics and components of smart campuses respond the question 'what composes a smart campus'. Figure 1.6 summarizes the set of dimensions and elements cited by the scholars aggregated according to its resemblance, despite the different titles used by authors.

Figure 1.6. Dimensions of a Smart Campus



Source: Elaborated by the authors.

Smart Mobility comprises actions mainly related to transportation within and outside campus, combining technologies to enhance the experience through location-based services. For instance, smart parking, intelligent signage, maps-based services, bicycle rental service, forecast traffic service, and bus information systems. Also, the scholars associate products related to sustainability in the mobility sector, such as electric and autonomous vehicles, smart streetlights, and energy trading systems. The dimension's primary goal is to combine technologies to make mobility more comfortable, effective, and sustainable on campus.

Smart Education is the core business of a university since it is an education facility. It is one of the most studied dimensions by the scholars involving learning improvements through new methodologies, such as game-based, optional supplementary courses, collaborative, open and adaptive learning; technology innovation through computerized adaptive testing, e-learning and smart teaching services. Besides, it includes living-lab environments, open-innovation framework, and a community-based knowledge transfer. The dimension has the primary goal of building an open, active, and collaborative environment for learning and teaching through smart services and technologies.

The Smart Security dimension focuses on better security, privacy, and protection in the campus through cybersecurity, smart locks, video monitoring, surveillance, evacuation, and face recognition systems. It also promotes campus disaster prevention, that is management and risk mitigation systems. The aim is to provide a secure physical and virtual environment for all stakeholders in the university.

Smart Living is related to health, fitness, special needs services, and smart life services to improve the livability in campus, but also concerns poverty-stricken student support. This dimension involves context-aware applications, health monitoring and medical systems, smart lawns, noise level monitors, robot platforms for welfare services, student electronic profile and development systems. Thus, the aim of this dimension is to provide better livability on campus through health encouragement and support, student development, and smart living services.

Smart Environment Sustainability aims to bring an "IntelliSense", eco-friendly and sustainable environment in the university with smart consumption, ecological awareness, and monitoring systems, such as waste, water, air quality, and weather. Also, this dimension objectives to reduce waste generation, improve recycling, and promote a net-zero energy consumption. Smart Management brings a unified, paperless, and intelligent management based on a shared vision with stakeholders to campus. It claims transparency and communication in the management, providing contingency plans, dashboards, reporting,

strategic planning, and shared decision-making. Thus, it aims to build an integrative, transparent, and open environment to manage campus with its stakeholders.

Smart Utility and Facility relates to a plethora of technologies that enhance energy, buildings, surroundings, facilities, and utilities of smart campuses. It uses Information Communication Technologies, Internet of Things, Edge computing, Big data, Cloud core networks, Fog computing, Mobile Edge Computing, Neural networks, and others to provide seamless interconnected systems. It is interesting to highlight that despite increasing focus on technology, there is not a specific dimension for it, such as Smart technology, instead, it is a mix of tech services to different uses on all dimensions.

Smart Economy includes information support systems, unified, friendly-use and personalized services based upon business cognition, innovation, patentability, commercialization, employability, and entrepreneurship on smart campuses. It focuses on improvements to the economy inside the campus with smart payment services, service-oriented architecture, e-wallet, dashboard services, e-transaction, and e-payment. Besides, it boosts the local economy and business ideas.

The Smart People dimension relates to the campus' personnel and public opinion since it proposes a sustainable employee management system. Also, the dimension focuses on open and collaborative research, work environment based on connectivity, collaboration, diversity, crowdsourcing and crowdsensing initiatives. It relates to how people connect inside campus through social networks, Opinion mining, User experience, User interface, and creating a campus own social network.

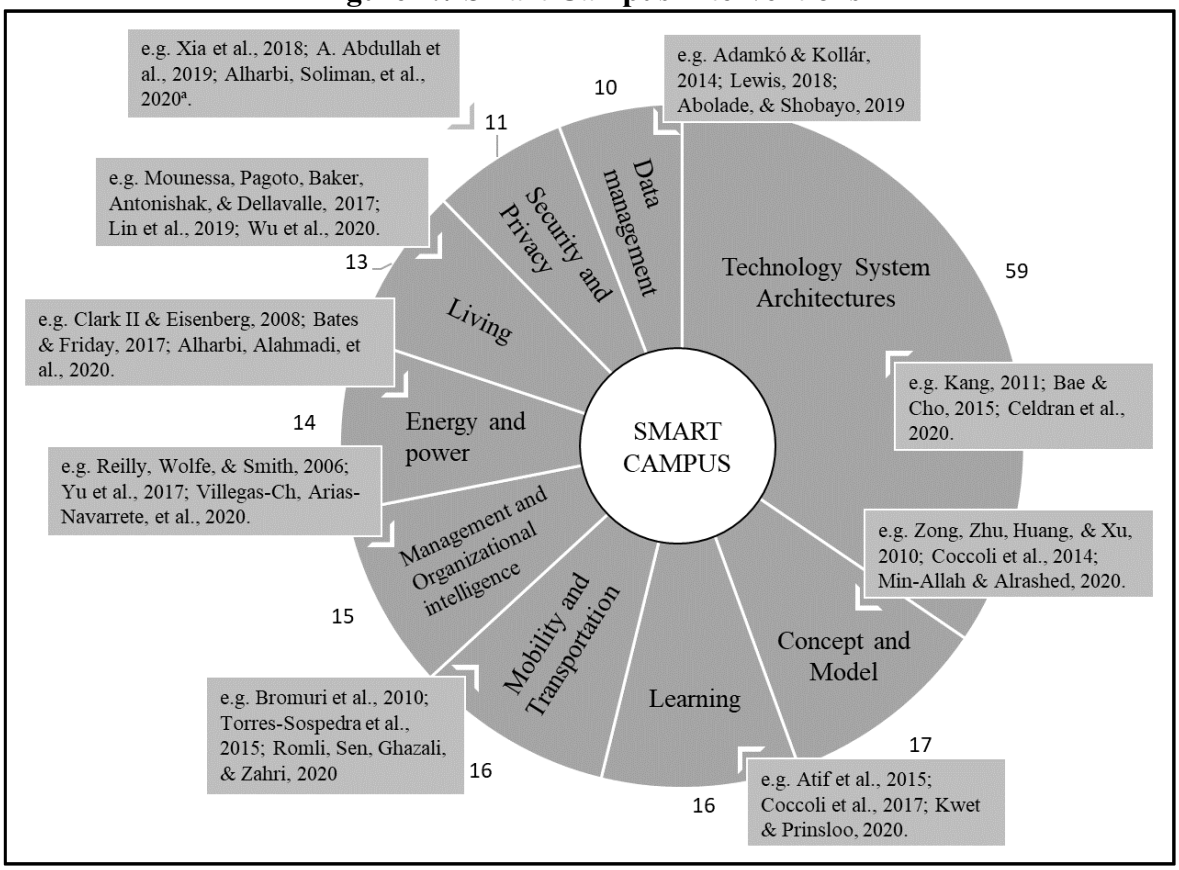
The results showed that technology initiatives exist in all dimensions as a transversal tool to improve the several areas of smart campuses, as well to interconnect them. For instance, a student can submit to the smart campus social network and receive personalized information about services and products inside campus, parking and bus information based on classes schedule, access the university system and places, pay, and have their attendance through a smart card. Thus, the technology promotes the interconnection of all dimensions to build a smart campus.

4.3 Interventions

The empirical evidence presented by papers and the article goals showed the interventions conducted or studied. We clustered them on nine categories according to the type of intervention, as shown on Figure 1.7. The highest number of studies was related to

Technology System Architectures (59), as already noted by the technology presence on all dimensions of a smart campus. The concept and model are the second cluster with 17 papers, followed by Learning (16); Mobility and Transportation (16); Management and Organizational Intelligence (15); Energy and Power (14); Living (13); Security and Privacy (11); and Data Management (10).

Figure 1.7 Smart Campus Interventions



Source: Elaborated by the authors.

The Technology System architecture is the most researched topic on smart campus, bringing innovation based on various technologies, networks, sensors, and so on. For instance, it relates to build the campus systems based on web service middleware (e.g. G. Stavropoulos et al., 2013), virtual and augmented reality (e.g. Y. Huang et al., 2016; Ramos et al., 2018), internet, Wi-fi, 5G, bandwidth and IoT systems (e.g. Arshad et al., 2018; Bin Ismail & Habaebi, 2019; Y. Guo et al., 2016; Jurva et al., 2020; Khamayseh et al., 2015), education network platform (F. Jing, 2018), mobile and network edge computing (Santa et al., 2018; Q. Xu et al., 2018), cloud computing (Ma & Fu, 2019; Zhang et al., 2018), fog computing (Amadeo et al., 2019; Fraga-Lamas et al., 2019), sensors system (Prandi et al., 2020), network function

visualization with software-defined networking (Celdran et al., 2020), deep convolution network (Banerjee et al., 2020), and deep neural network (Chiu et al., 2020).

Also, the results highlight an evolution in the empirical research timeline related to the campus technology architecture that started with web service middleware and currently focus on deep neural networks. Although other technologies like those associated with IoT are present along the years.

In this way, empirical research to smart technology architecture relates to attendance and occupancy systems (e.g. Bae & Cho, 2015; Griffiths et al., 2019; Husni, 2017b, 2017a; Witayangkurn, & Saengudomlert, 2020;), utility-driven services (Soldatos, Kefalakis, Serrano, & Hauswirth, 2014), web of events system (Y. Sun, Yan, Lu, Bie, & Zhou, 2014), self-service terminal (Xing et al., 2014), payment systems (R. Li et al., 2018; Ruttala, Balamurugan, & Chakravarthi, 2015), services computing systems framework (Kurniawan, Suhardi, Bandung, Prasetyo, & Yustianto, 2019), campus information system and information panel (Bi, Yang, & Ren, 2017; Pisařovic, Koubek, Ondroušek, & Procházka, 2018), unified system (Y. Guo et al., 2017), Platform-as-a-Service (Coccoli et al., 2015), agent-based modelling (Seidita & Chella, 2017), activity abstraction (Wen et al., 2018), social networks (Lim & Ahn, 2013; Peng, Zhou, Sun, Su, & Ji, 2019), situational awareness system (A. M. Yang et al., 2018), cyber-range service (Tian et al., 2018).

Management and organizational intelligence were built in a smart campus based upon archive and files management (Delgado-Dominguez et al., 2018; Reilly et al., 2006; J.-F. Yu et al., 2017), organizational processes (Staškevičiute & Čiutiene, 2008), iManagement (Caballero et al., 2014), assets management (Prasad et al., 2016), knowledge management and organizational learning (Passailaigue Baquerizo, Márquez Sánchez, Ortega Maldonado, & Febles Estrada, 2017), policies (Zapata-Ros, 2018), teaching performance evaluation (Xu et al., 2018), lean tools (Nikolaeva, Demyanova V, Aetdinova, & Mestnikova I, 2018), decision-making (Chang et al., 2018; Villegas-Ch, Arias-Navarrete, et al., 2020), smart tools (Valks, Arkesteijn, & Den Heijer, 2019), water management (Alharbi, Soliman, et al., 2020a), and key-performance indicators (Alrashed, 2020). This shows the technology as a driver to build intelligence in management of a smart campus.

Articles concerning the concept and models for a smart campus focus on administrative aspects (Staškevičiute & Neverauskas, 2008), IoT (Achenkunjujohn & Venkatesh Kumar, 2020; Zong, Zhu, Huang, & Xu, 2010), service encapsulation (Y. Chen et al., 2012), green campus (H. I. Wang, 2014), smarter universities (Coccoli et al., 2014), mobile platform (Dong, Kong, Zhang, Chen, & Kang, 2016), privacy (Anirudh, Pandey, Sodhi, & Bagga, 2017), smart

methodologies and smart education (Segredo et al., 2017; Tita, Bold, Popescu, & Nijloveanu, 2018), state-of-the-art on applications (Fernández-Caramés & Fraga-Lamas, 2019), sustainable smart campus (Villegas-Ch, Palacios-Pacheco, et al., 2019), strategic map of smart universities (Rico-Bautista, Medina-Cárdenas, et al., 2020), intelligent technologies (Rico-Bautista, Maestre-Góngora, et al., 2020), smart space (Gilman et al., 2020), stakeholders (V. Ahmed, Alnaaj, & Saboor, 2020), and smart city concepts (Min-Allah & Alrashed, 2020). This shows integration of the smart campus concept with similar terms and advancements in strategy, technology, and methodologies.

Mobility and Transportation cluster has interventions that improve the accessibility of People with Disabilities (PWD) (Bromuri et al., 2010), bus monitoring system (Feng et al., 2018; Hannan, Mustapha, Basri, & Hussain, 2010), guidance and navigation applications (L.-W. Chen, Chen, Chen, Liu, & Tsai, 2018; Romli, Sen, Ghazali, & Zahri, 2020; Torres-Sospedra et al., 2015; Yim, Joo, Lee, & Shim, 2014; C. Yu, Qi, Chen, Zhao, & Wang, 2019), indoor positioning systems (Azmitia, Mohnke, & Wiechers, 2016; Fernández, Santa, & Skarmeta, 2020), parking (Singh, Ravi, & Krishnan, 2018), electric and autonomous vehicles services (M. A. Ahmed, El-Sharkawy, & Kim, 2020; M. A. Ahmed & Kim, 2018; Marin-Plaza, Hussein, Martin, & de la Escalera, 2019), and prediction (Toutouh, Arellano, & Alba, 2018). This cluster is mostly composed by access and indoor mobility in a smart campus.

The interventions related to Learning are based upon ubiquitous learning (Atif et al., 2015), online and mobile learning (Y. Song, 2020), learning ecosystems and ambient intelligence (Bureš, Tučník, Mikulecký, Mls, & Blecha, 2016; Galego, Giovannella, & Mealha, 2016), big data (Ying, 2017), IoT (Chauhan, Goswami, & Patel, 2019; Elsaadany & Soliman, 2017; Nithin Rao & Sreenivasa Ravi, 2017), social e-learning platform (Dascalu, Bodea, Moldoveanu, & Dragoi, 2017), learning and teaching process (Coccoli et al., 2017; Elsakova et al., 2019), gamification methodologies (D. Song, Shi, Wang, & Xu, 2018; Zhai, Dong, & Yuan, 2018), and smart classrooms (Kwet & Prinsloo, 2020). This shows that the learning process in smart campuses is driven by technology enhancement in physical and virtual environments, but also to new methodologies.

The cluster composed by Living interventions show research in real-time monitoring (Alahmadi, 2020; Nan et al., 2018), routine gamification (Janssen & Prasetiyowati, 2018), space use (Valks, Arkesteijn, Den Heijer, & Vande Putte, 2018), predicting frameworks (Qu, Li, Zhang, & Wang, 2018), music service (Y. Liu, 2019), digital culture (Tikhonova, 2019), dormitory applications (Lin, Shieh, & Lin, 2019), students association and support (X. Y. Li, Yu, Zhang, Dai, & Yin, 2020; Wu et al., 2020). Living comprises environment, people flow

and opinion monitoring, changes in educational paradigm, student support, and applications to improve the campus livability.

Energy and Power interventions in a smart campus relates to sustainable power generation (Clark II & Eisenberg, 2008), monitoring systems (Qian, Ma, Peng, Ju, & Xu, 2014), microgrid (Alonso & Donsión, 2016), innovative energy and monitoring management (Alharbi, Alahmadi, et al., 2020; Bates & Friday, 2017; Moreno et al., 2017; Stavropoulos, Koutitas, Vrakas, Kontopoulos, & Vlahavas, 2016; Ullah et al., 2020; Weng, Zhang, & Xia, 2019; C. T. Yang, Chen, Liu, Liu, & Chang, 2020; W. Zheng, Yang, Feng, Fu, & Shi, 2019), and energy conservation (Jing, Li, Cheng, & Guo, 2020; Siddiqui et al., 2019). This cluster concerns about Sustainable Development in energy management, conservation, and monitoring.

Data management in a smart campus relates to a data management architecture and infrastructure (Williamson, 2018), data information standard system (X. Li & Zeng, 2018), data collection and analysis (Luo, 2018), learning analytics (Lewis, 2018), big data (Villegas-Ch, Molina-Enriquez, et al., 2019; Zhang & Jiang, 2018), open data (Vasileva et al., 2018), data mining and data online backup system (Tao, Wei, Yuan, & Huang, 2019). The research on Security and Privacy of smart campuses is based upon intelligent security system (Zeng & Li, 2018), cybersecurity (Sanchez-Torres et al., 2018), authentication protocol (L. Zheng et al., 2018), secure image extraction (Xia et al., 2018), compressive sensing (Zhu, Jiang, Deng, & Hu, 2018), virus propagation model (L. Wang, Yao, Yang, & Yu, 2018), disaster mitigation planning (Hatzivasilis, Papaefstathiou, Plexousakis, Manifavas, & Papadakis, 2018), anonymous region construction (R. Sun, Xi, Yin, Wang, & Kim, 2018), IoT (Abdullah, Thanoon, & Alsulami, 2019), and video surveillance system (Zhou, Yu, & Shi, 2020).

We clustered Context-aware interventions on a specific category because it has applications in various areas of smart campus, such as management (B. Guo, Zhang, Sun, Yu, & Zhou, 2013), ambient systems, service access (Lehsten, Bader, & Tavangarian, 2014), solution for people with disabilities (Kbar, Abidi, Mian, Al-Daraiseh, & Mansoor, 2016), and smart classrooms (L.-S. Huang, Su, & Pao, 2019). This show that interventions provide services, systems and applications related to the real context using technologies.

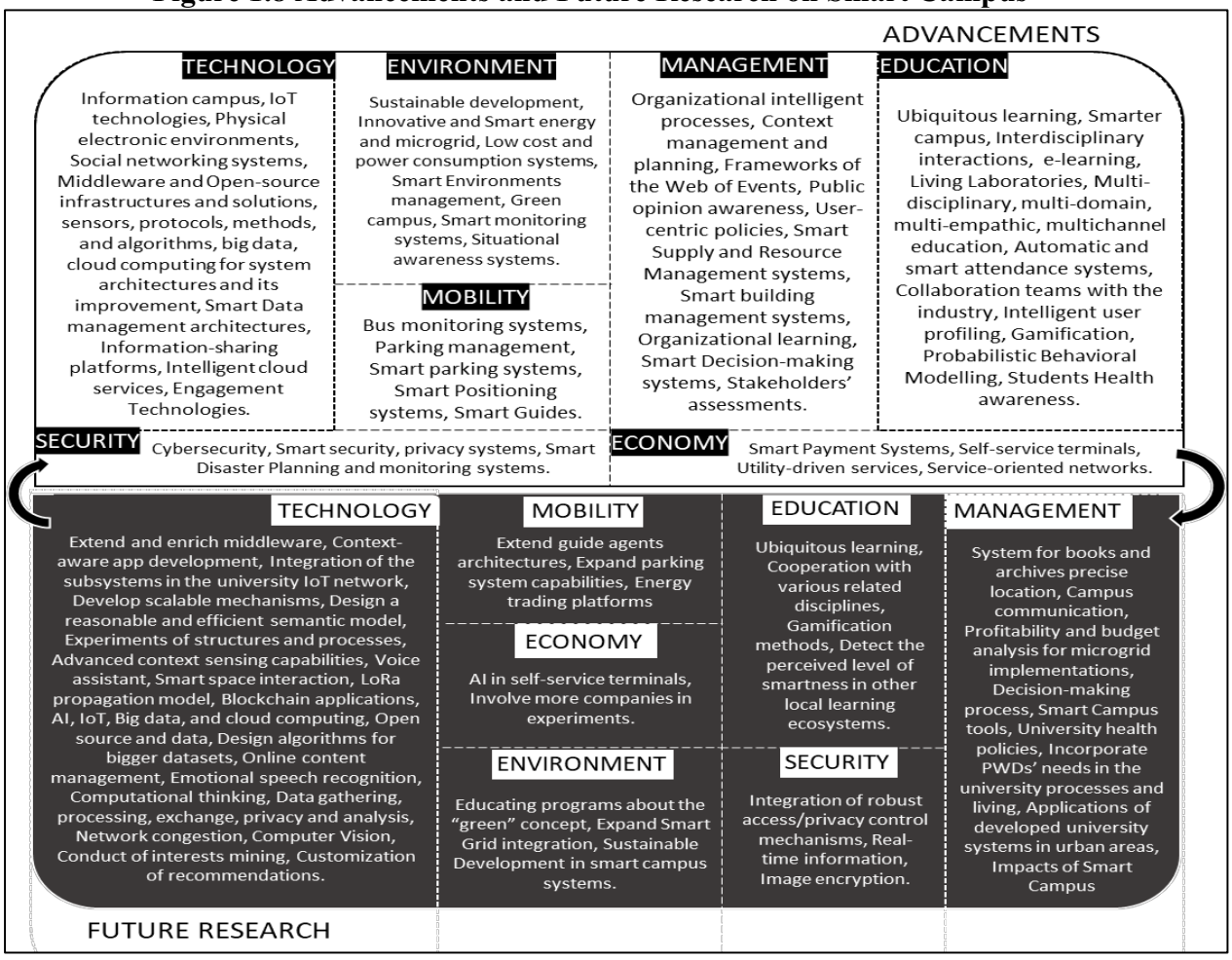
As seen in the smart campus dimensions, its interventions are also interconnected with overlapping systems, technologies, and applications to improve the user experience of all stakeholders. It promotes a unified progress of smart campuses, but still allows specific improvements in small areas, for instance a manager could focus attention on its own campus priority areas.

4.4 Advancements and Future Research

The last research questions proposed in the methodological design aimed to present the advancements of smart campus compared with traditional universities and to show what future research the scholars indicated. However, some papers did not point out future research. Figure 1.8 summarized these findings.

We grouped the results into eight clusters, namely: technology, environment, management, education, mobility, security, and economy. Technology is the most prominent cluster in both advancements and future research. On the one side, the improvements were in information systems, social networks, electronic environments, infrastructures, and solutions based on technologies, sensors, protocols, methods, and algorithms. On the other side, the scholars propose more future research to extend, develop, and enhance the existing systems, besides designing new models and algorithms.

Figure 1.8 Advancements and Future Research on Smart Campus



Source: Elaborated by the authors

Smart campus implementations improved the university management by promoting intelligent actions in processes, decision-making, policies, and systems. It also incorporated governance actions through stakeholders' assessments, public opinion awareness, and context-aware management and planning. Future research proposes the development of management systems in various university areas, such as libraries, but also related to policies and processes, for instance, health and people with disabilities' needs.

Concerning education, the advancements were ubiquitous and e-learning systems, active methodologies, interdisciplinarity, and collaboration that promoted changes in educational paradigms of universities. Further research proposes to detect the smartness level in other learning ecosystems. The smart campus also produced changes in the relationship between the university and the environment by actions related to the Sustainable Development, green campus, and smart monitoring systems. Future research also points out to educating programs for the green concept, to expand systems, and actions of Sustainable Development.

Universities may be considered as small-scale cities, so Mobility is an important topic of a smart campus that promotes advancements in bus, parking, and positioning systems through smart route systems, for instance. Security is also an important topic that smart campuses promote improvements and future research on cybersecurity, smart privacy and security systems, smart disaster monitoring systems, image encryption, real-time information, and mechanisms integration. Economic services are also part of universities that smart campuses promote self-service terminal, smart payment services, service-oriented networks, and utility-driven services. Future research on these areas mostly proposes to improve the developed systems.

5 Conclusions

This study aimed to identify the state-of-the-art and propose a framework of smart campus through an in-deep literature review based on definitions, dimensions, interventions, advancements, and indications for future research on the field. The methodological design followed the PRISMA and SPIDER methods since they are techniques suitable for systematic reviews.

Our findings are summarized in two groups of conclusions about the smart campus: (i) a framework proposition and, (ii) a research agenda. Firstly, the results showed that smart campus concept relates to technology innovations, sustainability, learning strategies, and

stakeholders' participation to promote changes in educational paradigms and livability on universities.

The smart campus dimensions are similar to Giffinger et al. (2007)'s Smart City approach composed of six smart dimensions: economy, mobility, people, governance, environment and living. Although some authors propose different dimensions terminologies, there is an overlap of variables. The results showed the characteristics and components of each smart campus dimension since our framework proposition summarizes the findings into eight smart campus dimensions. We already expected that technology was the core of the smartization process. However, the findings highlight that technology is more than a core, it is a crossline component in all dimensions; technology is the hub, process, and result at the same time.

The advancements of smart campus, compared with traditional universities, exposed extensive technology implementations, as well as the scholars indicated further research based on technology solutions. Although the smart campus is a broad concept that includes more than technology, mostly initiatives are related to universities informatization. The focus on technology appears in the smart campus interventions mainly focused on Technology System Architecture, Concept and Model, Living, and Mobility and Transportation.

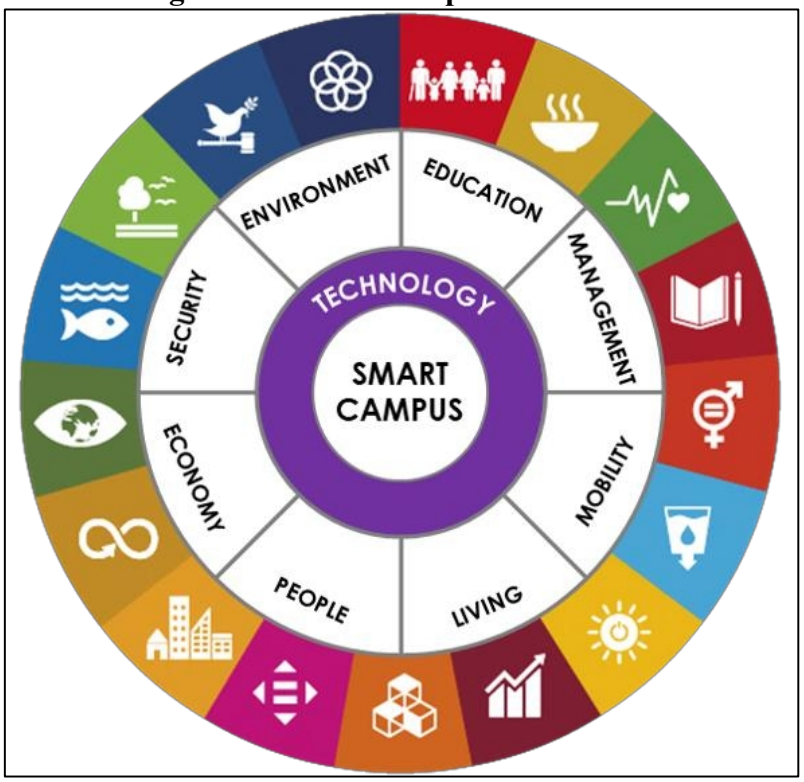
Based on the results, we offer an integrative framework for the smart campus based on the Sustainable Development Goals, which is an integrated and indivisible universal agenda that seeks to balance the three dimensions of sustainable development (economic, environmental, and social) through partnership of countries and organizations (UN, 2015).

Thus, we define Smart campus as a higher education ecosystem that uses technology to achieve the tripod of sustainability (environmental, economic, and social) in a model of governance, collaborative, and adaptive learning to promote better livability for its stakeholders. Eight smart dimensions compose a smart campus (Figure 1.9):

1. Smart Education builds an open, active, and collaborative environment for learning and teaching through services and technologies, which implements action towards SGD 4.
2. Smart Mobility combines technologies to make mobility more comfortable, effective, and sustainable on campus, which implements action toward SGD 7 and 11.
3. Smart Management builds an integrative, transparent, and open environment and a workplace to manage campus with active stakeholder participation, which attends to SGD 7, 9, 11, 16 and 17.
4. Smart Environment makes a sustainable campus through implementations of actions toward the SGD 6, 13, 14 and 15.

5. Smart Economy promotes personalized, safe, and smart services and payment systems, which attends SGD 8, 10, 12 and 17.
6. Smart Living includes health encouragement and support, student development, and smart living services, which implements action towards the SGD 1, 2, 3 and 5.
7. Smart Security to protect the people in both physical and virtual context, which attends SGD 11 and 16.
8. Smart Technology is a transversal dimension that connects and supports all others.

Figure 1.9 Smart Campus Framework



Source: Elaborated by the authors

The second group of findings identify a research agenda of Smart Campus to improve the knowledge and help practitioners transform traditional universities. Four main topics are the new frontier to the smart campus knowledge. Thus, they should be in the researchers' agenda:

i) The focus on people, livability and economy complements the smartization process. All services, processes, and technologies used to improve the living of stakeholders and universities' surroundings. Therefore, Smart Campus studies should consider people's needs and preferences.

ii) Research to develop tools to monitor the universities' smartization process, such as models, variables, indicators, and metrics to support the decision-makers, i.e., academic

managers. We suggest a general monitor creation to be standard and to allow comparison between universities.

iii) Studies to adapt the indicators and metrics of smart campus to the country's economic development and adjust to the cultural context.

iv) Research focused on specific dimensions of smart campus should be replaced by integrative perspectives of the smart campus approach because the smartization should achieve all organization levels and the SDGs.

Although we performed a deep analysis, the use of peer-reviewed articles published on the Web of Science and Scopus was a limitation of this study. Thus, a further literature review can include conference papers and the grey literature to extract more smart campus approaches.

Finally, the smart campus is undoubtedly the future of universities, but its integral concept is far from being achieved in most universities. There is an extensive road to run in which scholar research can support the academic managers.

References

Observation: The reference list is at the end of the document.

CHAPTER 2

SMART CAMPUS MONITOR: A METHOD TO SUPPORT DECISION-MAKING FROM LATIN AMERICAN UNIVERSITIES

SMART CAMPUS MONITOR: A METHOD TO SUPPORT DECISION-MAKING FROM LATIN AMERICAN UNIVERSITIES

Pedro Ivo Silva da Nóbrega
Postgraduate Program of Management
Federal University of Campina Grande, Brazil

Adriana Fumi Chim Miki
Federal University of Campina Grande, Brazil

Marysol Castillo Palacio
Pontífica Universidad Javeriana – Cali, Colombia

Abstract

"Smart" is no longer a characteristic exclusive to products, as phones and computers, but now it reaches institutions, homes, offices, cities, and universities. According to the social and economic contexts, Smart Campus initiatives may differ. This research formulates and validates a Smart Campus model with indicators to monitor the Latin American context's smartization process. The study used a qualitative methodology of online Focus Group (FG) in two steps. Firstly, an asynchronous and online FG; then, synchronous, and online FG. The participants were experts on Smart Campus, both scholars, and practitioners. Our results validated a Smart Campus definition and defined variables to monitor eight smart dimensions: economy, education, environment, living, management, mobility, security, and technology. The discussions mainly concerned how decision-makers and stakeholders need to address sustainability, technology, and social issues in smart campuses. Also, our research pointed out three groups of findings relating to an integrative concept, model, and managerial implication for smart campuses. The results indicated that a smart campus must be connected inside and outside its walls. The experts' discussions mainly concerned sustainability, technology, and social issues. The results provided a helpful model to any context. Still, it highlighted a Latin American point of view, which shows that social and economic regional level can change the concept of “smart”. Technologies and sustainability are the basis for the smart campus. However, developing countries may consider other components as priorities for a smart living environment, such as improvements in infrastructure, mobility, education, and social services.

Keywords: Smart Campus. Focus Group. Smartization Process. Latin American Universities.

1 Introduction

Smart initiatives are constantly evolving and changing the way we perceive the world, mainly through a smart environment and technologies able to acquire information and use it to better meet human needs (E. Ahmed, Yaqoob, Gani, Imran, & Guizani, 2016; Boni, Xu, Chen, & Baddoo, 2020). The wide range of applications and technologies are connected to perceive people's state and to act on the environment to facilitate their lives, which include the Internet of Things (IoT), Information and Communication Technologies (ICT), Artificial Intelligence

(AI), and others. These smart technologies associated with Sustainable Development Goals can improve human livability (Boni et al., 2020; Cesconetto et al., 2020; Gubbi, Buyya, Marusic, & Palaniswami, 2013; Hussain & Jain, 2020).

The “smart” is no longer a characteristic exclusive to products, as phones and computers, but it is reaching institutions, homes, offices, cities, and universities. The smartization process, i.e., the way to become smart (Nesti, 2020) takes diverse approaches on the Global North and South, given the different development levels. Smart cities on the Global North build technology and network frameworks on established institutions and well-developed infrastructures. On the other hand, cities in the Global South have more deficient public services, a lack of resources, a dynamic informal economy, and weaker institutions that pose distinct modes and articulations for smart city projects (Offenhuber, 2019; Söderström, 2020).

Smart Campus initiatives promote new educational paradigms and improvements in technology, environment, management, education, mobility, living, security, and economy of universities (Ahmed, Alnaaj, & Saboor, 2020; Min-Allah & Alrashed, 2020). It is an increasing research topic that needs more studies due to its novelty and lack of consensus from authors on its definition and dimensions (Min-Allah & Alrashed, 2020; Prandi, Monti, Ceccarini, & Salomoni, 2020).

To be 'smart' may also assume another perspective to universities located on the Global South compared to the Smart Campus perspectives to Global North. Despite a need to reach an integral view of the concept and dimensions of Smart Campus, the university region's economic, social, and cultural characteristics may influence its smartization process. Therefore, our research question is: “How the smartization process of a Smart Campus in a Latin American context can be monitored?".

Thus, this research aims to formulate and validate a Smart Campus model with indicators to monitor the smartization process in the Latin American Context. This paper proposes a Latin American school’s perspective through a qualitative exploratory study based on a Focus Group with Smart Campus experts and a Content Analysis.

This paper further presents a theoretical background section focused on the Sustainable Development Goals (SDG) and Smart Campus literature; Section 3 shows the methodological design to perform a Focus Group; Section 4 presents and discusses the results. At last, section 5 presents the conclusions, implications, limitations, and suggest further research.

2 Smart Campus

Sustainable Development may be composed of objective-based actions for people, the planet, and prosperity to be achieved by all countries and stakeholders, such as the 2030 Agenda proposed by the United Nations (United Nations, 2015). The plan has 17 Sustainable Development Goals (SDGs) and 169 targets to end poverty and set a path of peace, prosperity, and opportunity for all on a healthy planet by 2030. However, global efforts were still insufficient to deliver the changes, jeopardizing the agenda's promise, even before the COVID-19 pandemic (United Nations, 2020).

Technology and Sustainable Development are means to build smart environments, processes, and things to improve human livability to the present and future generations (Boni et al., 2020; Cesconetto et al., 2020). Smart institutions must focus on SDGs; for instance, the Smart campus, which is a path for the future university, should attend to its stakeholders' needs sustainably, becoming drivers to accomplish Sustainable Development (Clark II & Eisenberg, 2008; (Coccoli, Maresca, & Stanganelli, 2017).

The term "Smart Campus" was coined in 2000 with a technology perspective of video-conference facilities and internet networking systems in cooperation between university and industry (Kaneko et al., 2000). Although the technology is still a significant part of a university smartization, other characteristics were also added as pillars to build a smart campus over the years, such as creative learning (Clark II & Eisenberg, 2008), accessibility (Bromuri et al., 2010), high-tech and modern architecture (Y. Chen et al., 2012), shared knowledge (Mario Coccoli et al., 2014), social services and stakeholders interaction (Atif et al., 2015), systemic view with IoT and applications services (Y. Huang et al., 2016), social and sustainable structure based on technology tools (Coccoli et al., 2017), cybersecurity issues (Tian et al., 2018), innovation and management (Fortes et al., 2019), and intelligent ecosystems (W Villegas-Ch, Arias-Navarrete, et al., 2020).

The smart campus is at the exploratory stage; thus, it lacks a unified concept, dimensions, or characteristics (Chiu, Chang, Lee, Chen, & Lee, 2020); Min-Allah & Alrashed, 2020; Prandi et al., 2020). Nevertheless, the literature reveals three different perspectives to conceptualize the smart campus: 1) technology-driven approach, 2) organizational process-driven and 3) the smart city approach (Gilman et al., 2020; Muhamad et al., 2017; Prandi et al., 2020).

The technology-driven perspective of smart campus highlights universities' digitalization and informatization as the way to improve education and life on campus. This

smartization process is accomplished through the development of systems composed of ICT, IoT, big data, 5G, and other computing technologies, devices, sensors, and readers that builds an open, intelligent, and integrated information service platform (Chen et al., 2012; Fernández-Caramés & Fraga-Lamas, 2019; Xu et al., 2018; Yang et al., 2018; Yange, Xiaopin, Zhili, & Liang, 2016; Zheng, Yang, Feng, Fu, & Shi, 2019).

The Organizational process-driven approach of smart campus provides modernization of all university processes to build more smart management and services for stakeholders (Soldatos, Kefalakis, Serrano, & Hauswirth, 2014; Staškevičiute & Neverauskas, 2008). The smart campus is accomplished by a high degree of interconnected systems, resources, and applications to promote personalized, intelligent, and humanized services for campus users. At the same time, it is indispensable to managers since it improves efficiency in campus management (Guo, 2018; Nan, Suo, Jia, Wu, & Shan, 2018).

Based on the smart city perspective, the digitalization of a university should not become the outcome of its smartization process. Instead, universities should use technologies to build a comprehensive and sustainable living environment (Janssen & Prasetiyowati, 2018; Segredo, Miranda, & Leon, 2017). The Smart city is a well performing-city in smart dimensions (economy, people, governance, mobility, environment, and living) fueled by technologies to optimize the citizens quality of life through an integration of social, environmental, and economic spheres (Caragliu et al., 2011; Giffinger et al., 2007; Silva-Da-Nóbrega & Chim-Miki, 2021). Similarly, the smart campus is part of a smart city or, it has a similar structure formed by smart dimensions that prompt the technology and processes enhancement to other areas, such as environment, mobility, living, and health (Fraga-Lamas et al., 2019; Vasileva et al., 2018; Wu et al., 2020).

The smart campus dimensions follow a similar structure of a smart city (Fraga-Lamas et al., 2019; Torres-Sospedra et al., 2015). Nevertheless, there is no standard since there are different characteristics, components, architectures, frameworks, themes, and phases for the implementation of a smart campus (Ahmed, Alnaaj, & Saboor, 2020; Alrashed, 2020; Gilman et al., 2020; Jurva, Matinmikko-Blue, Niemelä, & Nenonen, 2020; Min-Allah & Alrashed, 2020; Prandi et al., 2020). Based on the literature review, Table 2.1 shows a synthesis of smart campus dimensions with the main characteristics aggregated according to their resemblance.

Table 2.1. Dimensions and main characteristics of Smart Campus

CHARACTERISTICS	AUTHORS
ECONOMY	
Personalized services; Information services; Unified and friendly-use services; Business cognition; Innovation; Patentability; Commercialization; Employability; Entrepreneurship; Smart Services; Improved Campus Services; Economic Sustainability.	(V. Ahmed et al., 2020; Anirudh et al., 2017; Chen et al., 2012; Fraga-Lamas et al., 2019; Min-Allah & Alrashed, 2020; Vasileva et al., 2018; Xing et al., 2014; Xu et al., 2018; Yang et al., 2018; Yange et al., 2016; Bi et al., 2017)
EDUCATION	
Collaborative Learning; Open Learning; Smart Teaching Service; Community-Based Knowledge Transfer; E-Learning; Adaptive Learning; Open Innovation Framework; Educational Services.	(V. Ahmed et al., 2020; Coccoli et al., 2017; Coccoli et al., 2014; Elsaadany & Soliman, 2017; Fernández-Caramés & Fraga-Lamas, 2019; Fortes et al., 2019; G. Guo, 2018; Min-Allah & Alrashed, 2020; Rico-Bautista, Medina-Cárdenas, et al., 2020; Villegas-Ch, Arias-Navarrete, et al., 2020; X. Xu et al., 2019, 2018; Yange et al., 2016)
ENVIRONMENT	
Environment Platforms; "Intellisense" Environment; Environmental Awareness; Sustainability; Environmental Monitoring; Smart Consumption; Eco-Friendly Campus; Environment Efficiency; Smart Environment Solutions.	(Alrashed, 2020; Chiu et al., 2020; Clark II & Eisenberg, 2008; Elsaadany & Soliman, 2017; Janssen & Prasetiyowati, 2018; Lin et al., 2019; Min-Allah & Alrashed, 2020; Prandi et al., 2020; Torres-Sospedra et al., 2015; Villegas-Ch, Palacios-Pacheco, et al., 2020; Xu et al., 2018)
INFRASTRUCTURE	
Smart Building; Smart Room; Smart Energy Systems; Smart Microgrid; Smart Campus Surroundings; Seamless Interconnection; Massive Data Support; Data Sharing; Full and Integrated Networks; Sustainable Energy; Facility Management Smart Systems; Information and Communication Technologies (ITC); Internet Of Things (IoT); Edge Computing; Cloud Core Networks; Room Occupation; Building Management System; Intelligent Buildings; Renewable Energy; Building Information System; Mobile Edge Computing; Fog Computing; Neural Networks; Wireless Sensor Network (WSN); Situational Awareness.	(V. Ahmed et al., 2020; Alrashed, 2020; Anirudh et al., 2017; Bromuri et al., 2010; Chen et al., 2012; Clark II & Eisenberg, 2008; Dong et al., 2016; Fernández-Caramés & Fraga-Lamas, 2019; Fortes et al., 2019; Fraga-Lamas et al., 2019; Gilman et al., 2020; Guo, 2018; Jurva et al., 2020; Luo, 2018; Min-Allah & Alrashed, 2020; Nan et al., 2018; Prandi et al., 2020; Torres-Sospedra et al., 2015; Vasileva et al., 2018; Xu et al., 2018, 2019; Yang et al., 2018; Yange et al., 2016)
LIVING	
Health and Fitness; Special Needs Services; Smart Life Services; Poverty-Stricken Student Support; Lifestyle for Education; Smart Living Services.	(V. Ahmed et al., 2020; Chiu et al., 2020; Coccoli et al., 2017; Coccoli et al., 2014; Dong, Kong, Zhang, Chen, & Kang, 2016; Fortes et al., 2019; Fraga-Lamas et al., 2019; Lin et al., 2019; Min-Allah & Alrashed, 2020; Villegas-Ch, Arias-Navarrete, et al., 2020; Wu et al., 2020)
MANAGEMENT	
Smart Governance; Unified Management; Shared vision with stakeholders; Paperless campus; University Key Operations; Resource Management.	(V. Ahmed et al., 2020; Anirudh et al., 2017; Chiu et al., 2020; Clark II & Eisenberg, 2008; Coccoli et al., 2017; Fernández-Caramés & Fraga-Lamas, 2019; Gilman et al., 2020; G. Guo, 2018; Luo, 2018; Min-Allah & Alrashed, 2020; Villegas-Ch, Palacios-Pacheco, et al., 2020; Xing et al., 2014)
MOBILITY	
Location-based services; Energy trading system, Transportation; Parking	(V. Ahmed et al., 2020; Anirudh et al., 2017; Elsaadany & Soliman, 2017; Fortes et al., 2019; Lin et al., 2019; Min-Allah & Alrashed, 2020; Torres-Sospedra et al., 2015)
PEOPLE	
Connectivity and Collaboration; Research and work environment; Diversity; Crowdsourcing and crowdsensing initiatives; Open collaborative working; People Management; Social Sustainability.	(V. Ahmed et al., 2020; Chiu et al., 2020; Coccoli et al., 2014; Janssen & Prasetiyowati, 2018; Min-Allah & Alrashed, 2020; Nan et al., 2018; Prandi et al., 2020; Torres-Sospedra et al., 2015; Vasileva et al., 2018; Villegas-Ch, Arias-Navarrete, et al., 2020; Villegas-Ch, Palacios-Pacheco, et al., 2020)
SECURITY	
Safety; Privacy and Security Systems; Protection Systems; Disaster Management; Campus Disaster Prevention; Risk Mitigation.	(V. Ahmed et al., 2020; Alrashed, 2020; Anirudh et al., 2017; Chiu et al., 2020; Fortes et al., 2019; Lin et al., 2019; Min-Allah & Alrashed, 2020; Nan et al., 2018; Yange et al., 2016)

Source: Elaborated by the authors.

The smart economy dimension supports better commercial services inside the university with intelligent and connected services, innovation, entrepreneurship, and business cognition. These service-oriented systems promote economic sustainability and employability for local commerce and personalized friendly-use products and services.

Education is the university's core business that is improved through e-learning technology, Artificial Intelligence, Cloud sharing platforms, and Virtual Reality. It should also change the education paradigm to include collaborative, adaptive, and open learning; community-based knowledge transfer; and innovative educational services, such as intelligent libraries and living labs.

The smart environment needs to be eco-friendly. Thus, monitoring systems – such as water, energy, and waste – are innovative environment solutions that promote universities' consumption efficiency. Also, the smart campus' environmental dimension demands other practices, such as waste generation reduction, recycling, and reuse of products.

A smart campus needs a smart infrastructure using technology to accomplish its concept. A system architecture composed of a plethora of hardware and software builds a seamless interconnection and supports massive data management. It is mainly related to wireless and internet technologies – IoT, ICT, 5G, Bluetooth, Long-Term Evolution (LTE). However, these systems also need a physical structure of sensors, devices, actuators, and terminals.

The smart living dimension focuses on improvements in the campus' quality of life through intelligent life services that monitor noise levels, and support health and welfare. Also, services and apps are built to support poverty-stricken students and those with special needs, such as people with disabilities. The lifestyle for education promotes translation support for international students and professors, creating a multi-cultural and diverse environment in universities.

The smart campus needs smart management that promotes a unified vision and active participation among stakeholders to build a governance-based administration. With technology aid, the processes run through electronic systems that turn the university into a paperless campus. Strategic planning, contingency plans, and decision-making processes relate to Information Systems and build upon transparency and reporting to better communicate with stakeholders.

Smart mobility provides location-based and connected services and systems that modernize inner streets and transportation of a university to make better access on a smart campus. Other methods, such as Global (GPS) and Indoor Positioning Systems (IPS), relate to

new technologies and the internet to enhance signaling, traffic, and parking. Fleet tracking, streetlights, bus shelters, and maps-based services are improved and connected to provide better information for users and planners, such as forecast traffic.

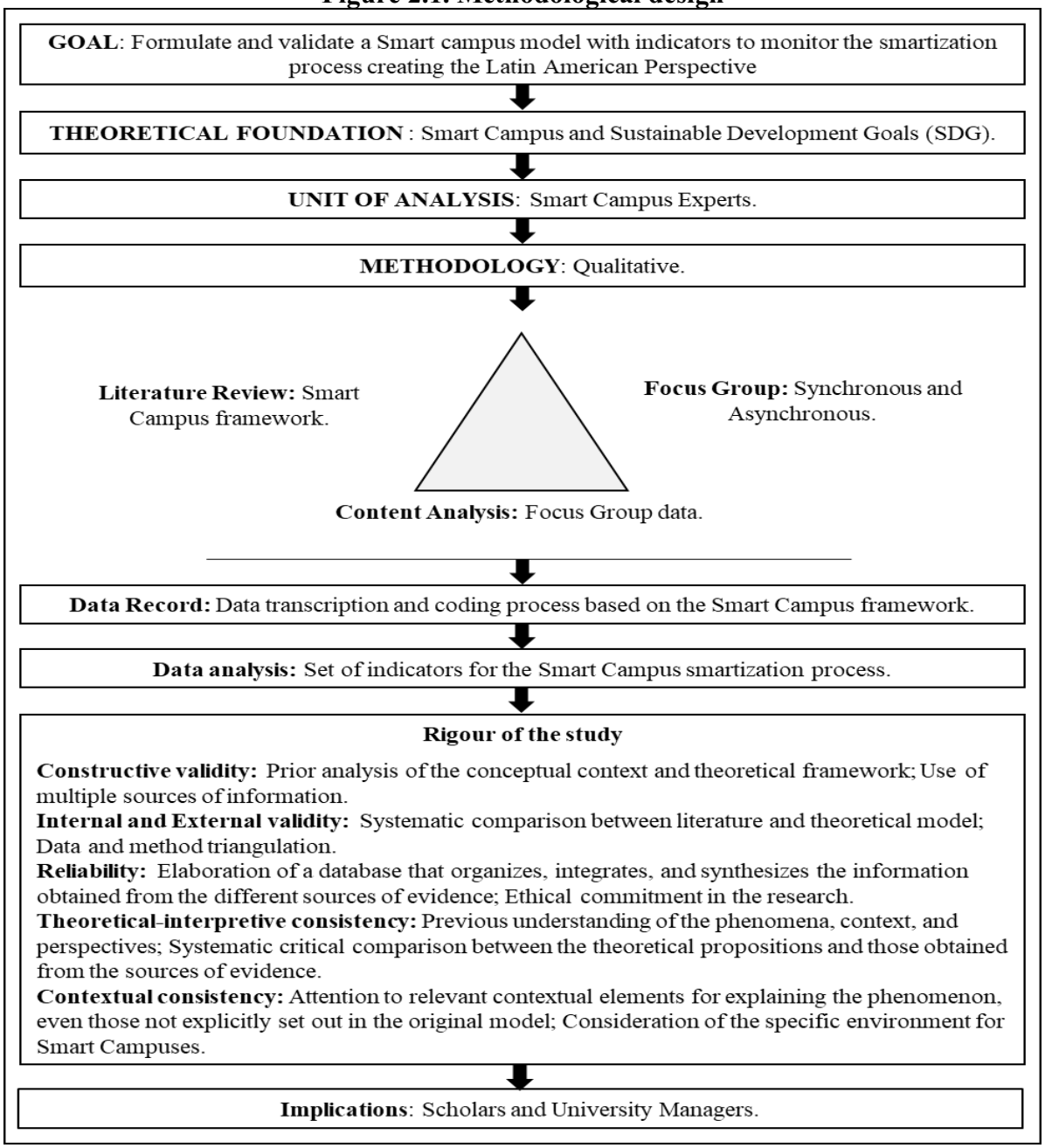
The smart people dimension helps the university to accomplish its goal of human development through connectivity, collaboration, and social sustainability. Technologies such as chatbots are used to rapidly deliver information and better solutions based on user experience and opinion mining. User interface and a campus social network improve employee management systems and encourage an open and collaborative working environment.

Smart security is essential to provide a safe physical and virtual environment in a smart campus. Face recognition systems and smart locks improve campus safety, together with video monitoring and cybersecurity systems. Connected services also promote better disaster management and prevention through more accurate information. Questions around data privacy become crucial in a technology-centered environment, such as an innovative campus that needs to build solid applications and privacy systems to prevent hacker attacks.

3 Methodology

We used a qualitative exploratory approach to formulate and validate a Smart Campus model with indicators to monitor the smartization process in the Latin American Context. We performed a three-step method: (1) Literature Review, (2) Focus Group (asynchronous and synchronous), and (3) Content Analysis. To ensure quality and rigor in our research, we adapted the methodological design from Villarreal and Calvo (2015), as summarized in Figure 2.1.

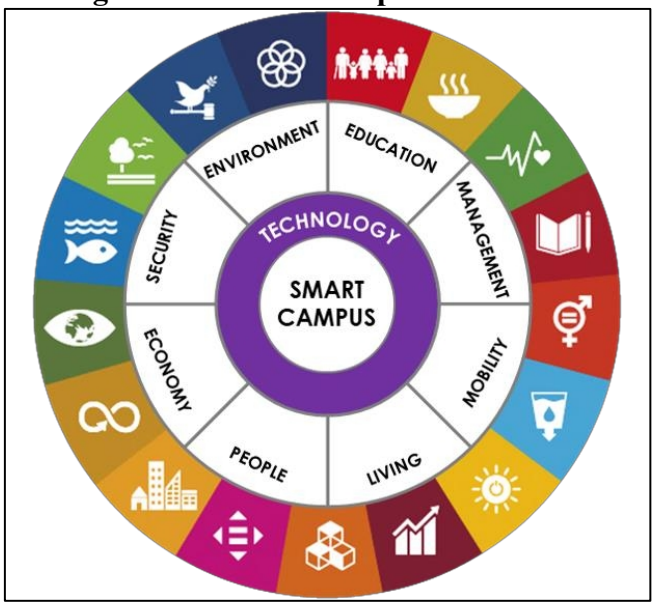
Figure 2.1. Methodological design



Source: Elaborated by the authors based on Villarreal and Calvo (2015).

A previous Systematic Literature Review of 178 papers published in Web of Science and Scopus on Smart Campus allowed the formulation of a definition for Smart Campus and a model with eight dimensions (Figure 2.2). In the sequence, both asynchronous and synchronous focus group sessions analyzed the proposition.

Figure 2.2. Smart Campus Dimensions



Source: Elaborated by the authors.

A Focus Group is a discussion organized to explore a set of specific issues. It is a collective activity to capitalize the communication between research participants to generate data (Kitzinger, 1994, 1995). The technique gathers data about a specific matter based on personal experiences, beliefs, attitudes, perceptions, and opinions (Guest et al., 2017; Morrison et al., 2020).

The sessions should have between 6 to 12 participants with a facilitator or moderator, i.e. a peripheral position in the focus group (Guest et al., 2017; O.Nyumba et al., 2018). This study focuses on Latin American smart campuses; thus, the criteria to select Focus Group participants were (1) be a researcher or professional working in themes related to Smart Campus, and (2) have work experience in Latin American universities.

Due to COVID-19 pandemic restrictions, we could not conduct a traditional focus group. Instead, we adopted the online focus group. Recent studies used web conferences to conduct the focus group sessions during the pandemic related to public health (Zhang, Young Leslie, Sharafaddin-Zadeh, Noels, & Lou, 2021) and education (Khlaif, Salha, Affouneh, Rashed, & ElKimishy, 2020). Also, some authors used social media to conduct sessions, such as WhatsApp, to understand the psychological effects of the pandemic (Radic, Lück, Ariza-Montes, & Han, 2020; Colom, 2021).

Despite the differences between online and offline Focus Groups, the content extracted from the data are similar (Woodyatt et al., 2016). An online focus group can occur through

synchronous or asynchronous internet-based techniques (Morrison et al., 2020; Tuttas, 2015). To provide more reliable results, we used both synchronous and asynchronous sessions.

At first, we sent invitations to participants for the asynchronous session via email containing a link to a questionnaire hosted in Google Forms (Appendix 1). This phase allowed the participants to agree or disagree with our smart campus definition, as they also indicated how to improve the concept. Similarly, the participants analyzed our eight smart campus dimensions regarding concepts and variables (Figure 2.2), and we requested them to suggest indicators for each dimension. This phase occurred in May/2021 with 7 participants of different scientific backgrounds, such as Management, Architecture, and Technology, from Brazil, Colombia, Cuba, Ecuador, England, Mexico, and Spain. The participants from Europe had experience with Latin American universities.

The asynchronous Focus Group data were clustered and used as a guide for the synchronous Focus Group that occurred on June 29, 2021, hosted on the Google Meet platform. We sent invitations for the same participants from the previous session, but in this phase, all attendees were scholars and practitioners from Colombia and Brazil. Since all were fluent in Spanish, we presented the statements and conducted the session in Spanish. One native Spanish speaker senior researcher helped to run the focus group, and two experts on smart campus acted as moderators. Thus, our total sample was composed of 10 panelists and one secretary (Appendix 2). The procedures followed both O.Nyumba et al. (2018)'s research design and web conference to focus group procedures indicated by Tuttas (2015).

Some qualitative analysis techniques support the focus group data analysis, such as Grounded Theory and Discourse Analysis, but Content and Ethnographic Analysis are more recommended (O.Nyumba et al., 2018). Thus, we chose Content Analysis to provide data interpretation through a systematic classification process of coding and identifying themes or patterns of the phenomenon under study (Hsieh & Shannon, 2005).

We used a deductive approach to code data since it uses pre-existent categories about the phenomenon from theories or models and tests it against the collected data (Graneheim et al., 2017; Seuring & Gold, 2012). According to the smart dimensions of a smart campus, we identified and defined groups of codes that share common characteristics (Graneheim et al., 2017).

To improve data reliability and minimize researcher bias, we invited two fluent Spanish-speaking independent researchers to take notes from the Focus Group synchronous session, which helped to compose the final framework along with the authors' notes. Also, with the participants' permission, we recorded the session. We compared the results of both

synchronous and asynchronous sessions to find consensus and acquire an in-depth understanding that supported the final framework.

4 Results and analysis

4.1 Smart Campus concept

According to the literature review, we proposed a definition for the smart campus: "Smart campus is a higher education ecosystem that uses technology to achieve the tripod of sustainability (environmental, economic, and social) in a governance, collaborative, and adaptive learning model to promote better livability for its stakeholders." The discussions in the asynchronous phase were soft with one comment about the physical space and its formative implications.

In the sequence, we presented our Smart Campus concept in the synchronous Focus Group session. The experts debated if there were differences between a smart campus and a smart university. Some participants defended that the first is related to the environment and physical space, while the second is connected to the overall higher education system. However, the literature considered no difference among the concepts.

The smart university has the same goal as the smart campus since it is an innovative university that implements technologies and new education methods to replace "classical education" with smart education thus improving experiences to its stakeholders (Khamayseh et al., 2015; Rico-Bautista et al., 2020; Zapata-Ros, 2018). Since the term "campus" is usual in the literature, we continued using it.

Another discussion emerged about the ecosystem term inclusion in the smart campus concept. An ecosystem is an aligned structure of a multilateral set of partners that need to interact for a focal value proposition through innovation, cooperation, connection, and interdependency of stakeholders (Adner, 2016; Cohen, 2006; Cohen & Muñoz, 2015; Ritala et al., 2013). Therefore, the participants agreed that a smart campus could be a higher education ecosystem that covers the relationship of all stakeholders, the inner spaces, and the environment.

Other issues emerged demanding grammatical changes in the concept for it to be broader or more specific and, e.g., extend the sustainability and specify technology aspects, such as ICT. Based on the results of both asynchronous and synchronous Focus Groups, we re-wrote the definition: "The Smart Campus is a higher education institution that creates an

ecosystem using Information and Communication Technologies (ICT) to achieve sustainability in a governance, collaborative, and adaptive learning model to promote better livability for its stakeholders".

4.2 Smart Economy

Table 2.2 shows the definition of Smart Economy in the context of Latin American universities that we proposed to the experts in both Focus groups sessions. Also, during the synchronous session, we presented three statements from the literature related to the smart economy. The participants agreed with the statements, and they suggested indicators to verify the level of the smart economy on campus.

Table 2.2. Smart Economy

SMART ECONOMY – PROPOSED DEFINITION
Smart Economy promotes smart, secure, and personalized payment systems and services that focus on improvements to the on-campus economy and drive the local economy and business ideas.
INDICATORS
- **A smart economy supports better commercial services inside a smart campus.** o Requirements and evaluations by international standards (e.g., ISO) o Availability of electronic means for transactions o Availability of services. - **A service-oriented architecture promotes economic sustainability and employability.** o Promotion of commercial ideas o Success in terms of economic benefits, such as the level of innovation and entrepreneurship o Collaborative economy. - **The smart economy improves all economic aspects of the smart campus and its stakeholders.** o Better local and global economy o The levels of impact on local development o Cost optimization, such as student cost o Purchasing capacity.
DEFINITION AFTER THE FOCUS GROUP
Smart Economy promotes personalized, safe, and smart economic services and systems focused on improvements in the university economy to promote collaborative consumption, promotion of business creation, and employability.

Source: Elaborated by the authors.

The first main point debated in the synchronous session was the difference between public and private universities' inner economy. Some participants exposed that since public universities in Latin America often offer free services, they need few or no payment systems. Thus, they defended that the dimension should focus on the technology applicability to move the economy inside the campus, such as promoting employability and collaborative consumption.

We obliterated "payment" and placed "economic systems and services" to adapt the concept to the participants' consensus. In this way, we broadened the concept to any economic

service on-campus, either from university or third parties. Also, we added collaborative consumption or shared economy in our definition to consider this socioeconomic phenomenon, since according to the experts, universities should promote this way of consumption (Table 2.2).

In the end, both scholars and practitioners from the focus group agreed that a smart economy, even in a public university, needs to include electronic transactions. Also, universities should support entrepreneurship and business ideas to promote economic sustainability and employability for local commerce. The literature already proposed personalized friendly-use products and services (Bi et al., 2017; Anirudh et al., 2017; Yang et al., 2018), however, the inclusion of collaborative economy in the dimension of the smart economy is new in the literature.

4.3 Smart Education

The expert group debated the smart education definition and three statements from the literature (Table 2.3). The discussion involved technology enhancement, changes in the educational paradigm, and student-centered methodologies. In the end, a new definition for the smart education dimension emerged after two Focus Group sessions.

Table 2.3. Smart Education

SMART EDUCATION – PROPOSED DEFINITION
Smart Education creates an open, active, and collaborative environment for learning and teaching through smart services and technologies.
INDICATORS
- **Technology enhancement (e.g., Artificial Intelligence and Virtual Reality) and e-learning improve the education on campus.** o Use of Smart Technologies (Cloud Computing, IoT, AI, Big Data ...) for teaching. o IT-supported courses. o The number of free terminals. o Bandwidth and coverage. - **Changes in the education paradigm (e.g., collaborative, adaptive, and open learning; and smart educational services) improves education in a smart campus.** o Accordance with the Ministry of Education regulations. o Accordance with the community needs. - **Student-centered methodologies (e.g., Student Behavior Analysis, Computerized Adaptive Testing, and Student self-assessments) must take place in a smart campus.** o Student and staff satisfaction. o Results-based learning.
DEFINITION AFTER THE FOCUS GROUP
Smart Education provides an active and collaborative education in the university with learning and teaching through smart services and technologies adapted to different pedagogical models.

Source: Elaborated by the authors.

The group disagreed with the term "open" in the definition since Latin American universities adopt restrictions, such as entrance exams. For this, the experts did not consider a smart campus an open environment for the overall public. Thus, we excluded the term from our definition. Also, the group debated the inclusion of pedagogical models in the smart education concept.

The experts concluded that each university has its methods, syllabus, and structure, despite national and international instructions and protocols. Therefore, the results remained composed of a general assumption using the statement "adapted to different pedagogical models". Eight indicators to verify this dimension were extracted from the Focus group, including ways to verify the IT support to education, student and staff satisfaction, and results-based learning (Table 2.3).

Therefore, a smart education in the smart campus is composed of technology-enhanced teaching, adaptive education paradigms, and innovative educational services. Despite the "open" term divergence in the concept, it was agreed that a dynamic learning environment based on the community needs benefits stakeholders.

4.4 Smart Environment

To the Smart environment dimension, we proposed a simple definition focused on the assumption of eco-friendly context and three statements based on the literature (Table 2.4).

Table 2.4. Smart Environment

SMART ENVIRONMENT – PROPOSED DEFINITION
Smart Environment makes a sustainable and eco-friendly campus.
INDICATORS
- **A smart campus is a sustainable and eco-friendly university.** o Consult the ITU (UN) indicators. o Attitudes towards climate change. o Protection of biodiversity and ecology. - **Smart monitoring systems promote intelligent consumption and environmental efficiency in a smart campus.** o Use of bioenergy. o Use of Smart Technologies for energy and water resources management. o Smart buildings. o Optimization of services that lead to the reduction of emissions. - **Traditional solutions (e.g., recycling) must also be prioritized in a smart campus.** o Reduction of air and water pollution. o Biodiversity studies.
DEFINITION AFTER THE FOCUS GROUP
Smart Environment implements environmentally sustainable actions at the university towards sustainable development based on international guidelines and adapted to the local context.

Source: Elaborated by the authors.

The participants considered the definition as limited and narrow. After discussions, they indicated to extend and direct it to higher education institutions. The main points focused on sustainability and the differences between a sustainable and an ecologic campus. Thus, to attend the group consensus, we addressed the concept towards sustainability and ecology on campus through "environmentally sustainable actions".

The participants also debated the use of sustainability index in the smart campus to be adapted to its surroundings, as well as to each territory and culture. They concluded that international standards could guide and measure environmental practices on campus, such as the Green Metric Report. Therefore, based on the analysis, we proposed that ecological actions in the university should be towards sustainable development guided by international guidelines but adapted to the local context. Also, the content analysis of the Focus Group discussions indicated seven indicators to monitor the level of smartization in the Smart Environmental dimension at Latin American universities. For instance, social action to preserve the environment, biodiversity studies, and technologies to optimize resources.

Thus, the smart environment relates to smart technologies, biodiversity, SDGs, and other sustainability practices, such as recycling. Innovative solutions promote environmentally sustainable actions to improve the university's environmental efficiency towards sustainable development based on international guidelines.

4.5 Smart Living

The literature review supported our definition and three statements related to the quality of life, livability, health support, and student development (Table 2.5).

Table 2.5. Smart Living

SMART LIVING – PROPOSED DEFINITION
Smart Living provides better livability on campus through encouragement and support of health, student development, and smart living services.
INDICATORS

- **A smart campus promotes a better quality of life for its stakeholders through health and welfare support.**
  o Levels of quality of life and well-being.
  o Occupational Health and Wellness Programs.
- **Poverty-stricken students and people with special needs must be supported by a smart campus.**
  o Levels of social inclusion.
- **The educational lifestyle of a smart campus must promote a multi-cultural and diverse environment.**
  o Livability levels.
  o Extracurricular activities for the community.
  o Additional livability services, such as leisure spaces.
  o Habitability allowances.

DEFINITION AFTER THE FOCUS GROUP
Smart Living provides better livability in the university through smart actions and services to support the stakeholders' well-being and development.

Source: Elaborated by the authors.

The participants discussed how the smart campus could support health and how the resources efficiency impacts the stakeholder's health. They also questioned smart living services in a smart campus and concluded it is “livability”. Thus, the definition changed. “Well-being” replaced health and, “smart living services” were replaced by "smart actions and services".

Therefore, Quality of Life is the guide for Smart Living to support health and welfare. Scholars highlighted the need for services towards people with disabilities and poverty-stricken students, while practitioners added the need to measure the level of social inclusion. Leisure and free time were considered a vital matter to improve livability on campus, as well as the building of a multi-cultural and diverse environment in universities. Our results pointed to seven indicators to this dimension related to wellness programs, social inclusion, extracurricular activities, leisure spaces, and livability.

4.6 Smart Management

We proposed a smart management dimension supported by a management model based on transparency, inclusion, and efficiency (Table 2.6). In the synchronous session, we presented three statements and the participants referred to new management models, open governance, active participation of the stakeholders, and constant evolution.

Table 2.6. Smart Management

SMART MANAGEMENT – PROPOSED DEFINITION
Smart Management creates an inclusive, transparent, and open environment and a campus management model with the active participation of stakeholders and focused on the efficient use of resources.
INDICATORS

- **A smart campus needs management with active stakeholder participation.**
  o Efficient and sustainable use of resources.
  o Result reports.
  o Dynamic management.
- **Transparency and governance are the foundation for strategic planning and administration of a smart campus.**
  o Strategic projects supported by ICT.
- **Managerial processes must use Information Systems to become paperless and faster in a smart campus.**
  o ICT Infrastructure Projects.
  o Data management platforms.
  o Open data.
  o Digital twins.

DEFINITION AFTER THE FOCUS GROUP
Smart Management creates an inclusive, transparent, and open management in the university through a model with the active participation of stakeholders, continuous improvement, and focused on the efficient use of resources.

Source: Elaborated by the authors.

The participants also indicated ICT improvements and audit processes to be part of the university management. Thus, we added “continuous improvement” to the definition. We extracted eight indicators to smart management regarding the efficient use of resources, openness, data management, dynamism, and management tools based on technology.

Thus, smart management needs the active participation of stakeholders to build a governance-based administration. Besides that, actions related to sustainability, transparency, and process efficiency are driven by smart technologies and information systems, which were agreed upon between both scholars and practitioners.

4.7 Smart Mobility

Smart mobility's proposed definition and statements included technologies, systems, and services to promote better mobility on campus through improvements in comfort, efficiency, and sustainability (Table 2.7).

Table 2.7. Smart Mobility

SMART MOBILITY – PROPOSED DEFINITION
Smart Mobility combines technologies to make mobility more comfortable, efficient, and sustainable on campus.
INDICATORS

- **Location-based services and systems modernize smart campus mobility.**
  o Number and style of trips.
  o Increased use of low-carbon vehicles.
- **New technologies and the internet are necessary to provide smart mobility services (e.g., smart signaling, traffic, and parking).**
  o Use of travel time.
  o Circulation routes vs programmed stays.
- **Connected smart services improve mobility for users and planners.**
  o Bicycle Availability.
  o Chargers for electric cars.
  o Incentives for collaborative transportation.
  o Efficiency and quality of transport.

DEFINITION AFTER THE FOCUS GROUP
Smart Mobility implements actions and technologies to make mobility more comfortable, efficient, and sustainable on and off-campus.

Source: Elaborated by the authors.

The participants discussed that one of the main problems for mobility was out of the university limits, referring to the city. Latin American cities often have deficient public transportation services. Also, they highlighted stakeholders often lose time on traffic, mainly in big cities, to access their universities. One participant added that people could take two hours to get to education centers, sometimes they needed more than one type of transport or spend more than 20 minutes finding a parking spot next to the university.

The group concluded that each university should implement smart mobility actions according to its context. For instance, one participant cited a university in Colombia placed on top of a mountain with many stairs, which makes bike usage not adequate. The analysis showed us that the concept needed more than technologies to accomplish mobility. Thus, we included "actions" in the definition. As noted before, mobility goes beyond the campus limits. Thereby we added "on and off-campus" in the concept. Finally, the analysis showed eight indicators towards eco-efficiency and quality of transport and innovation.

Thus, smart mobility is mainly based upon accessibility, efficiency, comfort, and sustainability through connected location-based services and systems. Practitioners also highlighted that universities should seek partnerships with the city to promote better access to the university, such as exclusive lanes and buses. Despite technology enhancement, smart mobility needs “offline” actions and to adopt initiatives to the university's local context.

4.8 Smart Security

A smart security definition and statements were based on the literature mainly concerned with physical and virtual safety, technology systems, and disaster prevention and management (Table 2.8). The participants questioned and discussed what a safe campus is. They considered that security is more than leaving criminals out of campus. They agreed smart security needs to promote safety on and off-campus, not building "little paradises inside the universities’ walls” to protect against external threats and violence.

Table 2.8. Smart Security

SMART SECURITY – PROPOSED DEFINITION
Smart Security protects people in both physical and virtual contexts on campus.
INDICATORS

- **Technology systems (e.g., face recognition systems and smart locks) improve security in a smart campus.**
  o Community Safety.
  o Levels of criminal cases prosecuted.
- **A cybersecurity system is necessary for a smart campus to prevent hacker attacks.**
  o Online information security.
  o The number of cyber-attacks.
  o Security levels on technology platforms.
- **Connected services and technologies improve disaster management and prevention in a smart campus.**
  o IT Risk Management and Mitigation.
  o Quick response to threats.

DEFINITION AFTER THE FOCUS GROUP
Smart Security promotes physical, virtual, technological, and biosafety protection to people on campus.

Source: Elaborated by the authors.

The content analysis presented those smart campuses should promote social development inside and outside the university. Also, participants highlighted security goes beyond physical protection and integrity. They emphasized other safety aspects, such as technological, virtual, and biosafety, as necessary; thus, we added to the concept. Results designated seven indicators to monitor this dimension related to using IT to manage and reduce many risks.

Therefore, it was agreed between both scholars and practitioners that universities should promote beyond physical and material safety. Cybersecurity was highlighted as necessary in a technology-centered environment, as well as biosafety procedures are needed in a post-pandemic reality. Other aspects were noted, such as actions towards disaster prevention and management, and support to off-campus security.

4.9 Smart Technology

We identified Smart Technology as a transversal dimension since it is necessary for all dimensions to build the smart campus. The experts debated the transversality considering how to get a level of technology in the smart dimensions and discussed three statements presented (Table 2.9). The participants highlighted the speed of technology innovations. Thus, they suggested the Smart technology should not focus on a specific technology.

Table 2.9. Smart Technology

SMART TECHNOLOGY – PROPOSED DEFINITION
Smart Technology is a transversal dimension that connects and supports all others to build a Smart Campus.
INDICATORS
- Internet technologies (e.g., IoT, ITC, 5G) are necessary to build a smart campus. - Data management and interconnection optimize the processes of a smart campus. - A smart campus must have physical systems (e.g., sensors, devices, actuators, and terminals) to provide a seamless interconnection.
DEFINITION AFTER THE FOCUS GROUP
Smart Technology is a transversal dimension that connects and supports all others with technological innovations that build a Smart Campus.

Source: Elaborated by the authors.

Also, the experts debated how universities could implement technology innovations in their context, for instance, in public and private universities or rural and urban contexts. To respond to the participants' demands we added "technological innovations" in the definition, to

neither relate to a specific technology nor context. From the experts' comments, we designated four indicators to monitor this dimension related to using IT to manage and reduce many risks.

Thus, smart technology is a transversal component that is present in all others. It is composed of a broad technology system architecture to interconnect and support massive data processes and management. It does not focus on a specific technology but comprehends technological innovations that adapt according to the university dimensions.

4.10 Smart Campus model: Validated indicators

Our results presented a Smart Campus with eight smart dimensions namely economy, education, environment, living, management, mobility, security, and technology, which is a transversal dimension in the others. The findings synthesized indicators and variables to monitor the smartization process on the campus (Table 2.10).

Table 2.10. Smart Campus indicators

DIMENSION	INDICATORS	VARIABLE
Smart Economy	On my campus, it is possible to do electronic transactions, such as to pay university fees or to do payments in stores.	Electronic services
	My Campus supports business ideas through entrepreneurship centers, innovation centers, entrepreneurs incubators, specialized centers, etc.	Entrepreneur and innovation support
	My campus has collaborative economy networks or actions of shared economy	Collaborative Economy
	My campus supports local economic development with projects and actions toward the community	Local development
	My campus has a department or sector to support employability.	Employability
Smart Education	My campus uses Smart Technologies for teaching, for example, Cloud Computing, IoT, IA, Big Data, etc.	Smart Education Technologies
	My campus has open and available internet bandwidth for all.	Internet access
	My campus consults the community about its educational needs (e.g., courses availability).	Community needs awareness
	My campus monitors the satisfaction level of students and staff.	Satisfaction
	On my campus, the teaching methodology is Results-based learning.	Results-based learning
Smart Environment	My campus develops actions towards the Sustainable Development Goals (SDGs).	SDGs
	On my campus, there are actions to protect the local biodiversity.	Biodiversity
	My campus uses bioenergy and Smart Technologies to manage energy and water resources, such as automatized lighting.	Eco-friendly resources
	My campus has smart buildings, e.g., buildings with automatized management of resources	Smart Buildings
	My campus recycles residues.	Recycling
Smart Living	On my campus, there is quality of life and well-being monitoring.	Quality of Life
	My campus implements occupational health and wellness programs.	Health
	My campus measures the level of social inclusion among students.	Social Inclusion
	My campus has adequate leisure spaces.	Leisure
	On my campus, there are extracurricular activities for the community.	Extracurricular activities

Smart Management	My campus has management focused on the sustainable use of resources.	Sustainable management
	My campus publishes the accountability annually	Transparency
	My campus performs participatory strategic planning.	Participation
	My campus has an online process management platform.	Process efficiency
Smart Mobility	There is adequate public transport to access my campus.	Accessibility
	There is traffic signaling on campus.	Signaling
	My campus encourages or uses low-carbon transport.	Sustainable transport
	My campus encourages collaborative transport, such as rides.	Collaborative economy
	My campus has support facilities for bikes.	Eco-friendly transport
Smart Security	My campus ensures physical and material security.	Security
	My campus has biosafety protocols.	Biosecurity
	My campus has technological systems to support security (e.g., facial recognition system).	Smart Technologies
	My campus has protection from cyber-attacks.	Cybersecurity
	My campus has protocols for the prevention and management of risks and disasters	Disaster prevention
Smart Technology	My campus uses internet technologies, such as the Internet of Things.	Internet technologies
	My campus has systems for data management and interconnection.	Data management
	My campus has technological control systems, such as sensors.	Information Systems
	My campus has systems (e.g., webpage) to offer and manage services to its stakeholders.	Internet Technologies

Source: Elaborated by the authors.

5 Conclusions

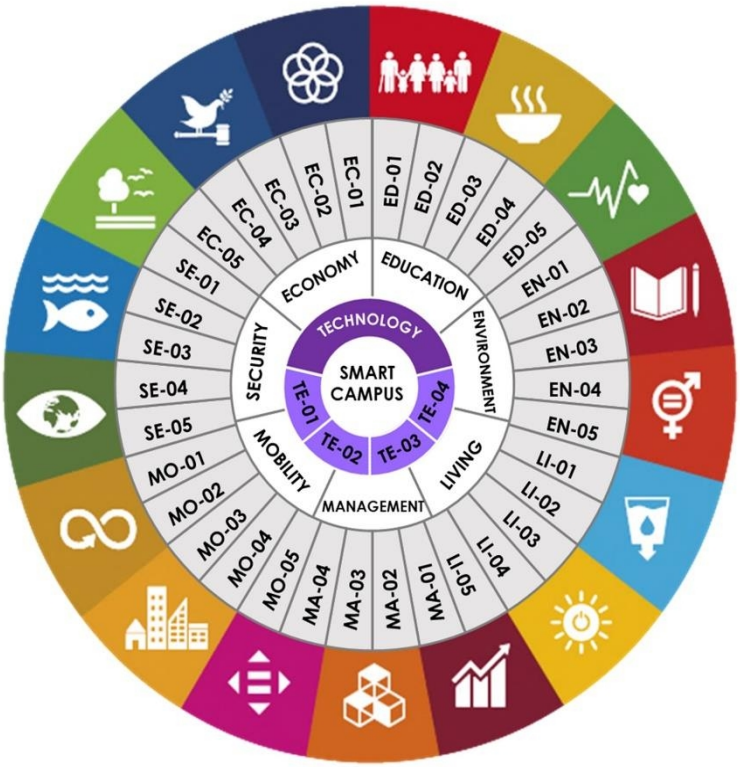
This study aimed to formulate and validate a Smart Campus model with indicators to monitor the smartization process in the Latin American Context through a qualitative approach mainly based on a focus group. We proposed definitions for the smart campus and its dimensions, as well as variables and indicators that were evaluated by experts from Latin America. The smart campus does not have a unified concept, dimensions, or characteristics in the literature (Chiu et al., 2020; Min-Allah & Alrashed, 2020; Prandi et al., 2020).

Our research provided three groups of findings. First, we developed an integrative concept according to the literature and experts' evaluation. A smart campus is a higher education institution that creates an ecosystem using Information and Communication Technologies (ICT) to achieve sustainability using a governance-based, collaborative, and adaptive learning model to promote better livability for its stakeholders.

Second, we validated with experts a model (Figure 2.3) with dimensions and variables to express the smartization process to universities. Although many authors already proposed indicators, to the best of our knowledge, there was not an integrative model associated with

SGDs. Thus, both findings contributed to consolidating the smart campus approaches according to the SGDs' perspective.

Figure 2.3. Smart Campus Framework



DIMENSION	CODE	VARIABLE
Smart Economy	EC-01	Electronic services
	EC-02	Entrepreneur and innovation support
	EC-03	Collaborative Economy
	EC-04	Local development
	EC-05	Employability
Smart Education	ED-01	Smart Education Technologies
	ED-02	Internet access
	ED-03	Community needs awareness
	ED-04	Satisfaction
	ED-05	Results-based learning
Smart Environment	EN-01	SDGs
	EN-02	Biodiversity
	EN-03	Eco-friendly resources
	EN-04	Smart Buildings
	EN-05	Recycling
Smart Living	LI-01	Quality of Life
	LI-02	Health
	LI-03	Social Inclusion
	LI-04	Leisure
	LI-05	Extracurricular activities
Smart Management	MA-01	Sustainable management
	MA-02	Transparency
	MA-03	Participation
	MA-04	Process efficiency
Smart Mobility	MO-01	Accessibility
	MO-02	Signaling
	MO-03	Sustainable transport
	MO-04	Collaborative economy
	MO-05	Eco-friendly transport
Smart Security	SE-01	Security
	SE02	Biosecurity
	SE-03	Smart Technologies
	SE-04	Cybersecurity
	SE-05	Disaster prevention
Smart Technology	TE-01	Internet technologies
	TE-02	Data management
	TE-03	Information Systems
	TE-04	Internet Technologies

Source: Elaborated by the authors.

Finally, the third finding is a managerial implication. Since we provided indicators to each variable of smart dimensions, the model can become a tool to manage the university's evolution towards a smart campus. That is, the final model helps the academic manager to monitor the smartization process. It is a tool to support decision-makers, prioritize actions, and optimize resources.

Our research indicated that a smart campus must be connected inside and outside its walls. The experts' discussions mainly concerned sustainability, technology, and social issues that smart campuses need to address. It is necessary to implement open and collaborative actions towards management, partnerships with the city government, protect the environment, and promote well-being and safety for stakeholders.

Thus, we could identify differences between the previous literature perspectives and our results from a Latin American perspective.

Our concept and model have broader connections with the community and city, leading to partnerships with stakeholders to achieve the smart campus goals. The Latin American perspective of the Smart campus follows a similar structure of a smart city (Fraga-Lamas et al., 2019; Torres-Sospedra et al., 2015). However, it focuses on sustainability, governance, collaborative systems and adaptive learning models. From the Latin American Perspective, technology is the way, not the end itself. It is the way to promote better livability for its stakeholders. In resume, the core concept in the Smart city Latin American perspective is livability.

Although the model is helpful in any context, our findings provided a Latin American point of view. The novelty found here relates to how the social and economic regional level can change the idea of a smart context. Most studies on Smart Campus analyzed developed countries. Thus, they usually focus more on technologies and sustainability than other dimensions. Smart campuses in developing countries may prioritize other components, such as infrastructure, mobility, and education improvements.

The number of participants has limited this study. However, we minimized this limitation following the Focus group technique; that is, there was a range of participants, representatives from different areas, Latin American countries, and diversity of roles inside the campuses. We indicate further studies to apply the model in a sample of universities using quantitative methods to provide another validation and, at the same time, to define the weights to the dimensions and variables.

References

Observation: The reference list is at the end of the document.

CHAPTER 3

PRIORITIZING DECISION-MAKING: INDICATORS TO THE SMARTIZATION PROCESS OF UNIVERSITIES

PRIORITIZING DECISION-MAKING: INDICATORS TO THE SMARTIZATION PROCESS OF UNIVERSITIES

Pedro Ivo Silva-da-Nóbrega
Postgraduate Program of Management
Federal University of Campina Grande, Brazil

Adriana Fumi Chim Miki
Federal University of Campina Grande, Brazil

Marysol Castillo Palacio
Pontífica Universidad Javeriana – Cali, Colombia

Abstract

Universities first emerged in medieval times and through the centuries they have changed personal and national realities through education and critical thinking. Technology improvements accelerated the digital transition of universities which built a path for smart campuses. Although, the smartization process is more than just promoting digitalization procedures. This research aims to identify the essential elements and the most significant deficiencies in the Smart Campus dimensions and its variables from the user viewpoint to offer a list of priorities to decision-makers. Through an Importance-Performance Analysis performed in both Microsoft Excel and IBP SPSS 26, we tested, in a Brazilian university, an integrative smart campus framework previously validated with Latin American Experts. Our results confirmed eight dimensions are important for a smart campus evaluation and provided a list of priorities to academic managers. The method indicated the main gaps among Importance-Performance. We concluded that the smartization process could not rely on technology attributes only. Universities should meet the present and emerging needs of modern society and the labor market in a sustainable, social and technological manner.

Keywords: Smart Campus Indicators. Importance Performance Analysis. Higher Education. Decision-making.

1 Introduction

For many centuries, universities have changed individual and national realities through education and critical thinking. Indeed, since scholasticism in medieval European monasteries, universities became a significant component of societal change, sustainability, and digital transitions (De Vaujany, Walsh, & Mitev, 2011; Melé, 2016). It has a crucial role in recent matters, such as fighting the COVID-19 pandemic through partnerships and support of governments and civil society (Arrais, Corcioli, & Medina, 2021).

Change and freedom highlight the history of universities with diverse roles to make the institution always fresh and aware of novelties both in national and global contexts. Technology

is a fundamental tool in replacing classical education with smart education led by industry 4.0, technical innovations, and socioeconomic challenges (Elsakova et al., 2019; Tikhonova, 2019). In this way, universities are towards the smartization process, that is, to become smart campuses.

The smartization process of universities aims to change the current framework to evolve an open university concept, adapt the management model, infrastructures, and relationships with the community, public and private sectors towards a common goal: sustainability and quality of life (Rico-Bautista, Maestre-Góngora & Guerrero 2020).

Smart campuses use Information and Communication Technologies (ICT) to interact with stakeholders to create an ecosystem that integrates physical and digital spaces. It establishes responsive, intelligent, and improved services to create a productive, creative, and sustainable environment (Min-Allah & Alrashed, 2020; Villegas-Ch, Arias-Navarrete, et al., 2020).

Open and integrative participation of stakeholders is part of the Smart Campus' primary purpose to achieve sustainability and quality of life. Therefore, it is necessary to assess how university stakeholders evaluate the importance and performance of the Smart Campus dimensions and its variables. Studies from the user's viewpoint can provide a map to academic managers to optimize the smartization process and improve the users' satisfaction level. Thus, this study contributes with an educational management tool, a list of prioritization items to decision-makers.

The Smart Campus concept, dimensions, and indicators are recent approaches, and the prioritization order of its elements varies according to the cultural, social, and economic context. Thus, our research question is: "What should be the decision-making priorities in the Smartization process of a Brazilian university?"

This research aims to identify the essential elements and the most significant deficiencies in the Smart Campus dimensions and its variables from the user point of view to offer a list of priorities to decision-makers. We used a quantitative descriptive-exploratory approach through an Importance-Performance Analysis (IPA) to accomplish our goal with a sample of students from the Federal University of Campina Grande, located at the Paraiba State in Brazil. After this introduction, the study follows a section of Literature Review presenting a background of university history and smart campus. Then, we indicate the methodology, results, and conclusions.

2 Literature Review

In the western world, universities emerged in European Christian monasteries by the 11th century. They became one of the oldest institutions of the western world, with an academic structure composed of theology, arts, law, and medicine (De Vaujany et al., 2011; Scholz, 2020). In the first universities, the teaching followed the scholasticism, a scientific practice or method based on the rigorous conception of different positions through the analysis and presentation of authorized texts in a phase of *Lectio*, followed by a step of debates, namely *disputatio* (Beck, 2016; De Vaujany et al., 2011; Melé, 2016).

Universities remained under the responsibility of the Christian church for centuries (De Vaujany et al., 2011). Although, the Protestant Reform and its political and cultural changes in the 16th century affected the university curricula, systems, and frameworks (Kintzinger, 2017). To spread the Reformed faith, new higher education institutions were founded throughout Europe, mainly supported by Lutherans and sovereigns that made universities a territorial state and a confessional formation (Kintzinger, 2017; Te Velde, 2016).

The university conception remained the same until the French Revolution, which also marked the decline of universities and the appearance of vocational schools, such as the *École Polytechnique*, with a focus on engineering (De Vaujany et al., 2011; Scholz, 2020). While in Germany, a new type of university introduced teaching and research as the inseparable core responsibilities of professors, committed to a humanistic education that became the classic university of the 19th and 20th centuries (Kintzinger, 2017; Scholz, 2020).

The development of universities continued to follow state and political directives, structuring new pedagogical landscapes, and founding new kinds of universities, such as the technical university, focused on business and commerce in France and later in the United States (De Vaujany et al., 2011; Kintzinger, 2017; Scholz, 2020). World War I also changed universities, introducing new courses, alterations of subjects, and ways of research, including the curtailing of academic freedom by soviets and destructive ideology by the Nazi Party (Scholz, 2020).

After World War II, universities increased the applied sciences and interdisciplinarity, such as Game Theory and operational research, but were also marked by student movements (Scholz, 2020). Those movements paved the way to build a contemporary university that focuses on methods, research paradigms, disciplines, institutions, and epistemologies. New universities are transdisciplinary with an active role in society (Scholz, 2020).

2.1 Latin American Universities

The first Latin American universities appeared in the 16th century with the Spanish colonization as a copy of the medieval model subordinated to the Crown and the Church (Arocena & Sutz, 2005). After the independence of Hispano-American countries, a new kind of university emerged: the republican university, inspired by the Napoleonic model that was connected with professional schools (Arocena & Sutz, 2005; J. G. Mora, Serra, & Vieira, 2018).

Those Latin American universities had the same structure and aimed at an intellectual elite and classical studies until the beginning of the 20th century when the University Reform Movement or Cordoba Reform took place in 1918 (Arnove, 1967; Arocena & Sutz, 2005; Baptista, Vasen, & Soto, 2019; J. G. Mora et al., 2018). The University Reform started as a student protest against the old universities' regime controlled by traditional oligarchies in Córdoba University in Argentina. This thinking quickly spread throughout Latin America and became one of the most important social movements of the continent (Arnove, 1967; Arocena & Sutz, 2005; J. G. Mora et al., 2018).

The Cordoba Reform also became the starting point for Latin America to mark the history of universities with its original contribution (Arocena & Sutz, 2005). The movement had broad goals related to political, cultural, economic, and social demands. However, the most relevant point was democratizing universities through autonomy, co-governance, and outreach or extension (Arocena & Sutz, 2005; Baptista et al., 2019; J. G. Mora et al., 2018).

The social engagement brought by the Reform changed the ethos of Latin American universities by the inclusion of outreach as the third mission of universities along with teaching and research (Arocena & Sutz, 2005; J. G. Mora et al., 2018). Currently, the Latin American universities profile includes autonomy, i.e., independence from state and church, and co-governance regarding the inclusion of professors, students, and alumni in the institution government. Also, it has outreach activities towards the community or disadvantaged sectors of society through technical assistance and projects, which is the most prominent characteristic of public Latin American universities (Arocena & Sutz, 2005; Baptista et al., 2019).

With a different history from its neighboring countries, Brazilian universities only emerged in the early 1920s (Arocena & Sutz, 2005; de Nez, 2018). Although, the movements claiming for the democratization of society from the Cordoba Reform and later on with the students' protests against the military dictatorship also marked the history of universities in the country (Arocena & Sutz, 2005; de Nez, 2018). Those social movements mainly contributed to the legal bounding of the integration and inseparability of teaching, research, and outreach as

the mission of universities, consecrated by the Brazilian Constitution of 1988 (Arocena & Sutz, 2005; de Nez, 2018).

2.2 Smart Campus

The digital transition of universities accelerated in 2020, due to the COVID-19 pandemic and restrictions, through Information and Communication Technologies (ICT), digital management, and distance teaching (Ramírez-Montoya, 2020). Along with technology, the future university needs to sustainably attend to its stakeholders' needs and promote better livability and quality of life, which is the main goal of smart campuses (Clark II & Eisenberg, 2008; Coccoli, Maresca, & Stanganelli, 2017; Durán-Sánchez, Álvarez-García, Del Río-Rama, & Sarango-Lalangui, 2018).

Starting in 2000 (Kaneko, Sugino, Suzuki, & Ishijima, 2000), the smart campus concept is still at the exploratory stage, with no common agreement for definition, dimensions, or characteristics (Chiu et al., 2020; Min-Allah & Alrashed, 2020; Prandi et al., 2020). However, three different perspectives conceptualize smart campus based on a (1) technology-driven approach, (2) organizational process-driven approach, and (3) smart city driven approach (Gilman et al., 2020; Muhamad et al., 2017; Prandi et al., 2020).

Technology is the driver of smart campuses, mainly through the Internet of Things (IoT) and Information Communication Technologies (ITC) to enhance the informatization level in colleges and universities (Alonso & Donsión, 2016; Celdran et al., 2020; Luo, 2018; Rico-Bautista, Maestre-Góngora, & Guerrero, 2020; Rico-Bautista et al., 2020a; Tian et al., 2018; Xu et al., 2019; Xu, Wang, & Yu, 2018). The wide range of technologies support and digitalize processes, teaching, research, and services to improve the university's efficiency in a rapid, intelligent, and harmonious manner (T. Bi, Yang, & Ren, 2017; Celdran et al., 2020; Fernandez-Carames & Fraga-Lamas, 2019; Sanchez-Torres et al., 2018; Yange et al., 2016).

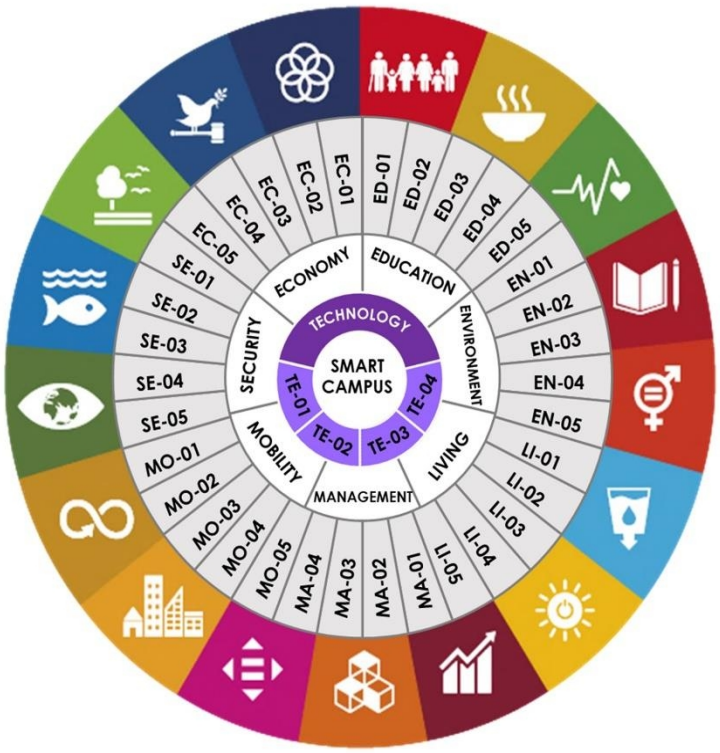
The Organizational process perspective focuses on replacing old manual services with smart ones to optimize processes through information sharing mechanisms (Khamayseh et al., 2015; G. Guo, 2018; Nan et al., 2018). The management should also provide personalized guidance and assistance for specific tasks based on the users' requirements to achieve the smart management and service on campus (Caballero et al., 2014; Soldatos et al., 2014; Yang et al., 2018).

The smart city promotes the integration of social, economic, and environmental awareness into a well-performing city, mainly based on smart dimensions (economy, people,

governance, mobility, environment, and living) to optimize the citizens quality of life through cutting-edge technologies, such as ICT and IoT (Caragliu et al., 2011; Giffinger et al., 2007; Silva-Da-Nóbrega & Chim-Miki, 2021). The smart campus is part of smart city movements that use technologies and sustainability to improve universities as an advanced pattern of digital and sustainable universities (Janssen & Prasetiyowati, 2018). Thus, they share a similar structure and smart campuses may be used as a small-scale city for smart city projects (Alvarez-Campana et al., 2017; Fortes et al., 2019; Ramos, Trilles, Torres-Sospedra, & Perales, 2018; Ren, Zhang, & Duan, 2018; Vasileva et al., 2018).

Despite the various analytical perspectives, according to our definition, a smart campus is a higher education institution that creates an ecosystem using Information and Communication Technologies (ICT) to achieve sustainability using a governance-based, collaborative, and adaptive learning model to promote better livability for its stakeholders. Also, we proposed a smart campus model with dimensions connected to the Sustainable Development Goals, namely economy, education, environment, living, management, mobility, security, and technology, which is a transversal one, i.e., present in all dimensions (Figure 3.1).

Figure 3.1. Smart Campus framework



DIMENSION	CODE	VARIABLE
Smart Economy	EC-01	Electronic services
	EC-02	Entrepreneur and innovation support
	EC-03	Collaborative Economy
	EC-04	Local development
	EC-05	Employability
Smart Education	ED-01	Smart Education Technologies
	ED-02	Internet access
	ED-03	Community needs awareness
	ED-04	Satisfaction
	ED-05	Results-based learning
Smart Environment	EN-01	SDGs
	EN-02	Biodiversity
	EN-03	Eco-friendly resources
	EN-04	Smart Buildings
	EN-05	Recycling
Smart Living	LI-01	Quality of Life
	LI-02	Health
	LI-03	Social Inclusion
	LI-04	Leisure
	LI-05	Extracurricular activities
Smart Management	MA-01	Sustainable management
	MA-02	Transparency
	MA-03	Participation
	MA-04	Process efficiency
Smart Mobility	MO-01	Accessibility
	MO-02	Signaling
	MO-03	Sustainable transport
	MO-04	Collaborative economy
	MO-05	Eco-friendly transport
Smart Security	SE-01	Security
	SE02	Biosecurity
	SE-03	Smart Technologies
	SE-04	Cybersecurity
	SE-05	Disaster prevention
Smart Technology	TE-01	Internet technologies
	TE-02	Data management
	TE-03	Information Systems
	TE-04	Internet Technologies

Source: Elaborated by the authors.

3 Methodology

The goal of this study is to identify the essential elements and the most significant deficiencies in the Smart Campus dimensions and its variables from the user point of view to offer a list of priorities to decision-makers. We conducted a quantitative descriptive-exploratory approach through an Importance-Performance Analysis (IPA) based on the Smart Campus framework previously validated.

The IPA technique was proposed by Martilla & James (1977) to develop more effective marketing feedback from consumers and help decision-makers to better manage resources and strategies through the service/product performance and importance. Thus, it aims to diagnose the performance of attributes and promotes management actions to prioritize the optimal allocation of resources and improve customer satisfaction (Sever, 2015).

Currently, it is employed in research in other areas, such as Smart Cities (Silva-da-Nóbrega & Chim-Miki, 2021), tourism (Boley, McGehee, & Tom Hammett, 2017), service satisfaction (H. Chen, Weiler, Young, & Lee, 2016), and satisfaction in higher education (McLeay, Robson, & Yusoff, 2017).

3.1 Data collection

Although the case choice was intentional and by accessibility, we established some criteria: i) The university should gather standard Brazilian Universities' characteristics, i.e., to be a public institution with different undergraduate and graduate programs; ii) The university should have some smart campus project or intention to start; iii) The university should have some recognition at the national level.

Thus, we chose the Federal University of Campina Grande (UFCG) located in the northeast of Brazil that has approximately 20,000 students, 124 programs of degree (undergraduate, master, and Ph.D.), 1500 professors, and 1400 employees (Federal University of Campina Grande, 2021b). Besides, UFCG has seven campuses, and recently it created the Smart Campus Project on its main campus. Also, in 2020, UFCG was highlighted by the national media for it led the National Ranking of Resident Depositors of Invention Patents, released by the National Institute of Industrial Property (Federal University of Campina Grande, 2021a; Madeiro, 2021).

Data collection was in November 2021 through an online survey hosted in Google Forms sent to UFCG students. The university has 20,427 students (Federal University of Campina Grande, 2021b), thus considering a random sample with a 95% confidence level and 5% error, the sample should be 378 respondents. The questions are from a previous framework that was pre-validated by a Latin American expert's panel. The validation occurred through online focus group sessions composed of 10 participants from different scientific backgrounds, such as Management, Architecture, and Technology, from Brazil, Colombia, Cuba, Ecuador, England, Mexico, and Spain.

The IPA results rely on the attributes' perception, so it is crucial to appropriately select each indicator and use the same set in both importance and performance. For this reason, we used a framework previously validated by international experts of smart campus (Table 3.1).

Table 3.1. Smart Campus indicators

DIMENSION	INDICATORS	VARIABLE
Smart Economy (EC)	On my campus, it is possible to do electronic transactions, such as to pay university fees or to do payments in stores.	Electronic services
	My Campus supports business ideas through entrepreneurship centers, innovation centers, entrepreneurs incubators, specialized centers, etc.	Entrepreneur and innovation support
	My campus has collaborative economy networks or actions of shared economy	Collaborative Economy
	My campus supports local economic development with projects and actions toward the community	Local development
	My campus has a department or sector to support employability.	Employability
Smart Education (ED)	My campus uses Smart Technologies for teaching, for example, Cloud Computing, IoT, IA, Big Data, etc.	Smart Education Technologies
	My campus has open and available internet bandwidth for all.	Internet access
	My campus consults the community about its educational needs (e.g., courses availability).	Community needs awareness
	My campus monitors the satisfaction level of students and staff.	Satisfaction
	On my campus, the teaching methodology is Results-based learning.	Results-based learning
Smart Environment (EN)	My campus develops actions towards the Sustainable Development Goals (SDGs).	SDGs
	On my campus, there are actions to protect the local biodiversity.	Biodiversity
	My campus uses bioenergy and Smart Technologies to manage energy and water resources, such as automatized lighting.	Eco-friendly resources
	My campus has smart buildings, e.g., buildings with automatized management of resources	Smart Buildings
	My campus recycles residues.	Recycling
Smart Living (LI)	On my campus, there is quality of life and well-being monitoring.	Quality of Life
	My campus implements occupational health and wellness programs.	Health
	My campus measures the level of social inclusion among students.	Social Inclusion
	My campus has adequate leisure spaces.	Leisure
	On my campus, there are extracurricular activities for the community.	Extracurricular activities
Smart Management (MA)	My campus has management focused on the sustainable use of resources.	Sustainable management
	My campus publishes the accountability annually	Transparency
	My campus performs participatory strategic planning.	Participation
	My campus has an online process management platform.	Process efficiency

Smart Mobility (MO)	There is adequate public transport to access my campus.	Accessibility
	There is traffic signaling on campus.	Signaling
	My campus encourages or uses low-carbon transport.	Sustainable transport
	My campus encourages collaborative transport, such as rides.	Collaborative economy
	My campus has support facilities for bikes.	Eco-friendly transport
Smart Security (SE)	My campus ensures physical and material security.	Security
	My campus has biosafety protocols.	Biosecurity
	My campus has technological systems to support security (e.g., facial recognition system).	Smart Technologies
	My campus has protection from cyber-attacks.	Cybersecurity
	My campus has protocols for the prevention and management of risks and disasters	Disaster prevention
Smart Technology (TE)	My campus uses internet technologies, such as the Internet of Things.	Internet technologies
	My campus has systems for data management and interconnection.	Data management
	My campus has technological control systems, such as sensors.	Information Systems
	My campus has systems (e.g., webpage) to offer and manage services to its stakeholders.	Internet Technologies

Note: SD – Standard Deviation; I-P: Importance - Performance
Source: Elaborated by the authors.

We conducted a content validity test with Brazilian undergraduate and graduate students and Smart Campus professors to improve the questions' reliability. We requested them to evaluate and suggest improvements related to each item's clarity and adequacy. We analyzed and changed to queries according to all suggestions. Also, a pilot test was conducted in October 2021 with UFCG's undergraduate and graduate students.

The questionnaire link was promoted through emails to academic secretaries and professors, as well as social networks, namely Instagram, Facebook, WhatsApp, and Telegram, to reach a broader range of students. However, to ensure that only UFCG's students would answer the survey, we included a filter question, asking the respondent which connection they had with the university. They had three options: (1) undergraduate student, (2) graduate student, or (3) no connection with the university. The questionnaire opened only if the student answered the first and second options. Also, we assured anonymity in completing the questionnaire since no email or identification data was collected.

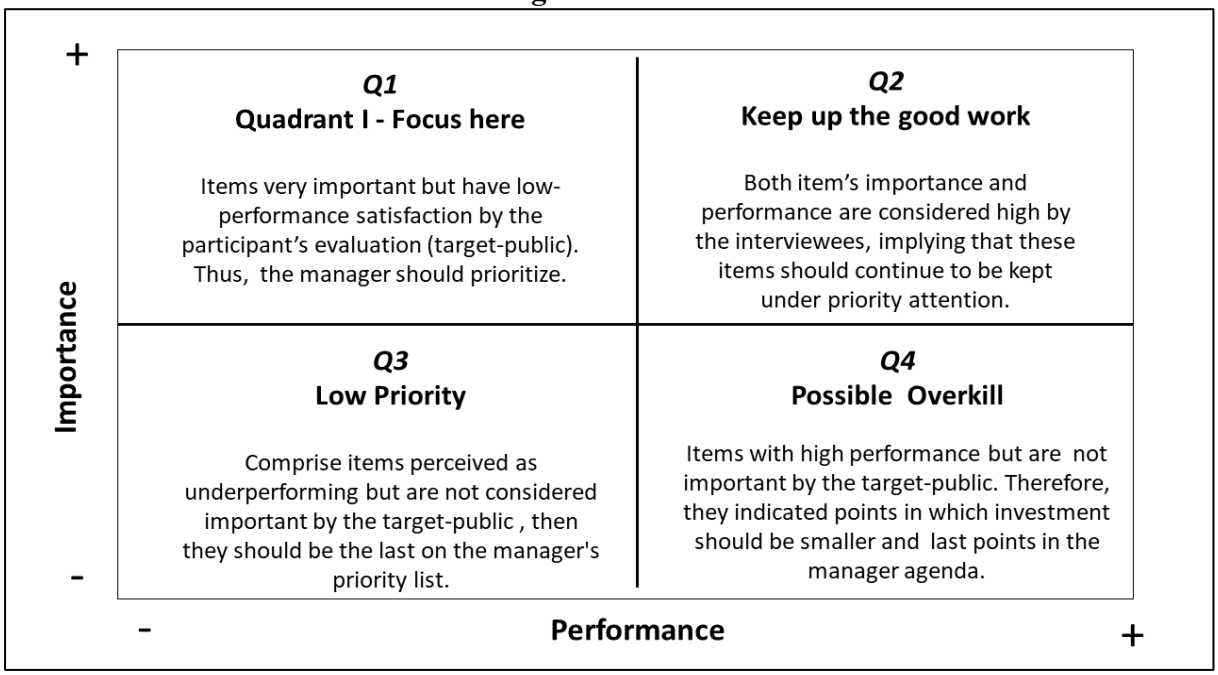
Firstly, the questionnaire presented the Smart Campus concept. Second, we asked the respondents for a twofold evaluation of 38 indicators (Table 3.1). On the one hand, they indicated the importance of each attribute to a smart campus. On the other hand, they evaluated the indicator performance. We chose a 5-points Likert scale, of which one was equal to the lowest level to both importance and performance, and five was the highest. Finally, there are demographic questions, such as sex and age.

3.2 Data Analysis

On Microsoft Excel, we managed the data, and on IBM SPSS 26, we performed data analysis through the IPA matrix, composed of four quadrants (Figure 3.2). The first quadrant concenters the most important variables but with low satisfaction, meaning that managers should prioritize those; the second quadrant indicates items with good performance and importance, therefore the managers should keep the good work on those; the third quadrant gathers underperforming and non-important items, which need to be kept as low priorities; and the fourth quadrant comprises items with high performance but low importance, indicating a possible overkill of resources (Martilla & James, 1977).

Selecting the optimal cut-off points in IPA is one of the biggest issues in this method (Sever, 2015). We chose the data-centered method to discriminate the IPA thresholds since it is the most applied method and has higher discriminative power than the scale-centered method (J. W. Bi, Liu, Fan, & Zhang, 2019; Lai & Hitchcock, 2015; Sever, 2015). Thus, our IPA uses the mean values to specify the threshold.

Figure 3.2 IPA Matrix



Source: Elaborated by the authors based on Martilla & James (1977).

4 Results and Analysis

We obtained 450 answers, but only 379 were valid because 45 respondents were not UFCG students, and 26 questionnaires had missing data. The main sample characteristics were 54.8% female in an age range of 18-30 years old (79.8%) from undergraduate courses (80.2%) in the main campus in Campina Grande city (76.4%), as shown in Table 3.2.

Table 3.2. Demographics

Charactheristc	Number of respondents	Percentage (%)
Sex		
Female	213	56.2
Male	166	43.8
Age		
Less than 18 years old	2	0.5
Between 18 and 30 years old	315	83.1
Between 31 and 40 years old	40	10.6
Between 41 and 50 years old	15	4.0
Between 51 and 60 years old	5	1.3
More than 61 years old	2	0.5
Course type		
Undergraduate	304	80.2
Graduate and Postgraduate	75	19.8
Campus		
Campina Grande city	291	76.8
Cajazeiras city	10	2.6
Cuite city	16	4.2
Patos city	13	3.4
Pombal city	10	2.6
Sousa city	29	7.7
Sume city	10	2.6

Source: Elaborated by the authors.

4.1 Descriptive analysis

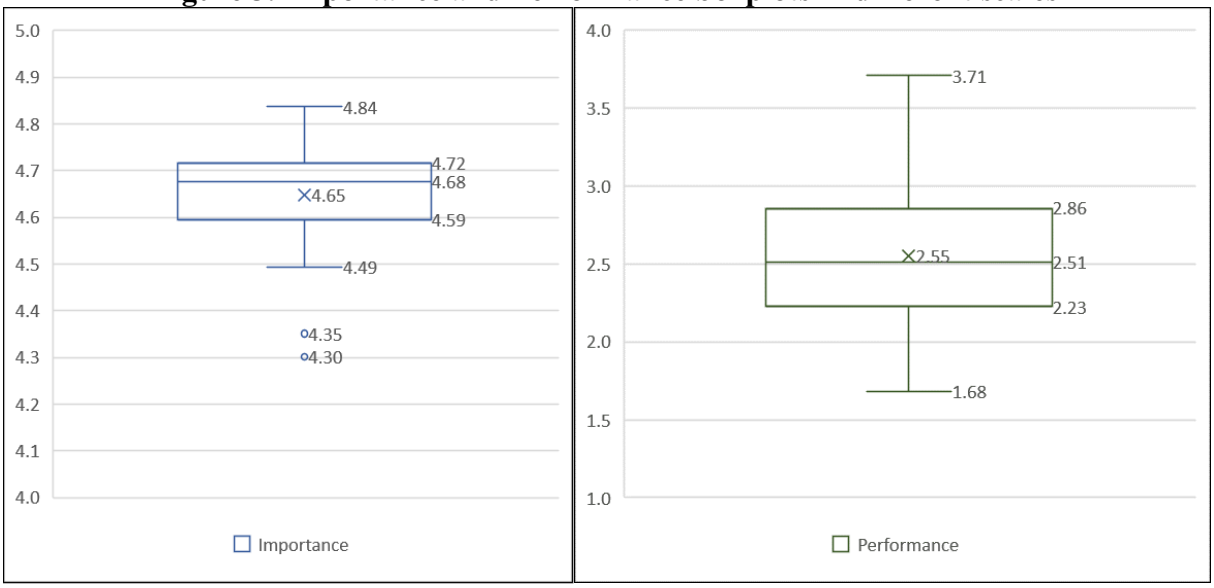
Descriptive statistics quickly describe the data characteristics through a simplified set of values (Potter, Kniss, Riesenfeld, & Johnson, 2010). To graphically summarize our results, we chose Tukey's (1977) boxplot, as it is one of the most used techniques for displaying and summarizing univariate data (Goldberg & Iglewicz, 1992; Hubert & Vandervieren, 2008; Potter et al., 2010). It mainly uses the data median and quartiles that compose the 5-number summary: minimum and maximum range values, marking the interval length by putting whiskers as the lines. Thus, it draws a box from the first to the third quartile that equals in the interquartile range (IQR = Q3 – Q1) and puts a line at the median (Q2) (Goldberg & Iglewicz, 1992; Hubert & Vandervieren, 2008; Potter et al., 2010).

The left side of Figure 3.3 summarizes the descriptive data for Importance scores with a 1-point scale (4-5). The respondents majorly considered all attributes as very important to measure a smart campus, as the range of 93% of the data was between 4.49 and 4.84. Even the

farthest outliers, which compose 7% of data, at the graph lower end scored 4.30, indicating a high level of importance. The interquartile range representing 50% of scores is relatively short, comprising a 0.13-point difference. Also, the median is closer to the boxplot upper end, with half the scores grouped higher than the mean. This result indicates that overall students have a high level of agreement with each other.

Also, the right side of Figure 3.3 shows the descriptive data of Performance scores with a 3-point scale (1-4). Students considered that the university underperformed as a smart campus since the overall data was plotted between 2.23 and 2.86. The interquartile representing 50% of the data is relatively short, as it ranges between 2.86 and 2.23, resulting in a 0.63-point difference. It points out a high level of agreement among respondents. Although, the upper whisker is more prolonged than the lower, which means that students' opinions varied in the most positive quartile. While in the most negative quartile, represented by the lower whisker, the students' views were more similar, which is also indicated by the median's position closer to the box lower end.

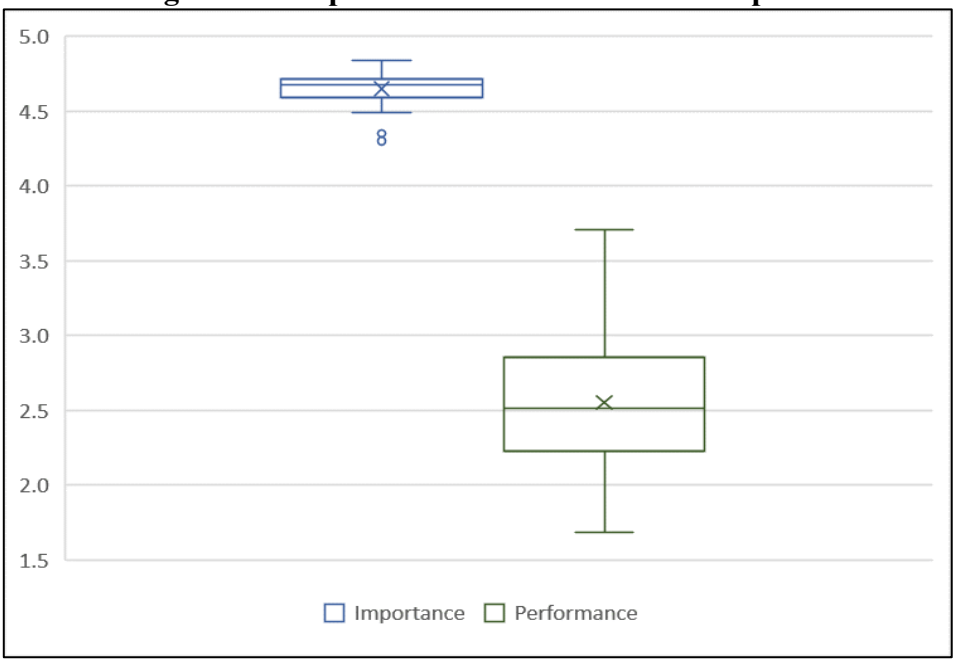
Figure 3. Importance and Performance boxplots in different scales



Source: Elaborated by the authors.

When compared using the same scale (Figure 4), the difference between Importance and Performance scores is clear. While respondents majorly agreed that all items are important to evaluate a smart campus as indicated by the higher and shorter boxplot, the university had a mild to bad performance, with students holding different opinions as represented by the lower and taller boxplot.

Figure 3.4. Importance and Performance boxplots



Source: Elaborated by the authors.

4.2 IPA Analysis

To ensure data reliability, we extracted the Cronbach's alpha coefficient for both importance and performance samples before conducting the IPA. All dimensions scored higher than 0.7, which is considered reliable and indicates adequate internal consistency of the dataset (Lai & Hitchcock, 2015). Table 3.3 presents the scale indexes and the general score by dimension.

The most important dimension is Smart Living with a mean of 4.713 and a standard deviation of 0.024 (Table 3.3). These results represent that students highly regard issues relating to their quality of life in a smart campus, such as health, leisure, and well-being. On the other hand, the less important dimension for students was Smart Economy, with a mean of 4.44 and a standard deviation of 0.107. However, we note EC is less important but had no low score. Thus, students highly value entrepreneurship, economic innovation, electronic payment systems, and other economic-related issues.

Regarding Performance results, the best dimension in UFCG is Smart Management, with a mean of 2.898 and a standard deviation of 0.578 (Table 3.3). However, the score attributed is medium, not high. This dimension includes process efficiency, sustainable

management, transparency, and participation. The worst performance relates to the Smart Security dimension with a mean of 2.382 and a standard deviation of 0.463. Thereby, students consider that UFCG underperforms in disaster prevention, biosecurity, cybersecurity, and other issues associated with this dimension. Despite the position in the ranking of performance, all dimensions indicate low functioning, as mentioned before.

Furthermore, we found considerable gaps between the students' expectancy of a smart campus and their reality in UFCG in all dimensions. The I-P Gaps vary between 1,779 to 2.325 on a scale of 1-5 points (Table 3.3).

Table 3.3 Dimensions statistics

Ranking	IMPORTANCE				PERFORMANCE				GAP	
	Dimension	Mean	SD	Alpha	Dimension	Mean	SD	Alpha	Dimension	I-P
1	LI	4.713	0.024	0.911	MA	2.898	0.578	0.737	MA	1.779
2	TE	4.710	0.082	0.845	TE	2.783	0.657	0.754	EC	1.878
3	SE	4.707	0.077	0.916	EC	2.562	0.289	0.775	TE	1.927
4	MA	4.677	0.042	0.907	ED	2.527	0.234	0.779	ED	2.122
5	EN	4.672	0.086	0.924	EN	2.495	0.484	0.815	EN	2.177
6	ED	4.649	0.040	0.887	LI	2.473	0.129	0.839	MO	2.221
7	MO	4.633	0.135	0.898	MO	2.412	0.726	0.745	LI	2.240
8	EC	4.440	0.107	0.893	SE	2.382	0.463	0.818	SE	2.325
-	**TOTAL**	**4.650**	**0.074**	**0.976**	**TOTAL**	**2.566**	**0.445**	**0.950**	**TOTAL**	**2.08**

Note: SD – Standard Deviation; I-P: Importante - Performance
Source: Elaborated by the authors.

Table 3.4 summarizes the average scores by indicators, presenting both mean and standard deviation results, as well as a ranking for higher values in both Importance and Performance. It also shows the gaps between importance and performance that represent unsatisfaction levels among respondents. The gaps point out the faultiest items to achieve the status of a smart campus and the way to guide academic managers towards a smartization process. In this case, the interpretation of gap ranking is for lower values since the smaller the gap, the better the quality of that attribute from the respondent's perspective.

The results indicated that the most important items for a smart campus are Accessibility (4.84), Security (4.83), and Internet Technologies (4.79). While the less important attributes are Electronic services (4.30), Collaborative Economy (4.35), and Entrepreneur and innovation support (4.49), all from the Economy dimension. However, as previously mentioned, all items are considered important. They have a score above 4, a mean of 4.65, and a standard deviation of 0.7.

In the first look, these responses can represent low discriminant power since all items are important. Nevertheless, these results support our proposition that a smart campus needs an integrative model and a balance among technology and other dimensions. It confirms that universities need to sustainably attend to their stakeholders' needs and promote better livability and quality of life, which is the primary goal of smart campuses (Clark II & Eisenberg, 2008; Coccoli, Maresca, & Stanganelli, 2017; Durán-Sánchez, Álvarez-García, Del Río-Rama, & Sarango-Lalangui, 2018).

Regarding performance, the most prominent items are Process efficiency (3.71), Internet Technologies (3.63), and Accessibility (3.22). The worst-performing variables are Sustainable transport (1.68), Smart Buildings (1.84), and Smart Technologies (1.96). Indeed, all items presented low-regular performance since they scored under 3, with a mean of 2.55 and a standard deviation of 1.2.

On the other side, the best levels of student satisfaction are related to Process efficiency (1.03), Internet Technologies (1.16), and Electronic services (1.52), as noted by the lowest gap between importance and performance. In comparison, the worst levels of satisfaction belong to Sustainable transport (2.87), Smart Buildings (2.69), and Smart Technologies (2.67).

Those higher results in technology-related attributes indicate that UFCG follows the smart campus technology-driven approach. In this view, a university enhances its informatization level through an interconnection of physical and virtual systems, characterized as an advanced digital campus (Y. Chen et al., 2012; Janssen & Prasetiyowati, 2018; Nan et al., 2018; Yange et al., 2016). However, recent smart campus perspectives promote new educational paradigms and improvements in different dimensions to better meet the stakeholders' needs (Ahmed et al., 2020; Min-Allah & Alrashed, 2020; Villegas-Ch et al., 2020). Thus, our results indicate that UFCG needs to amplify its perspective about what is a smart campus.

Also, it shows the difference from the Brazilian perspective from developed countries since basic infrastructure items are still not satisfied, such as accessibility, transport, and buildings. Indeed, developed countries build technology and network frameworks on established institutions and infrastructures, while developing countries suffer from deficient public services, lack of resources, and weaker institutions (Offenhuber, 2019; Söderström, 2020).

Table 3.4. Importance-Performance Analysis

Variables		Importance			Performance			Gap	
	Code	Mean	SD	Rank	Mean	SD	Rank	I-P	Rank
Electronic services	EC-01	4.30	0.92	38	2.78	1.31	13	1.52	3
Entrepreneur and innovation support	EC-02	4.49	0.83	36	2.64	1.18	16	1.85	11
Collaborative Economy	EC-03	4.35	0.90	37	2.28	1.19	26	2.07	17
Local development	EC-04	4.53	0.77	32	2.87	1.24	9	1.66	6
Employability	EC-05	4.52	0.86	34	2.23	1.11	28	2.29	26
Smart Education Technologies	ED-01	4.64	0.68	25	2.72	1.16	15	1.92	15
Internet access	ED-02	4.70	0.70	13	2.21	1.19	30	2.49	30
Community needs awareness	ED-03	4.61	0.74	27	2.46	1.12	21	2.16	20
Satisfaction	ED-04	4.68	0.64	19	2.45	1.21	23	2.23	24
Results-based learning	ED-05	4.61	0.69	28	2.80	1.17	12	1.81	9
SDGs	EN-01	4.75	0.61	5	2.93	1.10	7	1.81	10
Biodiversity	EN-02	4.72	0.61	10	2.85	1.29	10	1.86	12
Eco-friendly resources	EN-03	4.65	0.70	22	2.12	1.15	32	2.53	32
Smart Buildings	EN-04	4.53	0.81	33	1.84	1.01	37	2.69	37
Recycling	EN-05	4.71	0.67	11	2.72	1.21	14	1.99	16
Quality of Life	LI-01	4.69	0.65	18	2.27	1.18	27	2.41	28
Health	LI-02	4.70	0.65	12	2.43	1.15	24	2.28	25
Social Inclusion	LI-03	4.70	0.65	14	2.50	1.23	20	2.20	23
Leisure	LI-04	4.75	0.59	6	2.57	1.27	18	2.18	21
Extracurricular activities	LI-05	4.73	0.62	8	2.59	1.23	17	2.13	18
Sustainable management	MA-01	4.65	0.72	24	2.45	1.16	22	2.20	22
Transparency	MA-02	4.67	0.68	21	2.91	1.29	8	1.75	8
Participation	MA-03	4.65	0.70	23	2.52	1.21	19	2.13	19
Process efficiency	MA-04	4.74	0.63	7	3.71	1.24	1	1.03	1
Accessibility	MO-01	4.84	0.51	1	3.22	1.34	3	1.62	5
Signaling	MO-02	4.70	0.68	15	3.17	1.35	4	1.53	4
Sustainable transport	MO-03	4.55	0.87	31	1.68	0.97	38	2.87	38
Collaborative economy	MO-04	4.51	0.87	35	1.98	1.20	35	2.53	33
Eco-friendly transport	MO-05	4.57	0.83	30	2.01	1.15	34	2.56	34
Security	SE-01	4.83	0.48	2	2.95	1.28	6	1.88	13
Biosecurity	SE-02	4.72	0.67	9	2.81	1.28	11	1.91	14
Smart Technologies	SE-03	4.63	0.72	26	1.96	1.18	36	2.67	36
Cybersecurity	SE-04	4.67	0.76	20	2.17	1.16	31	2.51	31
Disaster prevention	SE-05	4.69	0.73	16	2.03	1.10	33	2.66	35
Internet technologies	TE-01	4.76	0.60	4	2.30	1.19	25	2.47	29
Data management	TE-02	4.69	0.64	17	2.98	1.24	5	1.71	7
Information Systems	TE-03	4.60	0.74	29	2.23	1.20	29	2.37	27
Internet Technologies	TE-04	4.79	0.52	3	3.63	1.29	2	1.16	2
AVERAGE	**-**	**4.65**	**0.70**	**-**	**2.55**	**1.20**	**-**	**2.10**	**-**

Note: SD – Standard Deviation; I-P: Importante - Performance
Source: Elaborated by the authors.

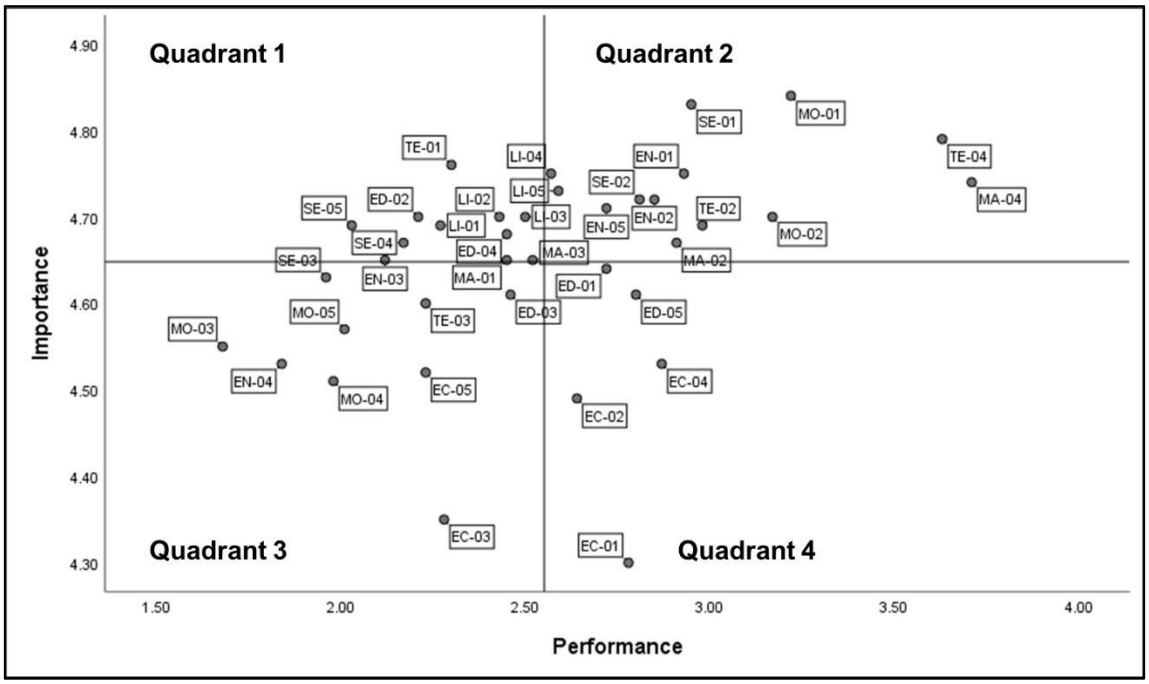
Figure 3.5 presents the IPA matrix with all quadrants to provide the priorities for UFCG towards the smartization process. The first quadrant gathered 28.9% of the attributes (11), indicating that they are important to respondents, but should receive more attention from decision-makers to improve their low performance. The most relevant attribute is Internet technologies (TE-01), which is also fourth in the general ranking, but its performance is ranked at 25 and satisfaction at 29. Quadrant 1 has variables of six different dimensions: Education (2), Environment (1), Living (3), Management (2), Security (2), and Technology (1).

Quadrant 2 collected the most attributes (13), representing 34.2% of variables, indicating that decision-makers should keep the good work. Thus, variables in this dimension have high importance for respondents and good performance in UFCG. The most significant item of the general ranking is in this quadrant, Accessibility, which is also third in best performance and fifth in satisfaction. This quadrant comprises variables of six dimensions, namely Environment (3), Living (2), Management (2), Mobility (2), Security (2), and Technology (2).

The third quadrant consists of 23.7% of the attributes (9) corresponding to low-scoring items for both importance and performance. Thus, managers should keep those at low priority. Smart Technologies (SE-03) is the most highlighted attribute in this quadrant; however, it is 26 at the general ranking, and even lower at performance and satisfaction (36). Quadrant 3 also aggregates variables of six dimensions: Economy (2), Education (1), Environment (1), Mobility (3), Security (1), and Technology (1).

At last, quadrant 4 clustered 13.2% of variables (5) that have high performance but are not much important for students, representing a possible overkill of resources. Smart Technologies (ED-01) is the most underlined attribute, but it ranks at 25 in the general ranking with both performance and satisfaction levels at 15. This quadrant included variables of two different, namely Economy (3) and Education (2).

Figure 3.5. IPA Matrix results



Source: Elaborated by the authors.

According to Figure 3.5, we may establish a priority list for the university to improve, based on Quadrant 1. IPA results showed decision-makers should prioritize actions towards Internet access (ED-02), Satisfaction (ED-04), Eco-friendly resources (EN-03), Quality of Life (LI-01), Health (LI-02), Social Inclusion (LI-03), Sustainable management (MA-01), Participation (MA-03), Cybersecurity (SE-04), Disaster prevention (SE-05), and Internet technologies (TE-01).

Quadrant 1 gathers almost all dimensions, emphasizing Smart Living that has three variables related to the students' quality of life, health, and social inclusion. As foreseen in the previous analysis, UFCG needs to implement actions towards the students' needs and sustainability to improve its smartization process.

These findings align with the statement that being smart should not confound with being digital. Since the smart campus composes a learning ecosystem of digital and social services to meet the present and emerging needs of both modern society and the labor market in a sustainable, social and technological manner (Atif et al., 2015; Caballero et al., 2016; Coccoli et al., 2017; Coccoli et al., 2014; Villegas-Ch et al., 2020).

5 CONCLUSIONS

This research aimed to identify the essential elements and the most significant deficiencies in the Smart Campus dimensions and its variables from the user point of view to offer a list of priorities to decision-makers. Our starting point was an integrative perspective of eight dimensions and their overlap with SGDs. Also, we used a perspective from Latin-American experts to consider the social and economic context influence.

Our research offered threefold results: theoretical, methodological, and empirical. Theoretically, we reinforce the use of an integrative perspective to analyze or implement a smart campus. A smartization process cannot focus only on technology attributes, but universities should use technologies to build a comprehensive and sustainable living environment (Janssen & Prasetiyowati, 2018; Min-Allah & Alrashed, 2020; Segredo et al., 2017). Thus, this research results tested eight smart dimensions: economy, education, environment, living, management, mobility, security, and technology.

Methodologically, we developed a set of indicators adapted to an IPA matrix, offering a management tool to decision-makers in the academic context. Empirically, our research has findings specifically to the Federal University of Campina Grande. The results indicated a route to the academic managers toward a smart campus, including a priority list.

The research used a quantitative approach based on the Importance-Performance Analysis technique. We synthesize our findings in two groups: (1) the test of the integrative model of smart campus and its indicators; (2) the position of UFCG as a smart campus and its priorities for improvements in each smart dimension.

Our framework qualitative validation previously performed with Latin American experts is now quantitatively validated by users, i.e., the students. Performed in a statistically significant sample with a 95% confidence level and 5% error, we gathered sufficient and reliable data. The alpha test results higher than 0.7 in all dimensions confirmed an adequate internal consistency of the dataset for an IPA analysis (Lai & Hitchcock, 2015). Consequently, we validated our smart campus integrative concept with the complete framework composed of eight smart dimensions connected to the SDGs. We can apply this framework to universities worldwide, but it has a closeness with the Latin American reality since its validation was in this context.

The participants validated all items as suitable for a smart campus evaluation since they attributed high importance (>4) to all variables. On the other side, the performance rating reflected how is the smartization level for this university. The low-performance average score

(2.55) and the high discrepancy between importance and performance (2.10) expose the user's dissatisfaction and the distance of UFCG as a smart campus.

Despite technology-related items being ranked as high importance, Quadrant 1 (Figure 3.5) exposes that issues related to life on campus have priority. This confirms that recent smart campus perspectives promote new educational paradigms and improvements in different dimensions to better meet the stakeholders' needs in a sustainable, social, and technological manner (Coccoli et al., 2017; Ahmed et al., 2020; Min-Allah & Alrashed, 2020; Villegas-Ch et al., 2020).

Overall, the most important dimensions for a smart campus are Living (4.713), Technology (4.71), and Security (4.7). This finding is aligned with the literature that presents smart campuses composed of technology, sustainability, and social actions to support the quality of life and needs of stakeholders (Coccoli et al., 2017; Villegas-Ch et al., 2020). The best-performing dimensions by UFCG in the students' opinion are Management (2.9), Technology (2.78), and Economy (2.56).

According to the results, the UFCG smart campus performance achieved only medium values; no indicator had excellent performance. Among these median values of the UFCG, some show a mild best performance and indicate that UFCG is building an integrative, transparent, and open workplace to manage campus with active stakeholder participation in the Smart Management, which attends to SGDs 7, 9, 11, 16, and 17. On the other side, the university needs to improve Smart Security, the worst-performing dimension. By doing this, UFCG will better protect people in both physical and virtual contexts, which attends SGD 11 and 16.

This study was limited by the students' unilateral opinion, rather than a multi-stakeholder perspective. Also, students were absent from presential activities in the university due to COVID-19 restrictions that could imply different perceptions. Thus, we suggest further research comprising the assessment of managers, employees, professors, and other stakeholders. Also, the sample expansion, using stratification-based sampling to understand better how a specific campus may improve its performance.

References

Observation: The reference list is at the end of the document.

CHAPTER 4

CONCLUSION

CONCLUSION

This Master thesis aimed to propose a Smart Campus framework adapted to the context of Latin-American universities and recommend indicators to monitor the smartization process for the Brazilian context based on technology, connectivity, and the Sustainable Development Goals (SDG). We followed the article's modality as regulated by the Postgraduate Program of Management (PPGA/UFCG). Each paper represents an individually published but interconnected study that culminates in a validated Smart Campus framework (Table 4.1). All papers were submitted to high-quality international journals to obtain peer-review evaluation and improvement (Appendix 4-6).

Motivated by the smartization process in smart cities and their monitors, we decided to research smart campuses and their applicability to improve educational institutions. We first needed to understand the smart campus to later identify and validate a framework, and ultimately apply it in a university. The first chapter highlighted the concept evolution throughout the years, dimensions proposed by the authors, interventions of smart campuses in different contexts, advancements in universities, and a research agenda for further studies.

Thereby, we formulated an integrative concept (Chapter 1), defining smart campus as a higher education institution that creates an ecosystem using Information and Communication Technologies (ICT) to achieve sustainability using a governance-based, collaborative, and adaptive learning model to promote better livability for its stakeholders.

Still in the first chapter, but improved in the second, we proposed a framework of eight smart dimensions. Thus, smart campuses are composed of Economy, Education, Environment, Living, Management, Mobility, Security, and Technology, which is a transversal dimension, i.e., present in all others. A sample of smart campus experts composed of both academics and practitioners validated our framework through two focus group sessions, synchronous and asynchronous (Chapter 2).

The experts' discussions mainly concerned sustainability, technology, and social issues that smart campuses need to address. Thus, as we validated definitions and indicators for each dimension, we provided a monitor for the university smartization process. Additionally, the

findings consolidated that while universities improve their smartization process, they also achieve the SGDs.

At last, we evaluated a Brazilian university in chapter 3 since the final framework comprehends a Latin American perspective (Chapter 2). It was a test of our framework. The Importance-Performance Analysis indicated that all smart campus attributes were considered important by the students for a university evaluation. These findings also provided a ranking of the most important dimensions for a smart campus: Living, Technology, and Security. Thus, our data agree with the literature that presents the smart campus composed by technology and actions towards stakeholders' quality of life. Table 4.1 summarizes the main results, contributions, limitations, and future studies suggestions from all articles.

Table 4.1. Summary of conclusions

ARTICLES	MAIN RESULTS	CONTRIBUTIONS	LIMITATIONS	FUTURE STUDIES
1st article: Status of knowledge on Smart Campus: Implications for educational institutions and sustainability.	It presented the overall trajectory and the smart campus's actual state based on its definition, dimension, interventions, advancements, and future studies.	It proposes an integrated definition for the smart campus, along with a standard set of dimensions and how they contribute to the SDGs achievement.	Only peer-reviewed papers on the Web of Science and Scopus databases were covered, thus we disregard grey literature and other journals not indexed in those platforms.	Formulation of tools to monitor the smartization process, as well as studies that express the integrated nature of smart campuses.
2nd article: Smart Campus Monitor: A method to support decision-making from Latin American universities.	This article validated a smart campus framework from the Latin American point of view.	From the Latin American experts' consensus, we defined the smart campus dimensions and proposed indicators to monitor its smartization process.	The small range of participants may not express the various contexts of Latin American universities.	Conduct new focus group sessions with more participants from different locations to confirm the framework.
3rd article: Prioritizing decision-making: Indicators to the Smartization process of universities.	It validated and tested the proposed framework from the user viewpoint, as well as evaluated a Brazilian university.	The students from a Brazilian university confirmed the framework's importance in evaluating smart campuses, at the same time they assessed their context.	The article only evaluated the students' opinions.	Conduct further studies appraising a broader and structured range of participants, including a multi-perspective from all stakeholders.

Source: Evaluated by the authors.

Consequently, we conclude that the articles are interdependent and have reached general and specific goals regarding our results. The use of different methods, both qualitative and

quantitative, to build data yielded contributions for both academic research and society. We presented an evolution to the smart campus field. While applicable to any smart campus, our framework closely relates to Latin American universities as we validate with Latin American Scholars and empirically apply in a Brazilian university.

We provided a priority list for the Federal University of Campina Grande to become a smart campus. Thus, our results also have a social impact, as it is applied-social research. Therefore, we hope this model may boost the smartization process of similar universities in this region and around Latin American.

The limitations of this study are related to the lack of consensus in the smart campus literature and the high number of indicators since it is a multidimensional concept. Another limitation is in the test phase. We evaluated only one Brazilian university that may have a context bias despite sharing common characteristics with Brazilian public universities. Thus, we suggest further studies with a comparative sample of Latin American universities and comparative analysis among developed countries to understand the difference of importance levels attributed in other social and economic contexts.

Finally, we recommend conducting a multivariate analysis, using both Exploratory and Confirmatory Factorial Analysis to evaluate this framework quantitatively. Additionally, to academic managers, we recommend applying our model in the universities to identify their performance, monitor their smartization process, and prioritize decision-makers toward the Smart Campus and SGDs.

ACKNOWLEDGEMENTS

We thank CAPES Foundation, Ministry of Education of Brazil for the received funding under the Grant Agreement No 88887.494001/2020-00.

REFERENCES

Abdullah, A., Thanoon, M., & Alsulami, A. (2019). Toward a smart campus using IoT: Framework for safety and security system on a university campus. *Advances in Science, Technology and Engineering Systems*, 4(5), 97–103. https://doi.org/10.25046/aj040512

Abdullah, D. A., Wakil, K., & Alshatri, S. H. H. (2020). Intelligent attendance system using artificial neural network based on students' background. *Journal of Computer Science*, 16(7), 1001–1009. https://doi.org/10.3844/JCSSP.2020.1001.1009

Achenkunjujohn, A., & Venkatesh Kumar, P. (2020). A new concept of smart universities using internet of things (IoT). *International Journal of Scientific and Technology Research*, 9(3), 6147–6151.

Adamkó, A., & Kollár, L. (2014). Extensible data management architecture for smart campus applications: A crowdsourcing based solution. *10th International Conference on Web Information Systems and Technologies*, WEBIST 2014, 1, 226–232. https://doi.org/10.5220/0004964802260232

Adekitan, A. I., Abolade, J., & Shobayo, O. (2019). Data mining approach for predicting the daily Internet data traffic of a smart university. *Journal of Big Data*, 6(1), 11. https://doi.org/10.1186/s40537-019-0176-5

Adner, R. (2016). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*. https://doi.org/10.1177/0149206316678451

Ahmed, E., Yaqoob, I., Gani, A., Imran, M., & Guizani, M. (2016). Internet-of-things-based smart environments: State of the art, taxonomy, and open research challenges. *IEEE Wireless Communications*, *23*(5). https://doi.org/10.1109/MWC.2016.7721736

Ahmed, M. A., & Kim, Y.-C. (2018). Energy trading with electric vehicles in smart campus parking lots. *Applied Sciences* (Switzerland), 8(10), 1749. https://doi.org/10.3390/app8101749

Ahmed, M. A., El-Sharkawy, M. R., & Kim, Y.-C. (2020). Remote monitoring of electric vehicle charging stations in smart campus parking Lot. *Journal of Modern Power Systems and Clean Energy*, 8(1), 124–132. https://doi.org/10.35833/MPCE.2018.000502

Ahmed, V., Alnaaj, K. A., & Saboor, S. (2020). An investigation into stakeholders' perception of smart campus criteria: The American University of Sharjah as a case study. *Sustainability (Switzerland)*, *12*(12). https://doi.org/10.3390/su12125187

Alahmadi, A. (2020). Design an optimum climate control system for efficient smart universities educational environment. *International Journal of Scientific and Technology Research*, 9(3), 440–449.

Alharbi, Y. M., Alahmadi, A. A. A., Ullah, N., Abeida, H., Soliman, M. S., & Khraisat, Y. S. H. (2020). Super Twisting Fractional Order Energy Management Control for a Smart University System Integrated DC Micro-Grid. *IEEE Access*, 8, 128692–128704. https://doi.org/10.1109/ACCESS.2020.3008858

Alharbi, Y. M., Soliman, M. S., Salem, F. A., Alahmadi, A. A., Abeida, H., & Khraisat, Y. S. H. (2020a). Dependable wireless sensors module hardware design for smart universities application. *International Journal of Engineering Research and Technology*, 13(5), 909–915.

Alharbi, Y. M., Soliman, M. S., Salem, F. A., Alahmadi, A. A., Abeida, H., & Khraisat, Y. S. H. (2020b). Design a wireless automated solar powered irrigation control system for smart universities green areas water management. *International Journal of Engineering Research and Technology*, 13(5), 891–899.

Alkhodre, A. B. (2018). Statistical-based trustful access control framework for smart campuses. *International Journal of Advanced Computer Science and Applications*, 9(9), 111–117. https://doi.org/10.14569/ijacsa.2018.090915

Alonso, D. Q., & Donsión, M. P. (2016). Contribution to the knowledge of a microgrid. Smart campus. *Renewable Energy and Power Quality Journal*, *1*(14), 725–730. https://doi.org/10.24084/repqj14.440

Alrashed, S. (2020). Key performance indicators for Smart Campus and Microgrid. *Sustainable Cities and Society*, *60*. https://doi.org/10.1016/j.scs.2020.102264

Altinay, F., Dagli, G., Altinay, Z., & Altinay, M. (2020). Readiness to Online Learning: to be a Smart University. *Revista Romaneasca Pentru Educatie Multidimensionala*, 12(1, 2), 9–14. https://doi.org/10.18662/rrem/12.1sup2/241

Alvarez-Campana, M., López, G., Vázquez, E., Villagrá, V. A., & Berrocal, J. (2017). Smart CEI moncloa: An iot-based platform for people flow and environmental monitoring on a Smart University Campus. *Sensors (Switzerland)*, *17*(12). https://doi.org/10.3390/s17122856

Amadeo, M., Ruggeri, G., Campolo, C., Molinaro, A., Loscrí, V., & Calafate, C. T. (2019). Fog computing in IoT smart environments via Named Data Networking: A study on service orchestration mechanisms. *Future Internet*, 11(11), 222. https://doi.org/10.3390/fi11110222

Angelidou, M. (2015). Smart cities: A conjuncture of four forces. *Cities,* 47, 95–106. https://doi.org/10.1016/j.cities.2015.05.004

Anirudh, A., Pandey, V. K., Sodhi, J. S., & Bagga, T. (2017). Next generation indian campuses going SMART. *International Journal of Applied Business and Economic Research*, *15*(21), 385–398.

Arnove, R. F. (1967). A survey of literature and research on Latin American universities. *Latin American Research Review*, *3*(1), 45–62.

Arocena, R., & Sutz, J. (2005). Latin American Universities: From an original revolution to an uncertain transition. *Higher Education*, Vol. 50. https://doi.org/10.1007/s10734-004-6367-8

Arrais, C. A., Corcioli, G., & Medina, G. da S. (2021). The Role Played by Public Universities in Mitigating the Coronavirus Catastrophe in Brazil: Solidarity, Research and Support to Local Governments Facing the Health Crisis. *Frontiers in Sociology*, *6*. https://doi.org/10.3389/fsoc.2021.610297

Arshad, S., Shahzaad, B., Azam, M. A., Loo, J., Ahmed, S. H., & Aslam, S. (2018). Hierarchical and Flat-Based Hybrid Naming Scheme in Content-Centric Networks of Things. *IEEE Internet of Things Journal*, 5(2), 1070–1080. https://doi.org/10.1109/JIOT.2018.2792016

Atif, Y., Mathew, S. S., & Lakas, A. (2015). Building a smart campus to support ubiquitous learning. *Journal of Ambient Intelligence and Humanized Computing*, *6*(2), 223–238. https://doi.org/10.1007/s12652-014-0226-y

Awofeso, N., Hassan, M., & Hamidi, S. (2016). Individual and collaborative technology-mediated learning using question & answer online discussion forums – perceptions of Public Health learners in Dubai, UAE. *Open Learning*, 31(1), 54–63. https://doi.org/10.1080/02680513.2015.1120662

Azmitia, A., Mohnke, J., & Wiechers, H. (2016). Where am I? iBeacons in Action in the Library of TUAS Wildau. *Bibliothek Forschung Und Praxis*, 40(3), 395–404. https://doi.org/10.1515/bfp-2016-0050

Bae, M.-Y., & Cho, D.-J. (2015). Design and implementation of automatic attendance check system using BLE beacon. *International Journal of Multimedia and Ubiquitous Engineering*, 10(10), 177–186. https://doi.org/10.14257/ijmue.2015.10.10.19

Banerjee, S., Ashwin, T. S., & Guddeti, R. M. R. (2020). Multimodal behavior analysis in computer-enabled laboratories using nonverbal cues. *Signal, Image and Video Processing*. https://doi.org/10.1007/s11760-020-01705-4

Baptista, B. V., Vasen, F., & Soto, J. C. V. (2019). Interdisciplinary Centers in Latin American Universities: The Challenges of Institutionalization. *Higher Education Policy*, *32*(3). https://doi.org/10.1057/s41307-018-0092-x

Barbato, A., Bolchini, C., Geronazzo, A., Quintarelli, E., Palamarciuc, A., Pitì, A., … Verticale, G. (2016). Energy optimization and management of demand response interactions in a smart campus. *Energies*, 9(6), 398. https://doi.org/10.3390/en9060398

Bates, O., & Friday, A. (2017). Beyond Data in the Smart City: Repurposing Existing Campus IoT. *IEEE Pervasive Computing*, 16(2), 54–60. https://doi.org/10.1109/MPRV.2017.30

Beck, A. J. (2016). Reformed confessions and scholasticism. Diversity and harmony. *Perichoresis*, *14*(3). https://doi.org/10.1515/perc-2016-0014

Bi, J. W., Liu, Y., Fan, Z. P., & Zhang, J. (2019). Wisdom of crowds: Conducting importance-performance analysis (IPA) through online reviews. *Tourism Management*, *70*. https://doi.org/10.1016/j.tourman.2018.09.010

Bi, T., Yang, X., & Ren, M. (2017). The Design and Implementation of Smart Campus System. *Journal of Computers*, *12*(6), 527–533. https://doi.org/10.17706/jcp.12.6.527-533

Bin Ismail, M. D., & Habaebi, M. H. (2019). Empirical evaluation of LORA link performance for smart city/smart campus environments. *International Journal of Innovative Technology and Exploring Engineering*, 8(8), 50–58.

Boley, B. B., McGehee, N. G., & Tom Hammett, A. L. (2017). Importance-performance analysis (IPA) of sustainable tourism initiatives: The resident perspective. *Tourism Management*, *58*, 66–77. https://doi.org/10.1016/j.tourman.2016.10.002

Boni, K. R. C., Xu, L., Chen, Z., & Baddoo, T. D. (2020). A security concept based on scaler distribution of a novel intrusion detection device for wireless sensor networks in a smart environment. *Sensors (Switzerland)*, *20*(17). https://doi.org/10.3390/s20174717

Bromuri, S., Urovi, V., & Stathis, K. (2010). Icampus: A connected campus in the ambient event calculus. *International Journal of Ambient Computing and Intelligence*, *2*(1), 59–65. https://doi.org/10.4018/jaci.2010010105

Bureš, V., Tučník, P., Mikulecký, P., Mls, K., & Blecha, P. (2016). Application of ambient intelligence in educational institutions: Visions and architectures. *International Journal of Ambient Computing and Intelligence*, 7(1), 94–120. https://doi.org/10.4018/IJACI.2016010105

Caballero, A., García-Valverde, T., Pereñíguez, F., & Botía, J. A. (2016). Activity recommendation in intelligent campus environments based on the Eduroam federation. *Journal of Ambient Intelligence and Smart Environments*, *8*(1), 35–46. https://doi.org/10.3233/AIS-150360

Caballero, A., Munoz, A., Soto, J., & Botía, J. A. (2014). Resource assignment in intelligent environments based on similarity, trust and reputation. *Journal of Ambient Intelligence and Smart Environments*, *6*(2), 199–214. https://doi.org/10.3233/AIS-140253

Cambridge Dictionary. (2020). *English Dictionary*. Retrieved October 27, 2020, from https://dictionary.cambridge.org/us/dictionary/english/

Caragliu, A., & Del Bo, C. F. (2016). Do Smart Cities Invest in Smarter Policies? Learning From the Past, Planning for the Future. *Social Science Computer Review*, 34(6), 657–672. https://doi.org/10.1177/0894439315610843

Caragliu, A., del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology*, *18*(2), 65–82. https://doi.org/10.1080/10630732.2011.601117

Celdran, A. H., Clemente, F. J. G., Saenz, J., De La Torre, L., Salzmann, C., & Gillet, D. (2020). Self-Organized Laboratories for Smart Campus. *IEEE Transactions on Learning*

Technologies, *13*(2), 404–416. https://doi.org/10.1109/TLT.2019.2940571
Cesconetto, J., Silva, L. A., Bortoluzzi, F., Navarro-Cáceres, M., Zeferino, C. A., & Leithardt, V. R. Q. (2020). PRIPRO—privacy profiles: User profiling management for smart environments. *Electronics (Switzerland)*, *9*(9). https://doi.org/10.3390/electronics9091519
Chang, K.-M., Dzeng, R.-J., & Wu, Y.-J. (2018). An automated IoT visualization BIM platform for decision support in facilities management. *Applied Sciences (Switzerland)*, 8(7), 1086. https://doi.org/10.3390/app8071086
Chaouche, A.-C., Seghrouchni, A. E. F., Ilié, J.-M., & Saïdouni, D. E. (2014). A formal approach for contextual planning management: Application to smart campus environment. *Lecture Notes in Computer Science*. Vol. 8864, pp. 791–803. https://doi.org/10.1007/978-3-319-12027-0_64
Chauhan, J., Goswami, P., & Patel, S. (2019). Cloud based smart virtual interactive environment for work in universities using IOT. *International Journal of Innovative Technology and Exploring Engineering*, 8(7), 250–258.
Chen, H., Weiler, B., Young, M., & Lee, Y. L. (2016). Conceptualizing and measuring service quality: towards consistency and clarity in its application to travel agencies in China. *Journal of Quality Assurance in Hospitality & Tourism*, *17*(4), 516–541. https://doi.org/10.1080/1528008X.2015.1133365
Chen, L.-W., Chen, T.-P., Chen, D.-E., Liu, J.-X., & Tsai, M.-F. (2018). Smart Campus Care and Guiding with Dedicated Video Footprinting Through Internet of Things Technologies. *IEEE Access*, 6, 43956–43966. https://doi.org/10.1109/ACCESS.2018.2856251
Chen, Y., Zhang, R., & Zhang, S. (2012). Service encapsulation-based model for smart campus. *Journal of Electronic Commerce in Organizations*, *10*(4), 31–41. https://doi.org/10.4018/jeco.2012100103
Chiu, P.-S., Chang, J.-W., Lee, M.-C., Chen, C.-H., & Lee, D.-S. (2020). Enabling intelligent environment by the design of emotionally aware virtual assistant: A case of smart campus. *IEEE Access*, *8*, 62032–62041. https://doi.org/10.1109/ACCESS.2020.2984383
Clark II, W. W., & Eisenberg, L. (2008). Agile sustainable communities: On-site renewable energy generation. *Utilities Policy*, *16*(4), 262–274. https://doi.org/10.1016/j.jup.2008.01.009
Coccoli, M, Guercio, A., Maresca, P., & Stanganelli, L. (2014). Smarter universities: A vision for the fast changing digital era. *Journal of Visual Languages and Computing*, *25*(6), 1003–1011. https://doi.org/10.1016/j.jvlc.2014.09.007
Coccoli, M, Maresca, P., & Stanganelli, L. (2017). The role of big data and cognitive computing in the learning process. *Journal of Visual Languages and Computing*, *38*, 97–103. https://doi.org/10.1016/j.jvlc.2016.03.002
Coccoli, M, Maresca, P., Stanganelli, L., & Guercio, A. (2015). An experience of collaboration using a PaaS for the smarter university model. *Journal of Visual Languages and Computing*, 31, 275–282. https://doi.org/10.1016/j.jvlc.2015.10.014
Cohen, B. (2006). Sustainable valley entrepreneurial ecosystems. *Business Strategy and the Environment*, *15*(1), 1–14. https://doi.org/10.1002/bse.428
Cohen, B., & Muñoz, P. (2015). Toward a Theory of Purpose-Driven Urban Entrepreneurship. *Organization and Environment*, *28*(3), 264–285. https://doi.org/10.1177/1086026615600883
Cooke, A., Smith, D., & Booth, A. (2012). Beyond PICO: The SPIDER tool for qualitative evidence synthesis. *Qualitative Health Research*, 22(10), 1435-1443. https://doi.org/10.1177/1049732312452938

da Cruz, M. A. A., Rodrigues, J. J. P. C., Sangaiah, A. K., Al-Muhtadi, J., & Korotaev, V. (2018). Performance evaluation of IoT middleware. *Journal of Network and Computer Applications*, 109, 53–65. https://doi.org/10.1016/j.jnca.2018.02.013

Dascalu, M.-I., Bodea, C. N., Moldoveanu, A., & Dragoi, G. (2017). Towards a smart university through the adoption of a social e-learning platform to increase graduates' employability. *Lecture Notes in Educational Technology*, pp. 23–28. https://doi.org/10.1007/978-981-10-2419-1_4

De Guimarães, J. C. F., Severo, E. A., Felix Júnior, L. A., Da Costa, W. P. L. B., & Salmoria, F. T. (2020). Governance and quality of life in smart cities: Towards sustainable development goals. *Journal of Cleaner Production*, 253. https://doi.org/10.1016/j.jclepro.2019.119926

de Nez, E. (2018). Antecedentes históricos da Universidade no Brasil e no mundo: Do predomínio da Igreja ao início da democratização do acesso. *Humanidades & Inovação*, *5*(8), 29–38.

De Vaujany, F. X., Walsh, I., & Mitev, N. (2011). An historically grounded critical analysis of research articles in IS. *European Journal of Information Systems*, Vol. 20. https://doi.org/10.1057/ejis.2011.13

de Wijs, L., Witte, P. A., de Klerk, D., & Geertman, S. C. M. (2017). Smart City trends and ambitions. Retrieved June 1, 2019, from *Proceedings Agile Conference Wageningen May* 9-12, 2017. https://dspace.library.uu.nl/handle/1874/355636

Delgado-Dominguez, A. I., Marcelo Fuertes-Diaz, W., & Patricia Sanchez-Gordon, S. (2018). Enterprise file synchronization and sharing services for educational environments in case of disaster. *Revista Facultad de Ingenieria, Universidad Pedagogica y Tecnologica de Colombia*, 27(47), 81–91. https://doi.org/10.19053/01211129.v27.n47.2018.7806

Del-Valle-Soto, C., Valdivia, L. J., Velázquez, R., Rizo-Dominguez, L., & López-Pimentel, J.-C. (2019). Smart campus: An experimental performance comparison of collaborative and cooperative schemes for wireless sensor network. *Energies,* 12(16), 3135. https://doi.org/10.3390/en12163135

Dong, X., Kong, X., Zhang, F., Chen, Z., & Kang, J. (2016). OnCampus: a mobile platform towards a smart campus. *SpringerPlus*, *5*(1). https://doi.org/10.1186/s40064-016-2608-4

Durán-Sánchez, A., Álvarez-García, J., Del Río-Rama, M. C., & Sarango-Lalangui, P. O. (2018). Analysis of the scientific literature published on smart learning. *Espacios*, *39*(10).

Elsaadany, A., & Soliman, M. (2017). Experimental Evaluation of Internet of Things in the Educational Environment. *International Journal of Engineering Pedagogy*, *7*(3), 50–60. https://doi.org/10.3991/ijep.v7i3.7187

Elsakova, R., Kuzmina, N., & Kochkina, D. (2019). Smart technology integration in the system of bachelors' language training. *International Journal of Emerging Technologies in Learning*, *14*(15), 25–39. https://doi.org/10.3991/ijet.v14i15.10565

Federal University of Campina Grande. (2021a). *Portal UOL destaca a UFCG como a maior inventora do país*. Retrieved November 29, 2021, from https://portal.ufcg.edu.br/ultimas-noticias/3096-portal-uol-destaca-a-ufcg-como-a-maior-inventora-do-pais.html

Federal University of Campina Grande. (2021b). *UFCG em números*. Retrieved November 29, 2021, from Portal UFCG website: https://portal.ufcg.edu.br/

Feng, X., Zhang, J., Chen, J., Wang, G., Zhang, L., & Li, R. (2018). Design of intelligent bus positioning based on internet of things for smart campus. *IEEE Access*, 6, 60005–60015. https://doi.org/10.1109/ACCESS.2018.2874083

Fernández, P. J., Santa, J., & Skarmeta, A. F. (2020). Hybrid positioning for smart spaces: Proposal and evaluation. *Applied Sciences (Switzerland),* 10(12), 4083. https://doi.org/10.3390/APP10124083

Fernandez-Anez, V., Fernández-Güell, J. M., & Giffinger, R. (2018). Smart City implementation and discourses: An integrated conceptual model. The case of Vienna. *Cities,* 78, 4–16. https://doi.org/10.1016/j.cities.2017.12.004

Fernández-Caramés, T. M., & Fraga-Lamas, P. (2019). Towards next generation teaching, learning, and context-aware applications for higher education: A review on blockchain, IoT, Fog and edge computing enabled smart campuses and universities. *Applied Sciences (Switzerland)*, *9*(21). https://doi.org/10.3390/app9214479

Fortes, S., Santoyo-Ramón, J. A., Palacios, D., Baena, E., Mora-García, R., Medina, M., … Barco, R. (2019). The campus as a smart city: University of málaga environmental, learning, and research approaches. *Sensors (Switzerland)*, *19*(6). https://doi.org/10.3390/s19061349

Fortino, G., Russo, W., Savaglio, C., Shen, W., & Zhou, M. (2018). Agent-oriented cooperative smart objects: From IoT system design to implementation. IEEE Transactions on Systems, Man, and Cybernetics: *Systems,* 48(11), 1949–1956. https://doi.org/10.1109/TSMC.2017.2780618

Fraga-Lamas, P., Celaya-Echarri, M., Lopez-Iturri, P., Castedo, L., Azpilicueta, L., Aguirre, E., Suárez-Albela, M., Falcone, F., & Fernández-Caramés, T. M. (2019). Design and experimental validation of a lorawan fog computing based architecture for iot enabled smart campus applications†. *Sensors (Switzerland)*, *19*(15). https://doi.org/10.3390/s19153287

Galego, D., Giovannella, C., & Mealha, O. (2016). An investigation of actors' differences in the perception of learning ecosystems' smartness: The case of university of aveiro. *Interaction Design and Architecture(S),* 31(1), 19–31.

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. (2007). Smart Cities Ranking of European Medium-Sized Cities. *Centre of Regional Science*. https://doi.org/10.1016/S0264-2751(98)00050-X

Gilman, E., Tamminen, S., Yasmin, R., Ristimella, E., Peltonen, E., Harju, M., Lovén, L., Riekki, J., & Pirttikangas, S. (2020). Internet of things for smart spaces: A university campus case study. *Sensors (Switzerland)*, *20*(13), 1–29. https://doi.org/10.3390/s20133716

Goldberg, K. M., & Iglewicz, B. (1992). Bivariate Extensions of the Boxplot. *Technometrics*, *34*(3). https://doi.org/10.2307/1270037

Graneheim, U. H., Lindgren, B. M., & Lundman, B. (2017). Methodological challenges in qualitative content analysis: A discussion paper. *Nurse Education Today*, *56*. https://doi.org/10.1016/j.nedt.2017.06.002

Griffiths, S., Wong, M. S., Kwok, C. Y. T., Kam, R., Lam, S. C., Yang, L., … Lu, K. (2019). Exploring bluetooth beacon use cases in teaching and learning: Increasing the sustainability of physical learning spaces. *Sustainability (Switzerland),* 11(15), 4005. https://doi.org/10.3390/su11154005

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), 1645-1660. https://doi.org/10.1016/j.future.2013.01.010

Guest, G., Namey, E., Taylor, J., Eley, N., & McKenna, K. (2017). Comparing focus groups and individual interviews: findings from a randomized study. *International Journal of Social Research Methodology*, *20*(6). https://doi.org/10.1080/13645579.2017.1281601

Guo, B., Zhang, D., Sun, L., Yu, Z., & Zhou, X. (2013). iCROSS: toward a scalable infrastructure for cross-domain context management. *Personal And Ubiquitous Computing*, 17(3, SI), 591–602. https://doi.org/10.1007/s00779-012-0564-8

Guo, G. (2018). Design and Implementation of Smart Campus Automatic Settlement PLC Control System for Internet of Things. *IEEE Access*, *6*, 62601–62611.

https://doi.org/10.1109/ACCESS.2018.2877023
Guo, Y, Zhu, H., & Yang, L. (2016). Service-oriented network virtualization architecture for Internet of Things. *China Communications*, 13(9), 163–172. https://doi.org/10.1109/CC.2016.7582308
Guo, Y, Zhu, H., & Yang, L. (2017). Smart Service Systern(SSS): A Novel Architecture Enabling Coordination of Heterogeneous Networking Technologies and Devices for Internet of Things. *China Communications*, 14(3), 130–144. https://doi.org/10.1109/CC.2017.7897329
Hannan, M. A., Mustapha, A. M., Basri, H., & Hussain, A. (2010). Intelligent campus bus identification and monitoring system. *Australian Journal of Basic and Applied Sciences*, 4(11), 5584–5589.
Hatzivasilis, G., Papaefstathiou, I., Plexousakis, D., Manifavas, C., & Papadakis, N. (2018). AmbISPDM: Managing embedded systems in ambient environments and disaster mitigation planning. *Applied Intelligence,* 48(6), 1623–1643. https://doi.org/10.1007/s10489-017-1030-0
Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*(9). https://doi.org/10.1177/1049732305276687
Huang, L.-S., Su, J.-Y., & Pao, T.-L. (2019). A context aware Smart classroom architecture for smart campuses. *Applied Sciences (Switzerland)*, *9*(9). https://doi.org/10.3390/app9091837
Huang, Y., Ali, S., Bi, X., Zhai, X., Liu, R., Guo, F., & Yu, P. (2016). Research on Smart campus based on the internet of things and virtual reality. *International Journal of Smart Home*, *10*(12), 213–220. https://doi.org/10.14257/ijsh.2016.10.12.20
Hubert, M., & Vandervieren, E. (2008). An adjusted boxplot for skewed distributions. *Computational Statistics and Data Analysis*, *52*(12). https://doi.org/10.1016/j.csda.2007.11.008
Husni, E. (2017a). Front-end and back-end application development for uBeacon smart campus system. *Advanced Science Letters*, 23(4), 3786–3791. https://doi.org/10.1166/asl.2017.9021
Husni, E. (2017b). Mobile application for smart campus system with iBeacon–uBeacon. *Advanced Science Letters*, 23(4), 3746–3750. https://doi.org/10.1166/asl.2017.9020
Hussain, M., & Jain, U. (2020). Simple and secure device authentication mechanism for smart environments using Internet of things devices. *International Journal of Communication Systems,* 33(16), e4570. https://doi.org/10.1002/dac.4570
Ismagilova, E., Hughes, L., Dwivedi, Y. K., & Raman, K. R. (2019). Smart cities: Advances in research—An information systems perspective. *International Journal of Information Management*, 47, 88-100. https://doi.org/10.1016/j.ijinfomgt.2019.01.004
J. W. Tukey. (1977). Exploratory Data Analysis by John W. Tukey. *Biometrics*, Vol. 33.
Janssen, A. R., & Prasetiyowati, M. I. (2018). Gamifying student routines to improve campus experience through mobile application in Indonesia. *International Journal of Engineering and Technology(UAE)*, *7*(4), 85–89. https://doi.org/10.14419/ijet.v7i4.40.24081
Jing, F. (2018). Construction of college ideological and political education network platform based on intelligent campus background. *Journal of Advanced Oxidation Technologies*, 21(2). https://doi.org/10.26802/jaots.2018.02238
Jing, X., Li, S., Cheng, J., & Guo, J. (2020). Multidimensional situational information fusion method for energy saving on campus. *Journal Of Intelligent & Fuzzy Systems*, 38(4), 4793–4807. https://doi.org/10.3233/JIFS-191513
Jurva, R., Matinmikko-Blue, M., Niemelä, V., & Nenonen, S. (2020). Architecture and Operational Model for Smart Campus Digital Infrastructure. *Wireless Personal Communications*, *113*(3), 1437–1454. https://doi.org/10.1007/s11277-020-07221-5

Kaneko, A., Sugino, N., Suzuki, T., & Ishijima, S. (2000). Step towards the Smart Campus: A venture project based on distance learning by a hybrid video conferencing system. *Proceedings of the IEEE International Conference on Systems, Man and Cybernetics*, *1*. https://doi.org/10.1109/icsmc.2000.884961

Kang, H.-Y. (2011). Design and realization of internet of things based on embedded system used in intelligent campus. *International Journal of Advancements in Computing Technology*, 3(11), 291–298. https://doi.org/10.4156/ijact.vol3.issue11.37

Kbar, G., Abidi, M. H., Mian, S. H., Al-Daraiseh, A. A., & Mansoor, W. (2016). A university-based smart and context aware solution for people with disabilities (USCAS-PWD). *Computers*, 5(3), 18. https://doi.org/10.3390/computers5030018

Khamayseh, Y., Mardini, W., Aljawarneh, S., & Yassein, M. B. (2015). Integration of wireless technologies in Smart University Campus environment: Framework architecture. *International Journal of Information and Communication Technology Education*, *11*(1), 60–74. https://doi.org/10.4018/ijicte.2015010104

Kim, J., & Cheong, S.-K. (2013). Research on an authentication algorithm for an electronic attendance system in the constructing of a smart campus. *International Journal of Security and Its Applications*, 7(6), 199–208. https://doi.org/10.14257/ijsia.2013.7.6.21

Kintzinger, M. (2017). Historiography of the University. A New Field for an Old Topic in German Historical Scholarship = Historiografía sobre la Universidad. Un nuevo campo para un viejo tema en la Historia de la Universidad alemana. *CIAN-Revista de Historia de Las Universidades*, *20*(1). https://doi.org/10.20318/cian.2017.3730

Kitzinger, J. (1994). The methodology of Focus Groups: the importance of interaction between research participants. *Sociology of Health & Illness*, 16(1), 103-121. https://doi.org/10.1111/1467-9566.ep11347023

Kitzinger, J. (1995). Qualitative Research: Introducing focus groups. *BMJ*, 311(7000), 299-302. https://doi.org/10.1136/bmj.311.7000.299

Kurniawan, N. B., Suhardi, Bandung, Y., Prasetyo, Y. A., & Yustianto, P. (2019). Evaluating services computing systems engineering framework using an acceptance model. *International Journal on Advanced Science, Engineering and Information Technology*, 9(3), 1079–1085. https://doi.org/10.18517/ijaseit.9.3.8845

Kwet, M., & Prinsloo, P. (2020). The 'smart' classroom: a new frontier in the age of the smart university. *Teaching in Higher Education*, 25(4), 510–526. https://doi.org/10.1080/13562517.2020.1734922

Lai, I. K. W., & Hitchcock, M. (2015). Importance-performance analysis in tourism: A framework for researchers. *Tourism Management*, *48*. https://doi.org/10.1016/j.tourman.2014.11.008

Lehsten, P., Bader, S., & Tavangarian, D. (2014). CASA - Context-aware service access. *Journal of Integrated Design and Process Science*, 18(1), 21–38. https://doi.org/10.3233/jid-2014-0008

Lewis, D. J. A. (2018). The SMART university: the transformational role of learning analytics. *Information and Learning Science*, 119(12), 758–760. https://doi.org/10.1108/ILS-11-2018-135

Li, R., Lian, Y., Tang, S., Niu, J., Chen, F., Xing, T., & Liu, C. (2018). SafeMP: Using Mechanical Wave Communication for Safer Payment. *IEEE Access*, 6, 53112–53122. https://doi.org/10.1109/ACCESS.2018.2870427

Li, X. Y., Yu, Q. Y., Zhang, Y., Dai, J. W., & Yin, B. C. (2020). Visual analytic method for students' association via modularity optimization. *Applied Sciences (Switzerland),* 10(8), 2813. https://doi.org/10.3390/APP10082813

Li, X., & Zeng, Y. (2018). Design of data information standard system based on smart campus construction. *Journal of Advanced Oxidation Technologies*, 21(2). https://doi.org/10.26802/jaots.2018.10872

Liang, Y., & Chen, Z. (2018). Intelligent and Real-Time Data Acquisition for Medical Monitoring in Smart Campus. *IEEE Access,* 6, 74836–74846. https://doi.org/10.1109/ACCESS.2018.2883106

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., … Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* (Clinical Research Ed.), 339. https://doi.org/10.1136/bmj.b2700

Lim, Y., & Ahn, S. (2013). Architecture for mobile group communication in campus environment. *Frontiers of Computer Science*, 7(4), 505–513. https://doi.org/10.1007/s11704-013-1306-4

Lin, Y.-W. Y.-B., Shieh, M.-Z., & Lin, Y.-W. Y.-B. (2019). DormTalk: Edge computing for the dormitory applications on campus. *IET Networks*, *8*(3), 179–188. https://doi.org/10.1049/iet-net.2018.5178

Liu, X. (2017). A study on smart campus model in the era of big data. In 2016 2nd International Conference on Economics, *Management Engineering and Education Technology* (ICEMEET 2016). Atlantis Press.

Liu, Y. (2019). Investigating users' willingness of acceptance for background music service in intelligent library. *Library Hi Tech*. https://doi.org/10.1108/LHT-02-2019-0052

Luo, L. (2018). Data Acquisition and Analysis of Smart Campus Based on Wireless Sensor. *Wireless Personal Communications*, *102*(4), 2897–2911. https://doi.org/10.1007/s11277-018-5314-4

Ma, N., & Fu, W. (2019). Analysis of cloud computing algorithm based on smart campus message system. *International Journal of Performability Engineering*, 15(2), 700–709. https://doi.org/10.23940/ijpe.19.02.p34.700709

Madeiro, C. (2021). *Como universidade no agreste paraibano virou maior inventora do Brasil*. Retrieved November 29, 2021, from UOL website: https://www.uol.com.br/tilt/noticias/redacao/2021/11/15/universidade-publica-no-agreste-paraibano-virou-a-maior-inventora-do-brasil.htm

Marin-Plaza, P., Hussein, A., Martin, D., & de la Escalera, A. (2019). iCab Use Case for ROS-based Architecture. *Robotics and Autonomous Systems*, 118, 251–262. https://doi.org/10.1016/j.robot.2019.04.008

Marin-Plaza, P., Hussein, A., Martin, D., & De La Escalera, A. (2018). Global and Local Path Planning Study in a ROS-Based Research Platform for Autonomous Vehicles. *Journal of Advanced Transportation*, 2018. https://doi.org/10.1155/2018/6392697

Martilla, J. A., & James, J. C. (1977). Importance-performance analysis. *Journal of Marketing*, *41*(1), 77–79.

McLeay, F., Robson, A., & Yusoff, M. (2017). New applications for importance-performance analysis (IPA) in higher education: Understanding student satisfaction. *Journal of Management Development*. https://doi.org/10.1108/JMD-10-2016-0187

Melé, D. (2016). Re-thinking Capitalism: What We can Learn from Scholasticism? *Journal of Business Ethics*, *133*(2). https://doi.org/10.1007/s10551-014-2368-4

Min-Allah, N., & Alrashed, S. (2020). Smart campus—A sketch. *Sustainable Cities and Society*, *59*. https://doi.org/10.1016/j.scs.2020.102231

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., Antes, G., … Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Mora, J. G., Serra, M. A., & Vieira, M. J. (2018). Social Engagement in Latin American Universities. *Higher Education Policy*, *31*(4). https://doi.org/10.1057/s41307-017-0069-1

Mora, L., Bolici, R., & Deakin, M. (2017). The First Two Decades of Smart-City Research: A Bibliometric Analysis. *Journal of Urban Technology*, 24(1), 3-27. https://doi.org/10.1080/10630732.2017.1285123

Moreno, M. V, Terroso-Saenz, F., Gonzalez-Vidal, A., Valdes-Vela, M., Skarmeta, A. F., Zamora, M. A., & Chang, V. (2017). Applicability of Big Data Techniques to Smart Cities Deployments. *IEEE Transactions on Industrial Informatics*, 13(2), 800–809. https://doi.org/10.1109/TII.2016.2605581

Morrison, D., Lichtenwald, K., & Tang, R. (2020). Extending the online focus group method using web-based conferencing to explore older adults online learning. *International Journal of Research and Method in Education*, *43*(1). https://doi.org/10.1080/1743727X.2019.1594183

Mounessa, J. S., Pagoto, S. L., Baker, K., Antonishak, J., & Dellavalle, R. P. (2017). Creating the first indoor tan-free skin smart college campus. *Preventive Medicine Reports*, 6, 44–46. https://doi.org/10.1016/j.pmedr.2017.02.015

Muhamad, W., Kurniawan, N. B., Suhardi, S., & Yazid, S. (2017). Smart campus features, technologies, and applications: A systematic literature review. *2017 International Conference on Information Technology Systems and Innovation, ICITSI 2017 - Proceedings*, *2018-January*. https://doi.org/10.1109/ICITSI.2017.8267975

Nan, F., Suo, Y., Jia, X., Wu, Y., & Shan, S. (2018). Real-Time Monitoring of Smart Campus and Construction of Weibo Public Opinion Platform. *IEEE Access*, *6*, 76502–76515. https://doi.org/10.1109/ACCESS.2018.2883799

Nesti, G. (2020). Defining and assessing the transformational nature of smart city governance: insights from four European cases. *International Review of Administrative Sciences*, *86*(1). https://doi.org/10.1177/0020852318757063

Nikolaeva, A. A., Demyanova V, O., Aetdinova, R. R., & Mestnikova I, Y. (2018). Application of Lean Manufacturing Methods in Improving The Quality of Educational Services in Conditions of Digitalization. *Iioab Journal*, *9*(2), 157–163.

Nikolaeya, A., Demyanova, O., & Aetdinova, R. (2018). Lean Management And Smart Education. *ORBIS*, 14(SI), 74–86.

Nithin Rao, K., & Sreenivasa Ravi, K. (2017). IoT (Internet of things) based smart E-learning campus. *Journal of Advanced Research in Dynamical and Control Systems*, 9(Special Issue 14), 699–706.

O.Nyumba, T., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1). https://doi.org/10.1111/2041-210X.12860

Offenhuber, D. (2019). The platform and the bricoleur—Improvisation and smart city initiatives in Indonesia. *Environment and Planning B: Urban Analytics and City Science*, *46*(8). https://doi.org/10.1177/2399808319865749

Ordanini, A., Rubera, G., & DeFillippi, R. (2008). The many moods of inter-organizational imitation: A critical review. *International Journal of Management Reviews*, 10(4), 375-398. https://doi.org/10.1111/j.1468-2370.2008.00233.x

Pasetti, M., Ferrari, P., Silva, D. R. C., Silva, I., & Sisinni, E. (2020). On the use of LoRaWAN for the monitoring and control of distributed energy resources in a smart campus. *Applied Sciences (Switzerland),* 10(1), 320. https://doi.org/10.3390/app10010320

Passailaigue Baquerizo, R. M., Márquez Sánchez, F., Ortega Maldonado, C. E., & Febles Estrada, A. (2017). Bases of a knowledge management strategy for the world-class intelligent university [Bases de una estrategia de gestión del conocimiento para la universidad inteligente de clase mundial]. *Espacios*, 38(50).

Peng, J., Zhou, Y., Sun, X., Su, J., & Ji, R. (2019). Social Media Based Topic Modeling for Smart Campus: A Deep Topical Correlation Analysis Method. *IEEE Access*, 7, 7555–7564. https://doi.org/10.1109/ACCESS.2018.2890091

Peng, W., Zhang, X., & Li, X. (2019). Intelligent Behavior Data Analysis for Internet Addiction. *Scientific Programming*, 2019. https://doi.org/10.1155/2019/2753152

Pisařovic, I., Koubek, T., Ondroušek, V., & Procházka, D. (2018). Smart displays: Personalisation of information panels. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 66(5), 1307–1314. https://doi.org/10.11118/actaun201866051307

Potter, K., Kniss, J., Riesenfeld, R., & Johnson, C. R. (2010). Visualizing summary statistics and uncertainty. *Computer Graphics Forum*, *29*(3). https://doi.org/10.1111/j.1467-8659.2009.01677.x

Prandi, C., Monti, L., Ceccarini, C., & Salomoni, P. (2020). Smart Campus: Fostering the Community Awareness Through an Intelligent Environment. *Mobile Networks and Applications*, *25*(3), 945–952. https://doi.org/10.1007/s11036-019-01238-2

Prasad, D. V. V., Jaganathan, S., & Padma Priya, R. (2016). An innovative cloud framework for tracking and monitoring tangible assets in a smarter campus using RFID. *Asian Journal of Information Technology,* 15(11), 1713–1722. https://doi.org/10.3923/ajit.2016.1713.1722

Puckdeevongs, A., Tripathi, N. K., Witayangkurn, A., & Saengudomlert, P. (2020). Classroom attendance systems based on bluetooth low energy indoor positioning technology for smart campus. *Information (Switzerland*), 11(6), 329. https://doi.org/10.3390/INFO11060329

Qian, K., Ma, X., Peng, C., Ju, Q., & Xu, M. (2014). A zigbee-based building energy and environment monitoring system integrated with campus GIS. *International Journal of Smart Home,* 8(2), 107–114. https://doi.org/10.14257/ijsh.2014.8.2.12

Qiu, L., Lei, Q., & Zhang, Z. (2018). Advanced Sentiment Classification of Tibetan Microblogs on Smart Campuses Based on Multi-Feature Fusion. *IEEE Access*, 6, 17896–17904. https://doi.org/10.1109/ACCESS.2018.2820163

Qu, S., Li, K., Zhang, S., & Wang, Y. (2018). Predicting Achievement of Students in Smart Campus. *IEEE Access*, 6, 60264–60273. https://doi.org/10.1109/ACCESS.2018.2875742

RabeyaAnzum. (2020). Empirical evaluation of lora propagation in a campus environment. *Journal of Critical Reviews*, 7(16), 873–881. https://doi.org/10.31838/jcr.07.16.113

Rademaker, L. L., Grace, E. J., & Curda, S. K. (2012). Using computer-assisted qualitative data analysis software (CAQDAS) to re-examine traditionally analyzed data: Expanding our understanding of the data and of ourselves as scholars. *Qualitative Report*, 17(22).

Ramírez-Montoya, M. S. (2020). Transformación digital e innovación educativa en Latinoamérica en el marco del COVID-19. *Campus Virtuales : Revista Científica Iberoamericana de Tecnología Educativa*.

Ramos, F., Trilles, S., Torres-Sospedra, J., & Perales, F. J. (2018). New trends in using augmented reality apps for smart city contexts. *ISPRS International Journal of Geo-Information*, *7*(12). https://doi.org/10.3390/ijgi7120478

Rashidi, P., Cook, D. J., Holder, L. B., & Schmitter-Edgecombe, M. (2011). Discovering activities to recognize and track in a smart environment. *IEEE Transactions on Knowledge and Data Engineering,* 23(4), 527-539. https://doi.org/10.1109/TKDE.2010.148

Reilly, W., Wolfe, R., & Smith, M. (2006). MIT's CWSpace project: Packaging metadata for archiving educational content in DSpace. *International Journal on Digital Libraries*, 6(2), 139–147. https://doi.org/10.1007/s00799-005-0131-2

Ren, G., Zhang, X., & Duan, S. (2018). Articulatory-acoustic analyses of Mandarin words in

emotional context speech for smart campus. *IEEE Access*, *6*, 48418–48427. https://doi.org/10.1109/ACCESS.2018.2865831

Rico-Bautista, D., Maestre-Góngora, G. P., & Guerrero, C. D. (2020). Smart university: Characterization of the current situation of intelligent technologies, based on two case studies [Caracterización de la situación actual de las tecnologías inteligentes para una universidad inteligente en Colombia/latinoamérica]. *RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao*, *2020*(E27), 484–501.

Rico-Bautista, D., Medina-Cárdenas, Y., Coronel-Rojas, L. A., Cuesta-Quintero, F., Barrientos-Avendaño, E., León, R. A. G., & Maestre-Góngora, G. P. (2020). Smart university: Strategic map since the adoption of technology [Universidad inteligente: Mapa estratégico desde la adopción de tecnología]. *RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao*, *2020*(E28), 711–724.

Ritala, P., Agouridas, V., Assimakopoulos, D., & Gies, O. (2013). Value creation and capture mechanisms in innovation ecosystems: a comparative case study. *International Journal of Technology Management*. https://doi.org/10.1504/ijtm.2013.056900

Romli, R., Sen, N. W., Ghazali, N. H., & Zahri, N. A. H. (2020). An augmented reality (Ar) marker-based application for smart campus: Unimap residential college. *Journal of Advanced Research in Dynamical and Control Systems*, 12(7 Special Issue), 2892–2899. https://doi.org/10.5373/JARDCS/V12SP7/20202432

Ruttala, U. K., Balamurugan, M. S., & Chakravarthi, M. K. (2015). NFC based smart campus payment system. Indian *Journal of Science and Technology*, 8(19). https://doi.org/10.17485/ijst/2015/v8i19/77134

Sanchez-Torres, B., Alberto Rodriguez-Rodriguez, J., Willmer Rico-Bautista, D., & Guerrero, C. D. (2018). Smart Campus: Trends in cybersecurity and future development. *REVISTA Facultad De Ingenieria, Universidad Pedagogica Y Tecnologica De Colombia*, *27*(47), 93–101. https://doi.org/10.19053/01211129.v27.n47.2018.7807

Santa, J., Fernández, P. J., Sanchez-Iborra, R., Ortiz, J., & Skarmeta, A. F. (2018). Offloading Positioning onto Network Edge. *Wireless Communications and Mobile Computing*, 2018. https://doi.org/10.1155/2018/7868796

Scholz, R. W. (2020). Transdisciplinarity: science for and with society in light of the university's roles and functions. *Sustainability Science*, *15*(4). https://doi.org/10.1007/s11625-020-00794-x

Segredo, E., Miranda, G., & Leon, C. (2017). Towards the Education of the Future: Computational Thinking as a Generative Learning Mechanism. *Education In The Knowledge Society*, *18*(2), 33–58. https://doi.org/10.14201/eks2017182335

Seidita, V., & Chella, A. (2017). Representing social intelligence: An agent-based modeling application. *Biologically Inspired Cognitive Architectures*, 22, 35–43. https://doi.org/10.1016/j.bica.2017.09.005

Selvaperumal, S. K., Al-Gumaei, W., Abdulla, R., & Thiruchelvam, V. (2019). Integrated wireless monitoring system using lora and node-red for university building. *Journal of Computational and Theoretical Nanoscience*, 16(8), 3384–3394. https://doi.org/10.1166/jctn.2019.8297

Seuring, S., & Gold, S. (2012). Conducting content-analysis based literature reviews in supply chain management. In *Supply Chain Management* (Vol. 17, Issue 5). https://doi.org/10.1108/13598541211258609

Sever, I. (2015). Importance-performance analysis: A valid management tool? *Tourism Management*, *48*. https://doi.org/10.1016/j.tourman.2014.10.022

Siddiqui, M. S., Husain, M., Alsaawy, Y., Noor, F., Rahman, A., Aljohaif, M., & Khan, K. R. (2019). Intelligent Platform to Enable Diverse Demand Response and Energy

Conservation Applications. *International Journal of Computer Science and Network Security*, 19(4), 195–200.

Silva, F. C., Ahmed, M. A., Martínez, J. M., & Kim, Y.-C. (2019). Design and implementation of a blockchain-based energy trading platform for electric vehicles in smart campus parking lots. *Energies*, 12(24), 4814. https://doi.org/10.3390/en12244814

Silva-Da-Nóbrega, P. I., & Chim-Miki, A. F. (2021). Decision making based on citizens standpoint: An Importance-Performance Analysis of Smart City Indicators. *International Journal of Management and Decision Making*, *20*(1). https://doi.org/10.1504/ijmdm.2021.10034295

Singh, J. J., Ravi, N. N., & Krishnan, P. S. (2018). Iot based parking sensor network for smart campus. *International Journal of Engineering and Technology (UAE),* 7(4), 26–34. https://doi.org/10.14419/ijet.v7i4.35.22316

Sinkovics, R., & Alfoldi, E. A. (2012). Facilitating the interaction between theory and data in qualitative research using CAQDAS. *Qualitative Organizational Research*: Core Methods and Current Challenges, 109–131.

Söderström, O. (2020). The three modes of existence of the pandemic smart city. *Urban Geography*. https://doi.org/10.1080/02723638.2020.1807167

Soldatos, J., Kefalakis, N., Serrano, M., & Hauswirth, M. (2014). Design principles for utility-driven services and cloud-based computing modelling for the Internet of Things. *International Journal of Web and Grid Services*, *10*(2–3), 139–167. https://doi.org/10.1504/ijwgs.2014.060254

Song, D., Shi, D., Wang, R., & Xu, H. (2018). Splitting and combining as a gamification method in engaging structured knowledge learning. *Sustainability (Switzerland),* 10(3), 800. https://doi.org/10.3390/su10030800

Song, Y. (2020). Application of mobile education in assisted autonomous learning platforms in intelligent campus. *International Journal of Continuing Engineering Education and Life-Long Learning*, 30(2), 104–119. https://doi.org/10.1504/IJCEELL.2020.106347

Staškevičiute, I., & Neverauskas, B. (2008). The intelligent university's conceptual model. *Engineering Economics*, *4*(59), 53–58.

Stavropoulos, T G, Koutitas, G., Vrakas, D., Kontopoulos, E., & Vlahavas, I. (2016). A smart university platform for building energy monitoring and savings. *Journal of Ambient Intelligence and Smart Environments*, 8(3), 301–323. https://doi.org/10.3233/AIS-160375

Stavropoulos, Thanos G., Gottis, K., Vrakas, D., & Vlahavas, I. (2013). AWESoME: A web service middleware for ambient intelligence. *Expert Systems with Applications*, 40(11), 4380–4392. https://doi.org/10.1016/j.eswa.2013.01.061

Streitz, N. A., Röcker, C., Prante, T., van Alphen, D., Stenzel, R., & Magerkurth, C. (2005). Designing smart artifacts for smart environments. *Computer,* 38(3), 41-49. https://doi.org/10.1109/MC.2005.92

Sun, R., Xi, J., Yin, C., Wang, J., & Kim, G.-J. (2018). Location privacy protection research based on querying anonymous region construction for smart campus. *Mobile Information Systems,* 2018. https://doi.org/10.1155/2018/3682382

Sun, Y., Yan, H., Lu, C., Bie, R., & Zhou, Z. (2014). Constructing the Web of Events from raw data in the Web of Things. *Mobile Information Systems*, 10(1), 105–125. https://doi.org/10.3233/MIS-130173

Sutjarittham, T., Gharakheili, H. H., Kanhere, S. S., & Sivaraman, V. (2019). Experiences with IoT and AI in a Smart Campus for Optimizing Classroom Usage. *IEEE Internet of Things Journal*, 6(5, SI), 7595–7607. https://doi.org/10.1109/JIOT.2019.2902410

Tagliabue, L. C., Manfren, M., Ciribini, A. L. C., & De Angelis, E. (2016). Probabilistic behavioural modeling in building performance simulation—The Brescia eLUX lab. *Energy and Buildings*, 128, 119–131. https://doi.org/10.1016/j.enbuild.2016.06.083

Tao, M., Wei, W., Yuan, H., & Huang, S. (2019). Version-vector based video data online cloud backup in smart campus. *Multimedia Tools and Applications*, 78(3), 3435–3456. https://doi.org/10.1007/s11042-018-6106-2

Te Velde, D. (2016). The relevance of reformed scholasticism for contemporary systematic theology. *Perichoresis*, *14*(3). https://doi.org/10.1515/perc-2016-0018

Tian, Z., Cui, Y., An, L., Su, S., Yin, X., Yin, L., & Cui, X. (2018). A real-time correlation of host-level events in cyber range service for smart campus. *IEEE Access*, *6*, 35355–35364. https://doi.org/10.1109/ACCESS.2018.2846590

Tikhonova, E. P. (2019). Possibilities Of Digital Culture In Searching Of Educational New Technologies And Academia Formation. *Vestnik Tomskogo Gosudarstvennogo Universiteta-Kulturologiya I Iskusstvovedenie-Tomsk State University Journal Of Cultural Studies And Art History*, *33*, 110–119. https://doi.org/10.17223/22220836/33/9

Tita, V., Bold, N., Popescu, D. A., & Nijloveanu, D. (2018). Modelling Smart Economy and Education-Related Environments Using System Dynamics Principles. *Scientific Papers-Series Management Economic Engineering In Agriculture And Rural Development*, 18(2), 471–474.

Torres-Sospedra, J., Avariento, J., Rambla, D., Montoliu, R., Casteleyn, S., Benedito-Bordonau, M., Gould, M., & Huerta, J. (2015). Enhancing integrated indoor/outdoor mobility in a smart campus. *International Journal of Geographical Information Science*, *29*(11), 1955–1968. https://doi.org/10.1080/13658816.2015.1049541

Toutouh, J., Arellano, J., & Alba, E. (2018). BiPred: A Bilevel Evolutionary Algorithm for Prediction in Smart Mobility. *Sensors (Basel, Switzerland),* 18(12), 4123. https://doi.org/10.3390/s18124123

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management,* 14(3), 207-222. https://doi.org/10.1111/1467-8551.00375

Tuttas, C. A. (2015). Lessons learned using web conference technology for online focus group interviews. *Qualitative Health Research*, *25*(1). https://doi.org/10.1177/1049732314549602

Ullah, I., Hussain, I., Uthansakul, P., Riaz, M., Khan, M. N., & Lloret, J. (2020). Exploiting multi-verse optimization and sine-cosine algorithms for energy management in smart cities. *Applied Sciences (Switzerland),* 10(6), 2095. https://doi.org/10.3390/app10062095

United Nations Transforming Our World: the 2030 Agenda for Sustainable Development. A/RES/70/1, 16301 United Nations (2015).

United Nations. (2020). *The Sustainable Development Goals Report 2020*. https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf

Uskov, V. L., Bakken, J. P., Pandey, A., Singh, U., Yalamanchili, M., & Penumatsa, A. (2016). Smart university taxonomy: features, components, systems. In *Smart education and e-learning 2016* (pp. 3-14). Springer, Cham. https://doi.org/10.1007/978-3-319-39690-3_1

Valks, B., Arkesteijn, M. H., Den Heijer, A. C., & Vande Putte, H. J. M. (2018). Smart campus tools – adding value to the university campus by measuring space use real-time. *Journal of Corporate Real Estate*, 20(2), 103–116. https://doi.org/10.1108/JCRE-03-2017-0006

Valks, B., Arkesteijn, M. H., Koutamanis, A., & den Heijer, A. C. (2020). Towards a smart campus: supporting campus decisions with Internet of Things applications. *Building Research and Information*, 1–20. https://doi.org/10.1080/09613218.2020.1784702

Valks, B., Arkesteijn, M., & Den Heijer, A. (2019). Smart campus tools 2.0 exploring the use of real-time space use measurement at universities and organizations. *Facilities*, 37(13–14), 961–980. https://doi.org/10.1108/F-11-2018-0136

Vasileva, R., Rodrigues, L., Hughes, N., Greenhalgh, C., Goulden, M., & Tennison, J. (2018). What smart campuses can teach us about smart cities: User experiences and open data. *Information (Switzerland)*, *9*(10). https://doi.org/10.3390/info9100251

Vienni Baptista, B., Vasen, F., & Villa Soto, J. C. (2019). Interdisciplinary Centers in Latin American Universities: The Challenges of Institutionalization. *Higher Education Policy*, 32(3). https://doi.org/10.1057/s41307-018-0092-x

Villarreal, O., & Calvo, N. (2015). From the Triple Helix model to the Global Open Innovation model: A case study based on international cooperation for innovation in Dominican Republic. *Journal of Engineering and Technology Management* - JET-M, 35, 71-92. https://doi.org/10.1016/j.jengtecman.2014.10.002

Villegas-Ch, W., Arias-Navarrete, A., & Palacios-Pacheco, X. (2020). Proposal of an Architecture for the Integration of a Chatbot with Artificial Intelligence in a Smart Campus for the Improvement of Learning. *Sustainability (Switzerland)*, *12*(4). https://doi.org/10.3390/su12041500

Villegas-Ch, W., Palacios-Pacheco, X., & Román-Cañizares, M. (2020). Integration of IoT and blockchain to in the processes of a university campus. *Sustainability (Switzerland)*, *12*(12). https://doi.org/10.3390/su12124970

Villegas-Ch, William, Molina-Enriquez, J., Chicaiza-Tamayo, C., Ortiz-Garcés, I., & Luján-Mora, S. (2019). Application of a Big Data Framework for Data Monitoring on a Smart Campus. Sustainability, 11(20), 5552.

Wang, H. I. (2014). Constructing the green campus within the internet of things architecture. *International Journal of Distributed Sensor Networks*, 10(3), 804627. https://doi.org/10.1155/2014/804627

Wang, L., Yao, C., Yang, Y., & Yu, X. (2018). Research on a Dynamic Virus Propagation Model to Improve Smart Campus Security. *IEEE Access*, 6, 20663–20672. https://doi.org/10.1109/ACCESS.2018.2817508

Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N., & Nelson, L. E. (2009). Helping CIOs understand "smart city" initiatives. *Growth*, 17(2), 1-17. https://doi.org/10.1029/2004RS003041

Wen, J., Zhou, Z., Shi, Z., Wang, J., Duan, Y., & Zhang, Y. (2018). Crossing scientific workflow fragments discovery through activity abstraction in smart campus. *IEEE Access*, 6, 40530–40546. https://doi.org/10.1109/ACCESS.2018.2857482

Weng, Y., Zhang, N., & Xia, C. (2019). Multi-Agent-Based Unsupervised Detection of Energy Consumption Anomalies on Smart Campus. *IEEE Access*, 7, 2169–2178. https://doi.org/10.1109/ACCESS.2018.2886583

Williamson, B. (2018). The hidden architecture of higher education: building a big data infrastructure for the 'smarter university.' *International Journal of Educational Technology in Higher Education,* 15(1), 1-26. https://doi.org/10.1186/s41239-018-0094-1

Woodyatt, C. R., Finneran, C. A., & Stephenson, R. (2016). In-Person Versus Online Focus Group Discussions: A Comparative Analysis of Data Quality. *Qualitative Health Research*, *26*(6). https://doi.org/10.1177/1049732316631510

Wu, F., Zheng, Q., Tian, F., Suo, Z., Zhou, Y., Chao, K.-M., Xu, M., Shah, N., Liu, J., & Li, F. (2020). Supporting poverty-stricken college students in smart campus. *Future Generation Computer Systems*, *111*, 599–616. https://doi.org/10.1016/j.future.2019.09.017

Xia, Z., Ma, X., Shen, Z., Sun, X., Xiong, N. N., & Jeon, B. (2018). Secure image LBP feature extraction in cloud-based smart campus. *IEEE Access*, 6, 30392–30401. https://doi.org/10.1109/ACCESS.2018.2845456

Xing, C.-J., Yuan, L., Yang, X., Lai, T.-P., & Zhang, Z.-K. (2014). Research and practice on self-service terminal in smart campus. *Tongxin Xuebao/Journal on Communications*, *35*, 118–123. https://doi.org/10.3969/j.issn.1000-436x.2014.z1.023

Xu, Q., Su, Z., Wang, Y., & Dai, M. (2018). A trustworthy content caching and bandwidth allocation scheme with edge computing for smart campus. *IEEE Access*, 6, 63868–63879. https://doi.org/10.1109/ACCESS.2018.2872740

Xu, T., Li, T., & Dong, X. (2018). Efficient High Utility Negative Sequential Patterns Mining in Smart Campus. *IEEE Access*, 6, 23839–23847. https://doi.org/10.1109/ACCESS.2018.2827167

Xu, X., Li, D., Sun, M., Yang, S., Yu, S., Manogaran, G., … Mavromoustakis, C. X. (2019). Research on Key Technologies of Smart Campus Teaching Platform Based on 5G Network. *IEEE Access*, *7*, 20664–20675. https://doi.org/10.1109/ACCESS.2019.2894129

Xu, X., Wang, Y., & Yu, S. (2018). Teaching performance evaluation in smart campus. *IEEE Access*, *6*, 77754–77766. https://doi.org/10.1109/ACCESS.2018.2884022

Yang, A. M., Li, S. S., Ren, C. H., Liu, H. X., Han, Y., & Liu, L. (2018). Situational Awareness System in the Smart Campus. *IEEE Access*, *6*, 63976–63986. https://doi.org/10.1109/ACCESS.2018.2877428

Yang, C. T., Chen, S. T., Liu, J. C., Liu, R. H., & Chang, C. L. (2020). On construction of an energy monitoring service using big data technology for the smart campus. *Cluster Computing*, 23(1), 265–288. https://doi.org/10.1007/s10586-019-02921-5

Yange, C., Xiaopin, Y., Zhili, Z., & Liang, Z. (2016). Study and Design of SDN Intelligent Campus Architecture Based on IPv6. *International Journal of Future Generation Communication and Networking*, *9*(12), 361–369. https://doi.org/10.14257/ijfgcn.2016.9.12.33

Yim, J., Joo, J., Lee, G., & Shim, K. (2014). Design and implementation of a smart campus guide android app. *Applied Mathematics and Information Sciences*, 8(1 L), 47–53. https://doi.org/10.12785/amis/081L07

Yin, R. K. (2014). Case study research: Design and methods (5th ed.). In *Thousand Oaks*, CA: SAGE Publications.

Ying, H. (2017). Study on the key algorithms and framework design of intelligent campus education platform based on big data technology. *Boletin Tecnico/Technical Bulletin*, 55(18), 63–69.

Yu, C., Qi, H., Chen, H., Zhao, S., & Wang, S. (2019). ICampusGuide: A multi-purpose guide system in intelligent campus. *International Journal of Simulation and Process Modelling*, 14(6), 546–558. https://doi.org/10.1504/IJSPM.2019.106173

Yu, J.-F., Hu, H.-Y., Li, Y.-C., Xiang, L.-H., Yang, B., Zhou, Y.-G., & Zhou, F.-M. (2017). The design and implement of monitoring system for intelligent university archive room based on zigbee wireless sensor networks. *Journal of Computers (Taiwan),* 28(3), 215–234. https://doi.org/10.3966/199115592017062803018

Zapata-Ros, M. (2018). The smart university The transition from Learning Management Systems (LMS) to Smart Learning Systems (SLS) in Higher Education . *Revista de Educacion a Distancia*, *57*. https://doi.org/10.6018/red/57/10

Zeng, Y., & Li, X. (2018). Intelligent security system of computer room on smart campus. *Journal of Advanced Oxidation Technologies*, 21(2). https://doi.org/10.26802/jaots.2018.09328

Zhai, X., Dong, Y., & Yuan, J. (2018). Investigating Learners' Technology Engagement - A Perspective from Ubiquitous Game-Based Learning in Smart Campus. *IEEE Access*, 6, 10279–10287. https://doi.org/10.1109/ACCESS.2018.2805758

Zhang, W., & Jiang, L. (2018). Algorithm Analysis for Big Data in Education Based on Depth Learning. *Wireless Personal Communications*, 102(4), 3111–3119. https://doi.org/10.1007/s11277-018-5331-3

Zhang, W., Zhang, X., & Shi, H. (2018). MMCSACC: A Multi-Source Multimedia Conference System Assisted by Cloud Computing for Smart Campus. *IEEE Access*, 6, 35879–35889. https://doi.org/10.1109/ACCESS.2018.2851956

Zheng, L., Song, C., Cao, N., Li, Z., Zhou, W., Chen, J., & Meng, L. (2018). A New Mutual Authentication Protocol in Mobile RFID for Smart Campus. *IEEE Access*, 6, 60996–61005. https://doi.org/10.1109/ACCESS.2018.2875973

Zheng, W., Pan, H., & Peng, Y.-S. (2018). Explore the ubiquitous learning on Campus: A friendship-based knowledge diffusion approach. *IEEE Access*, 6, 56238–56245. https://doi.org/10.1109/ACCESS.2018.2872785

Zheng, W., Yang, Z., Feng, L., Fu, P., & Shi, J. (2019). APP design of energy monitoring in smart campus based on android system. *International Journal of Online and Biomedical Engineering*, *15*(5), 18–27. https://doi.org/10.3991/ijoe.v15i05.8225

Zhou, Z., Yu, H., & Shi, H. (2020). Optimization of Wireless Video Surveillance System for Smart Campus Based on Internet of Things. *IEEE Access*, 8, 136434–136448. https://doi.org/10.1109/ACCESS.2020.3011951

Zhu, W., Jiang, M., Deng, M. Y., & Hu, J. (2018). Fast scattering center extraction with ddm based on compressive sensing for isar imaging. *IEEE Access*, 6, 49746–49754. https://doi.org/10.1109/ACCESS.2018.2868740

Zong, P., Zhu, H.-B., Huang, G., & Xu, J.-Z. (2010). Research and design of Smart Campus based on Internet of Things. *Nanjing Youdian Daxue Xuebao (Ziran Kexue Ban)/Journal of Nanjing University of Posts and Telecommunications (Natural Science),* 30(4), 15-19+51.

Zuhedy Zay, A. Z., Mohd Nor, R., Mohamed Razi, M. J., Mantoro, T., & Ayu, M. A. (2016). NFC based attendance: More than just a touch. *Jurnal Teknologi,* 78(9–3), 69–78. https://doi.org/10.11113/jt.v78.9720

APPENDIX 1. FOCUS GROUP ASYNCHRONOUS SESSION QUESTIONNAIRE

CUESTIONÁRIO - FOCUS GROUP

¡Saludos!

Le invitamos a contribuir con el Focus Group para la investigación de disertación del estudiante Pedro Ivo Silva da Nóbrega del Programa de Posgrado en Administración de la Universidad Federal de Campina Grande - UFCG (Brasil), bajo la dirección de la profesora Dra. Adriana Fumi Chim Miki (UFCG) y co-dirección de la Profesora Dra. Marysol Castillo Palacio (Pontíficia Universidad Javeriana, Colombia).

El objetivo del grupo focal es definir indicadores para las dimensiones del Smart Campus en el contexto Latinoamericano. Entendemos que usted es un experto en Smart Campus, que reside o ha vivido en Latinoamérica, o que tiene experiencia con Smart Campus en la región.

La información recopilada será organizada, analizada, y posteriormente presentada, en forma de artículo y tesis. No hay riesgos para los participantes de la investigación que respeta la ética y el rigor científico. No se pagará ningún tipo de bonificación por su participación. Los datos recopilados formarán parte de una tesis de máster, y podrán ser difundidos en eventos científicos y publicados en revistas nacionales o internacionales. Los investigadores estarán disponibles para cualquier aclaración durante todo el proceso de desarrollo de este estudio.

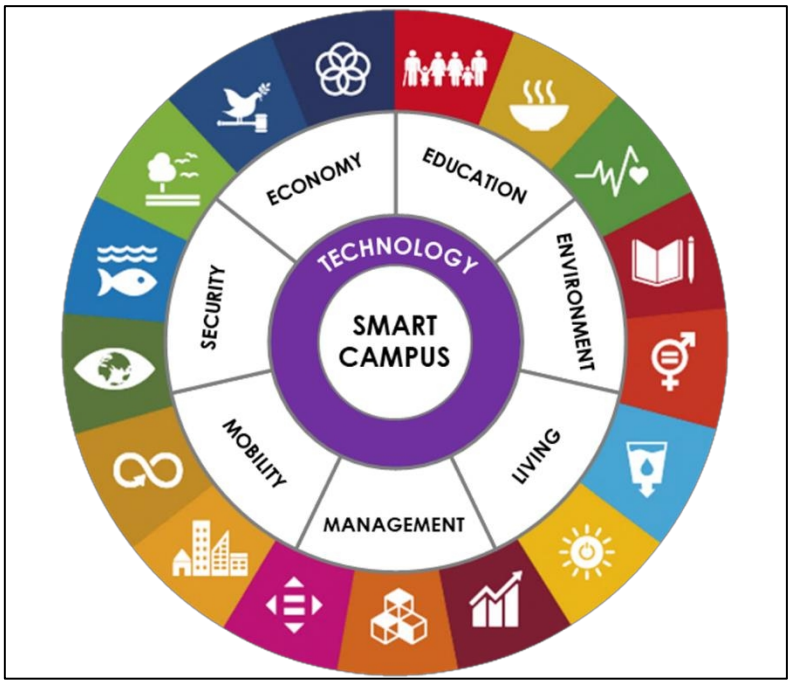
Agradecemos su participación.

Antes de continuar con el formulario, necesitamos que comprenda algunos requisites:

Acepto participar en esta investigación, manifestando que he sido debidamente informado sobre los objetivos de la investigación, los procedimientos a los que seré sometido y los posibles riesgos que pudieran derivarse de dicha participación. Se me garantizaron las aclaraciones que puedo solicitar durante la investigación y el derecho a retirarme de la participación en cualquier momento, sin que mi retirada implique ningún daño para mí. Por tanto, autorizo la publicación de los datos de la investigación.
Acepto participar en una reunión a través de Google Meet, a una fecha y hora previamente establecida, dando consentimiento para grabarla, con el único propósito de apoyar la investigación.

SESIÓN 1 - ¿Qué es un Smart Campus?

Como resultado del primer artículo de la tesis propusimos una definición y un modelo para Smart Campus, a saber:



El Smart Campus es un ecosistema de educación superior que utiliza la tecnología para lograr la tríada de la sostenibilidad (ambiental, económica y social) en un modelo de gobernanza, aprendizaje colaborativo y adaptativo para promover una mejor habitabilidad para sus partes interesadas.

Estoy de acuerdo.
No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

SESIÓN 2 - Smart Dimensiones

También propusimos un conjunto de dimensiones que conforman un smart campus.

A medida que continúe, se encontrará con cada definición de las dimensiones y propondrá indicadores en consecuencia. Además, puedes sugerir cambios según su experiencia.

2.1. Smart Economy

Smart Economy promueve servicios y sistemas de pago personalizados, seguros e inteligentes que se enfocan en mejoras a la economía dentro del campus e impulsa la economía local y las ideas comerciales.

Estoy de acuerdo.
No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

Sugiero como indicadores para componer una Smart Economy de un Smart Campus...

2.2. Smart Education

Smart Education crea un entorno abierto, activo y colaborativo para el aprendizaje y la enseñanza a través de servicios y tecnologías inteligentes.

Estoy de acuerdo.
No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

Sugiero como indicadores para componer una Smart Education de un Smart Campus...

2.3. Smart Environment

Smart Environment hace un campus sostenible y eco-friendly.

Estoy de acuerdo.
No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

Sugiero como indicadores para componer una Smart Environment de un Smart Campus...

2.4. Smart Living

Smart Living proporciona una mejor habitabilidad en el campus a través del estímulo y el apoyo a la salud, el desarrollo de los estudiantes y los servicios de vida inteligente.

Estoy de acuerdo.
No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

Sugiero como indicadores para componer una Smart Living de un Smart Campus...

2.5. Smart Management

Smart Management crea un entorno integrador, transparente y abierto y un modelo de gestión del campus con la participación activa de las partes interesadas y enfocado en el uso eficiente de los recursos.

Estoy de acuerdo.

No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

Sugiero como indicadores para componer una Smart Management de un Smart Campus...

2.6. Smart Mobility

Smart Mobility combina tecnologías para hacer que la movilidad sea más cómoda, eficaz y sostenible en el campus.

Estoy de acuerdo.
No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

Sugiero como indicadores para componer una Smart Mobility de un Smart Campus...

2.7. Smart Security

Smart Security protege a las personas tanto en el contexto físico como virtual dentro del campus.

Estoy de acuerdo.
No estoy de acuerdo.

No estoy de acuerdo con la definición, ustedes podrían mejorar...

Sugiero como indicadores para componer una Smart Security de un Smart Campus...

SESIÓN 3 – Datos demográficos

Nombre

Universidad/Organización/Local de trabajo

¿Cuál es tu conexión con Smart Campus?

Investigo sobre el tema
Trabajo en un Smart Campus
Trabajé en un proyecto de Smart Campus
Otro

¿Cuál es el mejor momento para realizar la reunión (GMT-5)?

Mañana (8:00 - 10:00)
Mañana (10:00 - 12:00)
Tarde (14:00 - 16:00)
Tarde (16:00 - 18:00)
Noche (18:00 - 20:00)
Noche (20:00 - 22:00)

Gracias por tu participación, te enviaremos por correo electrónico el resultado de los formularios para justificar mejor la reunión, además de enviarte información sobre el día del focus group.

APPENDIX 2. FOCUS GROUP PARTICIPANTS

NAME	UNIVERSITY	COUNTRY	FUNCTION
Researchers			
Adriana Fumi Chim Miki	Universidade Federal de Campina Grande	Brazil	Support
Marysol Castillo Palacios	Pontifícia Universidad Javeriana de Cali	Colombia	Support
Pedro Ivo Silva da Nóbrega	Universidade Federal de Campina Grande	Brazil	Host
Invitees			
Ailyn Febles Estrada	Unión de Informáticos de Cuba	Cuba	Panelist
Auta Inês Medeiros Lucas D'oliveira	Universidad San Buenaventura de Medellín	Colombia	Panelist
Dewar Willmer Rico-Bautista	Universidad Francisco de Paula Santander Ocaña	Colombia	Panelist
Emanuel Barbosa de Carvalho	Universidade Federal de Campina Grande	Brazil	Secretary
Gina Paola Maestre-Góngora	Universidad Cooperativa de Colombia	Colombia	Panelist
Ignacio Aguaded	Universidad de Huelva	Spain	Panelist
Leonardo Correa Velasquez	Universidad Pontificia Bolivariana	Colombia	Panelist
Lucelia Rodrigues	University of Nottingham	England	Panelist
Mauricio José Cortes Rodríguez	Pontifícia Universidad Javeriana de Cali	Colombia	Panelist
Paúl Oswaldo Sarango-Lalangui	Universidad Técnica Particular de Loja	Ecuador	Panelist
Regiane Relva Romano	Centro Universitário FACENS	Brazil	Panelist

APPENDIX 3. SURVEY FOR THE STUDENTS

QUESTIONÁRIO SOBRE SMART CAMPUS

Olá, o questionário que você vai responder agora, tem o objetivo de coletar dados sobre a Universidade Federal de Campina Grande, para uma pesquisa de Dissertação do Programa de Pós-graduação em Administração pela UFCG (PPGA/UFCG) do estudante Pedro Ivo Silva da Nóbrega, sob orientação da professora Dra. Adriana Fumi Chim Miki (UFCG) e co-orientação da professora Dra. Marysol Castillo Palacio (Pontíficia Universidad Javeriana, Colombia).

As informações coletadas serão organizadas, analisadas e, posteriormente, apresentadas na forma de artigo e dissertação. Não há riscos para os participantes de pesquisas que respeitem a ética e o rigor científico. Nenhum bônus será pago pela sua participação. Os dados coletados farão parte de uma dissertação de mestrado, podendo ser divulgados em eventos científicos e publicados em periódicos nacionais ou internacionais. Os pesquisadores estarão à disposição para qualquer esclarecimento ao longo do processo de desenvolvimento deste estudo.

Caso haja alguma dúvida, favor contactar o pesquisador: pedro.nobrega@estudante.ufcg.edu.br

Desde já, MUITO OBRIGADO por sua participação! =)

Antes de seguir respondendo o formulário, precisamos que você compreenda:

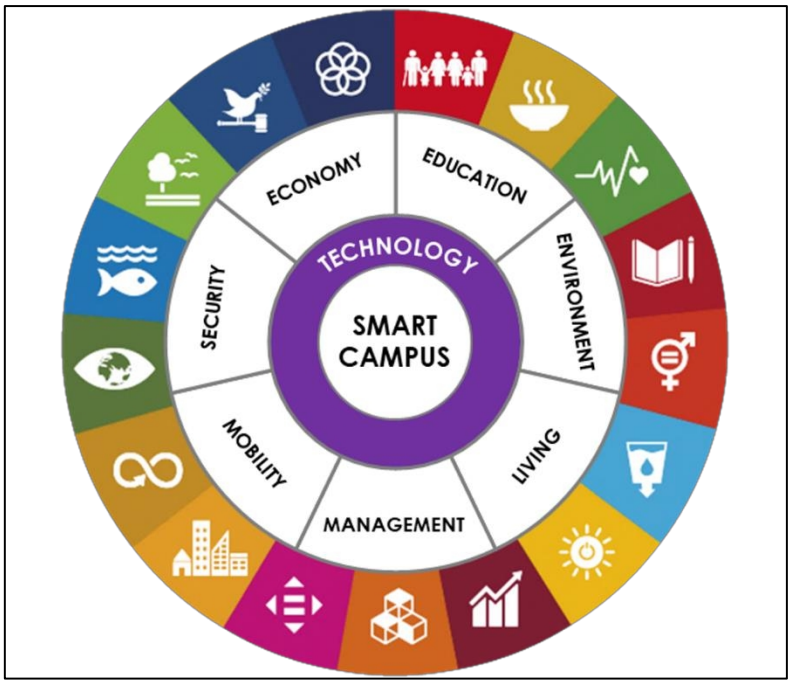
Concordo em participar desta pesquisa, informando que fui devidamente informado sobre os objetivos da pesquisa, os procedimentos a que serei submetido e os possíveis riscos que possam advir de tal participação. Foram-me garantidos os esclarecimentos que posso solicitar durante a investigação e o direito de desistir da participação a qualquer momento, sem que a minha desistência me prejudique. Portanto, autorizo a publicação dos dados da pesquisa.

Você tem vínculo com a UFCG?

Sim, sou estudante de graduação.
Sim, sou estudante de pós-graduação.
Não tenho vínculo na UFCG.

SESSÃO 1 - O QUE É UM SMART CAMPUS (universidade inteligente)?

O Smart Campus é uma instituição de ensino superior que cria um ecossistema usando Tecnologias de Informação e Comunicação (TIC) para alcançar a sustentabilidade em um modelo de governança, colaboração e aprendizagem adaptativa para promover melhor vivência aos seus stakeholders. O smart campus é composto por oito dimensões inteligentes, sendo a Smart Tecnologia uma dimensão transversal, ou seja, ela está presente em todas as outras.



Ok, entendi. Vamos lá!

SESSÃO 3 - AVALIE A UFCG – ECONOMIA

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA					REALIDADE				
Em meu campus, é possível efetuarmos transações eletrônicas como: pagar taxas de faculdade ou fazer pagamentos em lojas. *DICA: Nesse sentido, deve-se avaliar as transações eletrônicas existentes na universidade, como compras.*	1	2	3	4	5	1	2	3	4	5
Meu Campus apoia ideias de negócios. *DICA: Por exemplo, por meio de centros de empreendedorismo, spin-offs, centros de inovação, incubadoras de empreendedores, centros especializados, etc.*	1	2	3	4	5	1	2	3	4	5
Meu campus possui redes de economia colaborativa ou ações de economia compartilhada. *DICA: A economia colaborativa promove ações colaborativas, como um grupo de alunos compartilhando transporte*	1	2	3	4	5	1	2	3	4	5
Meu campus apoia o desenvolvimento econômico local com projetos e ações voltadas para a comunidade. *DICA: Você vai avaliar se sua universidade apoia o desenvolvimento de estabelecimentos comerciais locais, por exemplo abrindo espaço para comércio local dentro da universidade, oferecendo cursos básicos de negócios para os comerciantes locais, entre outros.*	1	2	3	4	5	1	2	3	4	5
Meu campus possui um departamento ou setor para apoiar a empregabilidade.	1	2	3	4	5	1	2	3	4	5

DICA: Você vai avaliar se a universidade promove ações que contribuam para a inserção e/ou manutenção de seus alunos no mercado de trabalho.											

SESSÃO 4 - AVALIE A UFCG – EDUCAÇÃO

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA					REALIDADE				
Meu campus possui e/ou utiliza tecnologias inteligentes para o ensino. *DICA: Nesse sentido, você deve avaliar o uso de tecnologias inteligentes para o ensino, como Inteligência Artificial, Internet das Coisas, entre outras.*	1	2	3	4	5	1	2	3	4	5
Meu campus possui Internet banda larga de boa qualidade aberta e disponível para todos. *DICA: Por exemplo, disponibilidade de Internet WiFi em todos os departamentos e salas de aula.*	1	2	3	4	5	1	2	3	4	5
Meu campus consulta a comunidade sobre suas necessidades educacionais. *DICA: Você avaliará se a universidade consulta a comunidade sobre as necessidades educacionais, por exemplo, um curso mais relevante.*	1	2	3	4	5	1	2	3	4	5
Meu campus monitora o nível de satisfação dos alunos e funcionários. *DICA: Você vai avaliar se a universidade mede a satisfação, por exemplo, por meio de questionários. Lembrando que você valoriza a importância disso para as universidades em geral e como funciona na sua universidade.*	1	2	3	4	5	1	2	3	4	5
Meu campus utiliza metodologias de ensino e aprendizagem baseadas em resultados. *DICA: Você avaliará se a universidade utiliza a aprendizagem baseada em resultados, ou seja, são realizadas atividades de aprendizagem com foco em resultados e com competências específicas e demonstráveis.*	1	2	3	4	5	1	2	3	4	5

SESSÃO 5 - AVALIE A UFCG – AMBIENTE

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA						REALIDADE				
Meu campus desenvolve ações voltadas aos Objetivos de Desenvolvimento Sustentável (ODS). *DICA: Nesse sentido, as ações da universidade em relação aos ODS devem ser avaliadas, por exemplo, na promoção da redução das desigualdades.*	1	2	3	4	5		1	2	3	4	5
Em meu campus, existem ações para proteger a biodiversidade local. *DICA: Por exemplo, catalogação de espécies locais, proteção de espaços verdes dentro do campus, etc.*	1	2	3	4	5		1	2	3	4	5
Meu campus utiliza bioenergia e tecnologias inteligentes para gerenciar recursos de água e energia, como iluminação automatizada. *DICA: Você vai avaliar se a universidade usa tecnologias inteligentes para gerenciar energia e água no campus, por exemplo, acendendo e apagando luzes com sensores.*	1	2	3	4	5		1	2	3	4	5
Meu campus possui edifícios inteligentes, por exemplo, edifícios com gerenciamento automatizado de recursos. *DICA: Você vai avaliar se a universidade utiliza prédios inteligentes, com interligação, automação de recursos elétricos e hídricos, entre outros.*	1	2	3	4	5		1	2	3	4	5
Meu campus realiza ações de reciclagem.	1	2	3	4	5		1	2	3	4	5

SESSÃO 6 - AVALIE A UFCG – GESTÃO

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA						REALIDADE				
Meu campus possui uma gestão focada no uso sustentável dos recursos. *DICA: Você vai avaliar se a universidade foca na sustentabilidade dos recursos que utiliza.*	1	2	3	4	5		1	2	3	4	5
Meu campus divulga sua prestação de contas anualmente. *DICA: Por exemplo, a publicação de rendimentos no site da universidade.*	1	2	3	4	5		1	2	3	4	5
Meu campus realiza planejamento estratégico participativo. *DICA: Você avaliará se a universidade realiza seu planejamento estratégico de forma participativa com professores, técnicos, funcionários e alunos.*	1	2	3	4	5		1	2	3	4	5
Meu campus tem uma plataforma de gerenciamento de processos online. *DICA: Você vai avaliar se a universidade possui uma plataforma virtual para gerenciar processos.*	1	2	3	4	5		1	2	3	4	5

SESSÃO 7 - AVALIE A UFCG – VIVÊNCIA

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA						REALIDADE				
Qualidade de vida e bem-estar são monitorados em meu campus. *DICA: Você vai avaliar se a universidade mede os níveis de qualidade de vida, por exemplo, por meio de questionários e pesquisas.*	1	2	3	4	5		1	2	3	4	5
Meu campus implementa programas de saúde ocupacional e bem-estar.	1	2	3	4	5		1	2	3	4	5
Meu campus mede o nível de inclusão social entre os alunos. *DICA: Você vai avaliar se a universidade mede os níveis de inclusão social, por exemplo, por meio de questionários e pesquisas.*	1	2	3	4	5		1	2	3	4	5
Meu campus possui espaços de lazer adequados.	1	2	3	4	5		1	2	3	4	5
Meu campus desenvolve atividades extracurriculares para o lazer da comunidade universitária. *DICA: Você vai avaliar se sua universidade possui atividades extracurriculares voltadas para o lazer, como esportes ou artes.*	1	2	3	4	5		1	2	3	4	5

SESSÃO 8 - AVALIE A UFCG – MOBILIDADE

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA						REALIDADE				
Há transporte público adequado para acessar meu campus. *DICA: Você vai avaliar se há transporte adequado para acessar a universidade, por exemplo, ônibus.*	1	2	3	4	5		1	2	3	4	5
Meu campus tem sinalização de trânsito adequada. *DICA: Irá avaliar se a universidade possui semáforos dentro do campus, faixas de pedestres, por exemplo.*	1	2	3	4	5		1	2	3	4	5
Meu campus incentiva ou usa transporte de baixo carbono. *DICA: Você vai avaliar se a universidade usa transporte de baixo carbono, como carregadores para carros elétricos, bicicletas.*	1	2	3	4	5		1	2	3	4	5

Meu campus incentiva o transporte colaborativo. *DICA: Por exemplo, grupo de alunos para compartilhar transporte.*	1	2	3	4	5		1	2	3	4	5
Meu campus possui instalações de apoio para bicicletas. *DICA: Por exemplo, bicicletário, instalações adequadas para tráfego e estacionamento.*	1	2	3	4	5		1	2	3	4	5

SESSÃO 9 - AVALIE A UFCG – SEGURANÇA

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA						REALIDADE				
Meu campus garante segurança física e material. *DICA: Por exemplo, presença de vigilantes e câmeras de vigilância na universidade.*	1	2	3	4	5		1	2	3	4	5
Meu campus tem protocolos de biossegurança.	1	2	3	4	5		1	2	3	4	5
Meu campus possui sistemas de tecnologia para oferecer suporte à segurança. *DICA: Por exemplo, sistemas de identificação para entrada no campus, reconhecimento facial, entre outros.*	1	2	3	4	5		1	2	3	4	5
Meu campus tem proteção contra ataques cibernéticos.	1	2	3	4	5		1	2	3	4	5
Meu campus possui protocolos de prevenção e gestão de riscos e desastres.	1	2	3	4	5		1	2	3	4	5

SESSÃO 10 - AVALIE A UFCG – TECNOLOGIA

Nesta seção, você irá avaliar a Universidade Federal de Campina Grande, com relação a alguns QUESITOS. Ao lado de cada um, você terá que marcar em duas colunas, uma de IMPORTÂNCIA, em que você vai dar sua opinião de 1 (nada importante) a 5 (muito importante); e outra de REALIDADE, em que você vai dar sua opinião de 1 (não funciona) a 5 (ótimo funcionamento).

ATENÇÃO - Para facilitar quando abrir no celular, puxa pro lado que tem opção até o 5.

ITEM	IMPORTÂNCIA						REALIDADE				
Meu campus usa tecnologias da Internet de boa qualidade. *DICA: Meu campus possui gerenciamento de dados e sistemas de interconexão.*	1	2	3	4	5		1	2	3	4	5
Meu campus possui gerenciamento de dados e sistemas de interconexão. *DICA: Por exemplo, plataforma de gerenciamento de dados do aluno.*	1	2	3	4	5		1	2	3	4	5
Meu campus possui sistemas tecnológicos para controle. *DICA: Por exemplo, sistemas de gerenciamento de recursos, como*	1	2	3	4	5		1	2	3	4	5

sensores para acionar luzes / ar condicionado, entre outros.											
Meu campus possui uma pagina na web (homepage) para oferecer e gerenciar serviços para seus stakeholders (partes interessadas). *DICA: Por exemplo: uma plataforma ou aplicativo para acesso ao cadastro escolar, cadastro, entre outros.*	1	2	3	4	5		1	2	3	4	5

SESSÃO 11 – DADOS DEMOGRÁFICOS

Sexo

Masculino
Feminino
Prefiro não declarar
Outro

Qual sua unidade acadêmica?

Qual seu campus da UFCG?

Sede - Campina Grande
Cajazeiras
Cuité
Patos
Pombal
Sousa
Sumé

Faixa etária

Abaixo de 18 anos
Entre 18 e 30 anos
Entre 31 e 40 anos
Entre 41 e 50 anos
Entre 51 e 60 anos
Acima de 61 anos

APPENDIX 4. ARTICLE 1 SUBMISSION

Gmail Pedro Ivo Nóbrega <pedroivo049@gmail.com>

RER RER-21-Aug-MS-433

RER <onbehalfof@manuscriptcentral.com> 22 de novembro de 2021 09:06
Responder a: rereditors@aera.net
Para: pedroivo049@gmail.com, adriana.c.miki@ufcg.edu.br, marysol.castillo@javerianacali.edu.co

22-Nov-2021

Dear Prof. Chim-Miki:

Your manuscript entitled "STATUS OF KNOWLEDGE ON SMART CAMPUS: IMPLICATIONS FOR EDUCATIONAL INSTITUTIONS AND SUSTAINABILITY" has been successfully submitted online and is presently being given full consideration for publication in RER.

Your manuscript ID is RER-21-Aug-MS-433.

You have listed the following individuals as authors of this manuscript:
Silva-da-Nóbrega , Pedro Ivo ; Chim-Miki, Adriana; Castillo-Palacio, Marysol

Please mention the above manuscript ID in all future correspondence or when calling the office for questions. If there are any changes in your street address or e-mail address, please log in to ScholarOne Manuscripts at https://mc.manuscriptcentral.com/rer and edit your user information as appropriate.

You can also view the status of your manuscript at any time by checking your Author Center after logging in to https://mc.manuscriptcentral.com/rer.

As part of our commitment to ensuring an ethical, transparent and fair peer review process SAGE is a supporting member of ORCID, the Open Researcher and Contributor ID (https://orcid.org/). We encourage all authors and co-authors to use ORCID iDs during the peer review process. If you have not already logged in to your account on this journal's ScholarOne Manuscripts submission site in order to update your account information and provide your ORCID identifier, we recommend that you do so at this time by logging in and editing your account information. In the event that your manuscript is accepted, only ORCID iDs validated within your account prior to acceptance will be considered for publication alongside your name in the published paper as we cannot add ORCID iDs during the Production steps. If you do not already have an ORCID iD you may login to your ScholarOne account to create your unique identifier and automatically add it to your profile.

Thank you for submitting your manuscript to RER.

Sincerely,
Dr. P. Karen Murphy
RER
rereditors@aera.net

APPENDIX 5. ARTICLE 2 SUBMISSION

Gmail — Pedro Ivo Nóbrega <pedroivo049@gmail.com>

Confirm co-authorship of submission to Technology in Society

Technology in Society <em@editorialmanager.com> 24 de novembro de 2021 18:11
Responder a: Technology in Society <support@elsevier.com>
Para: Pedro Ivo da Silva-da-Nóbrega <pedroivo049@gmail.com>

This is an automated message.

Journal: Technology in Society
Title: Smart Campus Monitor: A method to support decision-making from Latin American universities.
Corresponding Author: PhD Adriana Fumi Chim-Miki
Co-Authors: Pedro Ivo da Silva-da-Nóbrega, MsC; Marysol Castillo-Palacio, PhD
Manuscript Number:

Dear Pedro Ivo da Silva-da-Nóbrega,

The corresponding author PhD Adriana Fumi Chim-Miki has listed you as a contributing author of the following submission via Elsevier's online submission system for Technology in Society.

Submission Title: Smart Campus Monitor: A method to support decision-making from Latin American universities.

Elsevier asks all authors to verify their co-authorship by confirming agreement to publish this article if it is accepted for publication.

Please read the following statement and confirm your agreement by clicking on this link: https://www.editorialmanager.com/techis/l.asp?i=238413&l=LH8Y55IQ

I irrevocably authorize and grant my full consent to the corresponding author of the manuscript to: (1) enter into an exclusive publishing agreement with Elsevier on my behalf (or, if the article is to be published under a CC BY license, a non-exclusive publishing agreement), in the relevant form set out at www.elsevier.com/copyright ; and (2) unless I am a US government employee, to transfer my copyright or grant an exclusive license of rights to Elsevier as part of that publishing agreement, effective on acceptance of the article for publication. If the article is a work made for hire, I am authorized to confirm this on behalf of my employer. I agree that the copyright status selected by the corresponding author for the article if it is accepted for publication shall apply and that this agreement is subject to the governing law of the country in which the journal owner is located.

If you did not co-author this submission, please contact the corresponding author directly at adriana.c.miki@ufcg.edu.br.

Thank you,

Technology in Society

More information and support
FAQ: What is copyright co-author verification?
https://service.elsevier.com/app/answers/detail/a_id/30181/supporthub/publishing/

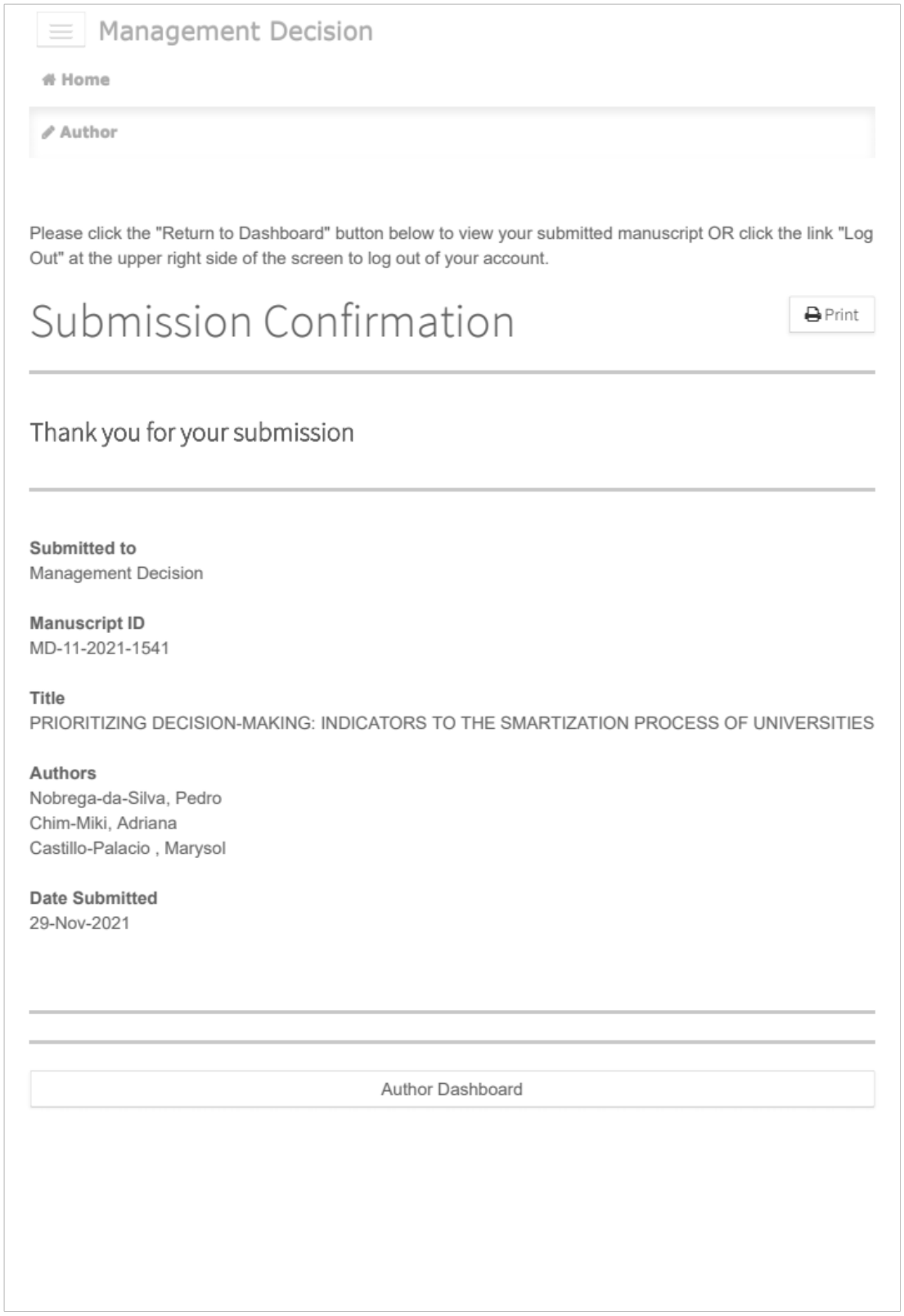
You will find information relevant for you as an author on Elsevier's Author Hub: https://www.elsevier.com/authors
FAQ: How can I reset a forgotten password?
https://service.elsevier.com/app/answers/detail/a_id/28452/supporthub/publishing/kw/editorial+manager/

For further assistance, please visit our customer service site: https://service.elsevier.com/app/home/supporthub/publishing/. Here you can search for solutions on a range of topics, find answers to frequently asked questions, and learn more about Editorial Manager via interactive tutorials. You can also talk 24/7 to our customer support team by phone and 24/7 by live chat and email.

#AU_TECHIS#

To ensure this email reaches the intended recipient, please do not delete the above code

APPENDIX 6. ARTICLE 3 SUBMISSON



Management Decision

Home

Author

Please click the "Return to Dashboard" button below to view your submitted manuscript OR click the link "Log Out" at the upper right side of the screen to log out of your account.

Submission Confirmation

Print

Thank you for your submission

Submitted to
Management Decision

Manuscript ID
MD-11-2021-1541

Title
PRIORITIZING DECISION-MAKING: INDICATORS TO THE SMARTIZATION PROCESS OF UNIVERSITIES

Authors
Nobrega-da-Silva, Pedro
Chim-Miki, Adriana
Castillo-Palacio , Marysol

Date Submitted
29-Nov-2021

Author Dashboard