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Smart Campus as Digital Transformation in Indonesian Universities: A Research Landscape Perspective

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ABSTRACT: The smart campus idea has come up as a strategic way for colleges and universities all around the world, including Indonesia, to deal with digital disruption. Even while more and more researchers are interested in smart campuses, the study is still scattered and mostly focused on technology. This study seeks to delineate the intellectual framework, prevailing themes, and thematic development of smart campus research, with a particular emphasis on the Indonesian environment. We used a bibliometric method with the Bibliometric package in R. This included co-word analysis, thematic mapping, and conceptual structure analysis based on Multiple Correspondence Analysis (MCA). The findings indicate that topics such as students and smart campus serve as motor themes, whereas higher education, educational computers, and smart universities are identified as fundamental themes marked by high centrality and low density. These findings suggest that while core ideas hold structural significance, they lack conceptual coherence. This study adds to the body of knowledge by giving a systematic overview of smart campus research and suggesting a future research agenda that focuses on socio-technical integration and institutional transformation in Indonesian higher education.

KEYWORDS: Smart Campus, Bibliometrix, Thematic Map, Higher Education

I. INTRODUCTION

Digital transformation has become a fundamental objective in higher education institutions internationally, spurred by significant improvements in information and communication technology (ICT), artificial intelligence, and data analytics (Bond et al., 2019). More and more, universities are required to use digital technology to make learning better, make administration more efficient, and encourage sustainable campus growth (Yigitcanlar & Cugurullo, 2020).

In this context, the idea of the smart campus has become more popular as a way to apply the smart city model to higher education settings (Bellaj et al., 2024; Zhang et al., 2022). A smart campus is a single ecosystem that includes digital infrastructure, learning systems, governance processes, and services that put people first (Min-Allah & Alrashed, 2020). Smart campus projects in Indonesia are in line with the country's policies on digital education, reform of higher education, and accreditation of institutions (Anggara, 2023; Supriati et al., 2022).

Nevertheless, current research on smart campus development is predominantly disjointed and focuses more on technological implementation than comprehensive institutional reform (Polin et al., 2023). Furthermore, comprehensive assessments delineating the conceptual framework and development of smart campus research, especially within the Indonesian setting, are still scarce. Bibliometric analysis offers a comprehensive analytical framework to bridge this gap by elucidating intellectual frameworks, theme clusters, and research paths within a certain domain

This study aims to tackle the subsequent research inquiries:

1. What is the thematic structure of smart campus research?
2. Which themes function as basic themes in the smart campus literature?
3. What are the implications of these themes for smart campus development in Indonesia?

II. LITERATURE REVIEW

A. *Smart Campus as a Digital Transformation Paradigm*

The smart campus idea is often described as an intelligent learning environment that uses ICT, IoT, cloud computing, and data analytics to help with research, learning, campus administration, and sustainability (Min-Allah & Alrashed, 2020). Smart campuses, like smart cities, focus on bringing together technology, organizations, and people (McKenna, 2020).

In developing nations like Indonesia, smart campus efforts are frequently propelled by infrastructure enhancement and the implementation of digital services (Susanto et al., 2022). Nevertheless, scholars argue that without adequate attention Nonetheless, experts contend that insufficient focus on organizational culture, governance, and user acceptance may result in technical investments failing to yield enduring value (Xie, 2022).

B. Smart Campus as an Extension of Digital Transformation in Higher Education

The idea of a "smart campus" has come up as part of the larger conversation about how higher education is changing with technology. Digital transformation is the planned use of digital technologies in areas like governance, teaching and learning, and organizational culture. This affects how universities work and what value they provide (Bond et al., 2019; Nugroho et al., 2025).

A smart campus is often thought of as an intelligent and interconnected educational ecosystem that uses technologies like the Internet of Things (IoT), cloud computing, data analytics, and artificial intelligence to improve learning environments, campus management, and sustainability efforts (Min-Allah & Alrashed, 2020). Based on the idea of a smart city, smart campuses focus on bringing together people, technology, and institutions (Lara et al., 2016; McKenna, 2020).

Nonetheless, numerous research indicate that smart campus development frequently emphasizes technical infrastructure above pedagogical innovation and institutional transformation (S. Chen et al., 2024; Elbertsen et al., 2025). This imbalance may lead to fragmented implementations that may not have a lasting effect on education and organizations.

C. Smart Campus Research in Developing and Indonesian Contexts

In developing nations, particularly Indonesia, smart campus projects are often influenced by external factors such as government policies, accreditation standards, and financing availability (Susanto et al., 2022). After the COVID-19 pandemic, Indonesian colleges and universities started using digital platforms more and more for managing learning, academic services, and campus life.

Despite these advancements, existing research suggests that smart campus implementations in Indonesia are often technology-led rather than strategy-driven, with limited consideration of organizational readiness, leadership, and cultural factors (Susanto et al., 2022). Studies tend to focus on system development and deployment, while empirical investigations into institutional transformation, governance models, and user acceptance remain scarce.

This environment highlights the necessity for a comprehensive synthesis of smart campus research to discern prevailing themes, conceptual deficiencies, and prospects for theoretical progression, an objective ideally suited to bibliometric and thematic analysis methodologies.

D. Bibliometric Analysis and Thematic Mapping in Education Research

Bibliometric analysis has emerged as a prevalent technique for delineating scientific information, discerning research trends, and examining the conceptual framework of academic disciplines. In educational and information systems research, bibliometric methodologies, including citation analysis, co-authorship analysis, and co-word analysis, are frequently employed to investigate the progression of study areas (Aria & Cuccurullo, 2017).

Co-word analysis is one of the best ways to find connections between study issues by looking at how often keywords appear together (Callon et al., 1991). Thematic mapping uses two main measures, Callon centrality and Callon density, to sort themes based on how important they are to strategy and how far along they are in their development (Cobo et al., 2011).

- Centrality reflects the extent to which a theme is connected to other themes within the research field.
- Density indicates the internal cohesion and conceptual maturity of a theme.

This framework helps scholars tell the difference between motor themes, basic themes, specialty themes, and topics that are growing or shrinking. This gives them a better idea of where a field is in its evolution.

E. The Role of Basic Themes in Knowledge Development

Basic themes are very important in thematic mapping since they have a lot of centrality but not a lot of density (Callon et al., 1991). These issues are fundamental and extensively interconnected within the research domain; nonetheless, they lack internal conceptual coherence. In nascent multidisciplinary domains, the prominence of fundamental themes frequently indicates a transitional phase wherein foundational concepts are formulated but not yet comprehensively articulated.

In the realm of smart campus research, prospective fundamental themes, including higher education, educational computing, and smart universities, signify expansive institutional and technological frameworks. Although these themes are commonly cited, previous research indicates that they are often approached descriptively rather than analytically, hence constraining their theoretical impact (Singgih et al., 2025; Zhang et al., 2022).

To find research gaps and help future theoretical growth, it is important to know where core themes fit in and what their main features are. Bibliometric thematic analysis offers an empirical foundation for these discoveries by demonstrating not only the subjects of study but also the level of maturity and integration of those subjects within the discipline.

III. RESEARCH METHODOLOGY

This research employs a quantitative bibliometric methodology. We used terms relating to smart campus and higher education, such as "smart campus," "smart university," "higher education," and "education computing," to find bibliographic data in indexed academic databases. We used the Bibliometrix software and its web interface, Biblioshiny, to analyze the data. Here are the procedures we used (Aria & Cuccurullo, 2017):

1. Data preprocessing and keyword normalization
2. Co-word analysis
3. Thematic mapping based on Callon centrality and density
4. Conceptual structure analysis using Multiple Correspondence Analysis (MCA)

IV. RESULT

This This part shows the results of the bibliometric and thematic analysis that are clearly related to the research questions. The results come from utilizing the Bibliometric tool to do co-word analysis and theme mapping. This package is commonly used for science mapping and detecting thematic structures.

RQ1: What Is the Thematic Structure of Smart Campus Research?

The theme map shows that smart campus research is built around a technology-driven and user-oriented thematic core. This shows how important digital technologies are in changing higher education (Yigitcanlar et al., 2020). Themes like students and smart campus are at the center of the map,

where they have high Callon centrality and high Callon density.

According to thematic mapping theory, themes with high centrality and density are classified as motor themes, as they actively drive the development and direction of a research field (Callon et al., 1991; Cobo et al., 2011). The predominance of these motor themes indicates that smart campus research primarily concentrates on user interface, learning systems, and the practical application of digital campus technology, along with previous findings in digital education research (Bond et al., 2019; C.-F. Chen & Huang, 2021).

On the other hand, some themes have a lot of connections to other topics but not many connections within themselves. This means that they are strongly related to other topics but not very cohesive within themselves. This pattern illustrates a research framework where underlying notions are extensively cited yet inadequately conceptualized, a trait frequently noted in nascent interdisciplinary fields. From the standpoint of Indonesian higher education, this thematic framework reflects a pronounced focus on infrastructure deployment and system utilization, frequently motivated by digital transformation initiatives and accreditation standards rather than holistic institutional strategies (Susanto et al., 2022).

A. RQ2: Which Themes Function as Basic Themes in Smart Campus Research?

Thematic mapping highlights higher education, educational technology, and intelligent universities as the main subjects in smart campus research. Basic themes are characterized by elevated Callon centrality and diminished Callon density, signifying robust exterior connectivity while exhibiting restricted internal development (Callon et al., 1991; Cobo et al., 2011).

The issue of higher education serves as a transversal notion that connects discussions about technology, teaching, and institutions. Nevertheless, the literature mostly regards higher education institutions as contexts for implementation rather than as analytical units, which constrains the theoretical depth concerning governance, organizational structure, and policy environments (Yigitcanlar et al., 2020).

In the same way, educational computing connects new technology with the way schools work. Current research focuses on system development, digital platforms, and computational solutions, frequently overlooking pedagogical alignment, learning outcomes, and organizational integration (Bond et al., 2019; Min-Allah & Alrashed, 2020). This mismatch is a factor in the low density seen for this topic. The idea of smart universities signifies a conceptual shift from fragmented digital projects to comprehensive institutional transformation. Even though it is strategically important, the low density shows that there aren't many defined definitions, conceptual frameworks, or evaluation measures, especially in developing countries like Indonesia ((Min-Allah & Alrashed, 2020; Polin et al., 2023).

Overall, the presence of these basic themes indicates that smart campus research relies heavily on broad foundational concepts that have not yet matured into cohesive research domains.

B. RQ3: What Are the Implications of the Identified Themes for Smart Campus Development in Indonesia?

The theme configuration established in this study has substantial ramifications for the advancement of smart campuses in Indonesia. The prevalence of motor themes concerning students and digital systems indicates that both research and practice emphasize technology utilization, user engagement, and operational efficiency (Bond et al., 2019). While these factors are important, focusing too much on how well technology works could mean missing out on how ready an institution is and how long it will last.

The predominance of fundamental themes underscores a conceptual disparity between technology execution and institutional integration. Many Indonesian institutions pursue smart campus efforts as independent projects motivated by compliance mandates, financial availability, or short-term success metrics (Susanto et al., 2022). The low density of institutional themes indicates that research has inadequately tackled issues such as organizational change, leadership, governance, and cultural acceptance, which are essential elements of effective digital transformation (Yigitcanlar et al., 2020).

The transitory aspect of the smart universities theme suggests that Indonesian higher education institutions are still working on the transfer from digitalization to full digital transformation. Smart campus initiatives may face challenges in achieving sustained educational and organizational outcomes without strong theoretical foundations and empirical validation (Min-Allah & Alrashed, 2020).

These findings indicate that forthcoming smart campus research in Indonesia ought to concentrate on the consolidation of fundamental themes using theory-driven and contextually attuned methodologies, thereby enhancing their thematic density and promoting their transformation into pivotal themes.

V. DISCUSSION

A. The Structural Role of Basic Themes in Smart Campus Research

The thematic map shows that higher education, education computing, and smart universities are some of the main ideas in the smart campus research field. Thematic mapping theory posits that fundamental themes exhibit elevated centrality and diminished density, signifying their structural significance while remaining conceptually underdeveloped (Callon et al., 1991; Cobo et al., 2011). This stance indicates that these issues constitute the conceptual foundation of the area, however they lack adequate theoretical integration.

In smart campus research, the prominence of core themes shows that the field is still in its early to middle stages of development. People talk a lot about technical solutions, but the basic ideas behind changing institutions, governance, and educational ecosystems are still not very clear. This finding is consistent with prior research indicating that smart campus projects are mostly technology-driven rather than strategy-oriented (Min-Allah & Alrashed, 2020).

B. Technology-Centric Bias and Limited Socio-Technical Integration

A significant finding from the analysis is the prevalence of technology-focused viewpoints in smart campus research. Motor themes like students and smart campus focus on how systems are used, digital services, and how users interact with each other. This shows that there is a strong focus on the benefits of technology and the results of its use. But the fact that there aren't many institutional elements shows that the

organizational, cultural, and governance aspects aren't well thought out.

This disparity illustrates a prevailing tendency in digital education research, where the adoption of technology frequently occurs prior to pedagogical and organizational alignment (Akbari & Pratomo, 2022; Selwyn, 2017). From a socio-technical systems viewpoint, this strategy may hinder the long-term viability of smart campus efforts, given that technological success relies on institutional preparedness, stakeholder involvement, and cultural receptivity ((Bond et al., 2019; Yigitcanlar et al., 2020).

C. Implications for Smart Campus Development in Indonesia

The results are especially important for higher education in Indonesia. As part of national digital transformation plans and accreditation requirements, many Indonesian universities have started smart campus programs. But these projects are often done as separate tech projects instead of as part of a larger institutional strategy.

The recognition of higher education as a fundamental issue suggests that Indonesian institutions are frequently regarded as uniform entities, lacking enough attention to contextual diversity, including institutional governance approaches, geographical variations, and organizational culture. In the same way, education computers is still mostly about developing and using systems, with little attention paid to how effective they are for teaching and how they affect behavior.

The idea of smart colleges is a big idea that many want to see happen, but the fact that there aren't many of them shows that people don't agree on how to put it into action or how to measure success. This gap underscores the necessity for context-sensitive models that include the legislative, cultural, and resource limitations of Indonesian higher education institutions.

D. From Basic Themes to Motor Themes: Directions for Conceptual Advancement

A From a developmental perspective, the transformation of basic themes into motor themes requires theoretical integration and empirical validation. Future research should move beyond descriptive and technical studies toward the development of comprehensive frameworks that integrate:

- Information systems theories (e.g., technology acceptance, digital capability models),
- Organizational change and governance perspectives,
- Cultural and human-centered dimensions.

Such integration would increase the internal coherence (density) of basic themes while maintaining their strategic relevance (centrality). Over time, this process could elevate themes such as smart universities from foundational concepts to fully developed motor themes that drive scholarly discourse and practical innovation.

E. Contribution to the Smart Campus Literature

This work adds to the smart campus literature in three important areas. First, it fills a vacuum in regional-level studies by giving a systematic bibliometric map of smart campus research, with an emphasis on Indonesia. Second, it finds and critically looks at the role of basic themes, giving us a better understanding of the field's structural strengths and conceptual weaknesses. Third, it suggests a research program based on theory that focuses on socio-technical integration as a method to build a smart campus that will last.

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