# Smart Campus and Student Learning Engagement

Shaobin Chen, University of Electronic Science and Technology of China, Zhongshan Institute, China
Qingrong Li, Southwestern University of Finance and Economics, China*
https://orcid.org/0009-0005-7651-1012
Tao Wang, Southwestern University of Finance and Economics, China

## ABSTRACT

This study aims to assess the implementation of smart campus and the students' learning engagement at Zhongshan College, China. A well-structured questionnaire was developed, and information was collected from 277 students and 377 teachers. The results indicate that both groups of respondents highly agree on the construction levels of the smart campus in terms of security operations, academic technology assistance, public relation services, and stakeholders' experience. Furthermore, respondents emphasized that the level of smart campus construction affects students' learning engagement. Specifically, students' personalized learning engagement is affected by the level of smart campus construction in security operations and public relations services. And the degree of students' use of smart learning resources is significantly related to the smart campus construction levels in all four dimensions. This study fills research gaps and provides valuable guidance for the development of smart campuses.

## KEYWORDS

Digital Technology, Learning Engagement, Personalized Learning, Smart Campus, Smart Learning Resources

## SMART CAMPUS AND STUDENT LEARNING ENGAGEMENT

With the rapid evolution of smart technologies and the advent of the Internet of Things (IoT), many campuses are now realizing the importance of these advancements in optimizing student and faculty engagement (Anagnostopoulos et al., 2021). The number of IoT connected devices is expected to skyrocket to over 75 billion by 2025. Campuses across the nation are witnessing the integration of connected devices, cameras, sensors, and smart technologies, leading to the emergence of what we now refer to as a "smart campus" (Dong et al., 2020; Sneesl et al., 2022).

A smart campus is a learning environment that allows students' learning and teachers' teaching to be fully conducted on the basis of science and technology. It consists of all-round intelligent construction, which mainly includes a smart teaching environment, smart teaching resources, smart

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*Corresponding Author

teaching services, and smart campus management (Huang et al., 2012; Zhou et al., 2022). The utilization of digital technology in education opens a realm of possibilities.

China, with its vast population and rapid technological advancements, has emerged as a global leader in digital technology and innovation. In recent years, the country has exhibited remarkable enthusiasm for adopting digital solutions across various sectors including education (Song & Li, 2018). The implementation of smart campuses and the utilization of digital technology in Chinese educational institutions hold significant potential for transforming the traditional educational landscape and creating innovative learning environments. Nevertheless, implementing smart campuses and efficiently utilizing the technology in the Chinese educational context presents unique challenges (Yang & Liu, 2013). The vastness of the education system, the diversity of student populations, and the need for equitable access to technology pose significant implementation hurdles. Questions regarding infrastructure readiness, teachers' training, digital resource availability, and data security need to be addressed to ensure successful integration and maximize the potential benefits (Chagnon-Lessard et al., 2021).

Understanding the current state of smart campus implementation, along with exploring opportunities and challenges, is crucial for policymakers, educators, administrators, and researchers. The number of studies on the construction of smart campuses, however, is small, and the field of research is narrow. Some universities have rudimentary smart campus constructions, and administrators lack a deep understanding of their essence and functional value. There is a lack of scientifically valid evaluation criteria to measure the level of smart campus construction. In this study, we aim to fill these gaps by delving into the implementation of a smart campus within the context of 5G technology development, elucidating the key components involved and the effective utilization of digital technology. By conducting an empirical study at Zhongshan College and using descriptive statistics and quantitative research methods, we address the following questions.

Q1: What aspects should be considered in evaluating the level of smart campuses?
Q2: Do respondents from different groups exhibit variations in their evaluations of smart campuses?
Q3: How do various aspects of smart campuses influence the level of students' learning engagement?

## LITERATURE REVIEW

### Smart Campus

The concept of smart campuses is derived from that of smart earth (Min-Allah & Alrashed, 2020); there is no unified definition for a smart campus. Some scholars have contributed their own interpretations in their respective research. Bandara et al. (2016) defined smart campuses as the use of information and communication technology (ICT) within university campuses to enhance service quality and performance, reduce costs, and optimize resource consumption. Muhamad et al. (2017) suggested that the primary role of a smart campus is to utilize intelligent systems to dynamically present services based on user needs. In this article, we define a smart campus as a university that provides an intelligent teaching and learning environment, as well as applications that contribute to resource integration, teacher-student interaction with the support of the Internet, communication, and other technologies, and that ultimately promotes comprehensive development of teachers and students. By summarizing and consolidating the relevant literature, we found that research on the subject mainly focuses on the following four aspects.

#### *Technology*

The existence of smart campuses is intricately linked with technological advancements, particularly in information and communication technology. Emerging technologies such as IoT, big data, artificial intelligence, and 5G are frequently mentioned in literature related to smart campuses. The campuses leverage emerging technologies to establish a fully perceptible physical environment, recognizing students' learning characteristics and contexts to provide enhanced learning services (Zhang & Hu, 2020). Hu et al. (2014) observed an evolution in the external environment of education informatization after a cycle of construction, with new ideas and technologies emerging. The term "smart campus" has gradually replaced "digital campus" as the prevailing theme and trend in current information development.

### *System Architecture and Functional Modules*

Pagliaro et al. (2016) introduced a comprehensive framework for orchestrating smart campus deployments, exemplifying its application at the University of Rome. This framework addresses five key dimensions: 1) people & living, 2) economic, 3) energy, 4) environment, and 5) mobility. Additionally, the Massachusetts Institute of Technology (MIT) proposed the iCampus model, conceptualizing a smart campus digital nervous system categorized into six major areas: 1) iLearning, 2) iManagement, 3) iGovernance, 4) iSocial, 5) iGreen, and 6) iHealth (Ng et al., 2010). According to Wang (2018), smart campuses comprise four layers: 1) intelligent perception, 2) network interconnection, 3) data center, and 4) application service.

### *Stakeholders*

The main subjects of most studies involve teachers, students, and campus administrators. For instance, Wang (2022) pointed out a gap between teachers' information literacy and the requirements of smart campus construction through an action research on teachers' information literacy. Tang (2020) indicated that the lack of a network platform for students' independent learning and the failure to meet students' personalized learning needs are the main problems faced by students' high mathematics learning in the smart campus environment. Zheng and Cheng (2020) conducted a study on the informational leadership of school organization personnel, focusing on the connotation and framework of informational leadership.

### *Evaluation System*

In addition to the previously mentioned research areas encompassing technology, system architecture, and relevant stakeholders, the assessment of smart campuses has emerged as a pivotal focus in scholarly investigations. Scholars have introduced diverse evaluation models and index systems aimed at systematically assessing the developmental stage of smart campuses. For example, Jiang et al. (2017) formulated a maturity model specifically tailored for evaluating smart campuses in colleges, while Li and Wang (2020) devised a comprehensive smart campus evaluation index system designed for colleges and universities.

## Students' Learning Engagement

### *Personalized Learning*

Personalized learning is an educational approach designed to offer a customized learning experience tailored to each student's unique needs, learning style, interests, and progress (Shemshack & Spector, 2020). When students have the flexibility to customize their learning journey, it enhances their motivation and commitment to the educational process. Personalized learning is an efficient approach that increases students' motivation, engagement, and understanding (Falcão et al., 2018), maximizing learners' satisfaction and learning efficiency and effectiveness (Gómez et al., 2014). Personalized learning ensures that the experience dynamically adjusts to students' evolving needs, providing real-time feedback on current learning outcomes within intelligent learning environments (Liu et al., 2017). It is important to note that personalized learning is not a static product but an ongoing process. It places emphasis on providing support services for the learner's academic journey. The essence of a smart campus aligns with this concept, as it aims to support students' learning and promote the achievement of their goals, thereby reinforcing the principles of personalized learning.

### *Smart Learning Resources*

Smart learning resources refer to educational resources designed and provided using advanced technologies such as artificial intelligence and big data analysis (Dong et al., 2023), which aim to support the learning process in an intelligent and personalized manner. Smart learning resources may include but are not limited to online courses, educational applications, virtual laboratories, and intelligent textbooks (Jeong & Hmelo-Silver, 2010). These resources integrate innovative technologies to based on students' learning needs and characteristics. They provide unique opportunities for constructing profound understanding, representing a compilation of cultural and scientific knowledge accumulated over the years (Hill & Hannafin, 2001; Yeo & Tan,2010). Some studies, however, indicate that achieving the production and utility of online learning resources is challenging. Despite the easy accessibility of various resources, students are often unwilling or hesitant to use them (Cramer et al., 2007). Thus, merely providing resources is insufficient to ensure their utilization. It is necessary to enhance the smart campus system to increase opportunities for students to use smart learning resources, enabling them to engage in resource-driven explorations and enhance the level of learning engagement.

Current research on smart campuses has achieved significant progress, primarily focusing on infrastructure technology including framework design and specific applications (Imbar et al., 2020). While these studies excel in detailing the functionalities of smart campus infrastructure, they often lack comprehensive discussions on practical application effects. Additionally, there are certain deficiencies in the evaluation standards for smart campuses in existing research, with a lack of involvement from frontline personnel and feedback from smart campus users. Therefore, further research on smart campuses should consider the depth of their relevance to educational instruction, increase attention to frontline personnel, and solicit suggestions for optimizing smart campuses.

Despite the mention of smart campus support for student-teacher interactions, there is a lack of in-depth exploration of the exact relationship between smart campuses and students' learning engagement, especially in terms of personalized learning and the use of smart learning resources. In this study, we consider these aspects, dividing the evaluation of smart campuses into four dimensions: 1) security operations, 2) academic technology assistance, 3) public relation services, and 4) stakeholders' experience. By engaging students and teachers as respondents, we see their evaluations and suggestions of smart campuses contribute to advancing smart campus research, providing insights into practical and effective development.

## METHODOLOGY

### Development of Hypotheses

#### *Security Operations*

Security operation is an important part of evaluating the level of smart campus construction. Zhang et al. (2023) recommended deploying a campus network security situation awareness platform, establishing a network security management center to achieve unified network security management, which contributes to students' learning engagement. Qiao (2019) used the continuous cycle model (CRM) to develop a digital campus construction project risk assessment form, which involves risk identification, risk assessment, risk response, and other aspects. According to the risk assessment form, a detailed risk management plan is developed, the risk factors are classified, and solutions are developed to effectively reduce the risk level and improve the project success rate. These arguments lead to the following hypotheses.

H1: The level of evaluation of security operations significantly affects the extent of students' personalized learning.
H2: The level of evaluation of security operations significantly affects the extent of students' use of smart learning resources.

### Academic Technology Assistance

The construction of a smart campus is an intelligent application, characterized by five aspects of characteristics: 1) intelligent environmental awareness, 2) seamless network design, 3) comprehensive and effective data support, 4) open and mutually supportive learning environment, and 5) personalized learning and teaching services to meet the needs of students and teachers (Huang, 2021). Added by Hu and Zhang (2017), it is believed that the construction of a smart campus is an intelligent service for campus teaching and management through new technologies such as cloud computing and the IoT, which enhances the personalized service and responsiveness of the campus. From the perspective of campus network facilities, a smart campus utilizes new IT infrastructure and technology to deeply combine with teaching, scientific research, management, life services, and other businesses, thereby changing the IT infrastructure construction and service model, driving the development of the school and enhancing its competitiveness. Smart applications are the key points in the construction of a smart campus, and they are the final landing display (Zhao & Shen, 2020). With the increasing application of internet information technology in schools, the feasibility of smart campus construction has grown. This technological integration provides students with access to a broader range of learning resources, while teachers can enhance their teaching methodologies using advanced technology and resources. These arguments lead to the following hypotheses.

H3: The level of evaluation of academic technology assistance significantly affects the extent of students' personalized learning.
H4: The level of evaluation of academic technology assistance significantly affects the extent of students' use of smart learning resources.

### Public Relation Services

In the context of a smart campus, public relation services involve leveraging communication channels, technologies, and strategies to promote the benefits and achievements of the smart campus, address concerns or queries from stakeholders, and ensure transparency in sharing information about the smart campus initiatives. Its key functions include publicizing the objectives and benefits of the smart campus initiatives, engaging stakeholders through feedback mechanisms, managing crises through effective communication, fostering positive media relations, and building strong community connections. The construction of a smart campus needs to be thought of at both the large system and small system levels. The so-called "big system" refers to the social ecosystem and the system of education itself in the development of smart education. The small system refers to the internal education system (Zheng et al., 2022).

In the future innovative development of smart education, we need the dynamic balance of education construction and the articulation between different education systems. By implementing effective public relation services in a smart campus, the institution can enhance its reputation, build trust and credibility among stakeholders, and create a positive environment for collaboration and engagement. The review of these studies leads to the following hypotheses.

H5: The level of evaluation of public relation services significantly affects the extent of students' personalized learning.
H6: The level of evaluation of public relation services significantly affects the extent of students' use of smart learning resources.

### *Stakeholders' Experience*

The construction and development of a smart campus requires the joint efforts of teachers, students, parents and other groups, which is a systematic and huge undertaking (Cao, 2019). Stakeholders' experience refers to the perceptions, attitudes, and overall satisfaction of individuals or groups who have a personal stake or are affected by a particular organization, project, or initiative (Kujala et al., 2022). In the context of a smart campus, stakeholders include students, faculty, staff, parents, local community members, and other relevant entities (Agbehadji et al., 2021). Stakeholders' experience is multifaceted and hinges on factors like user-friendly technology, enhanced educational experiences, convenience, accessibility, inclusivity, and robust support and training. Understanding and addressing stakeholders' experience is crucial for developing personalized learning approaches, offering targeted learning resources, and enhancing the overall construction level of a smart campus. These arguments lead to the following hypotheses.

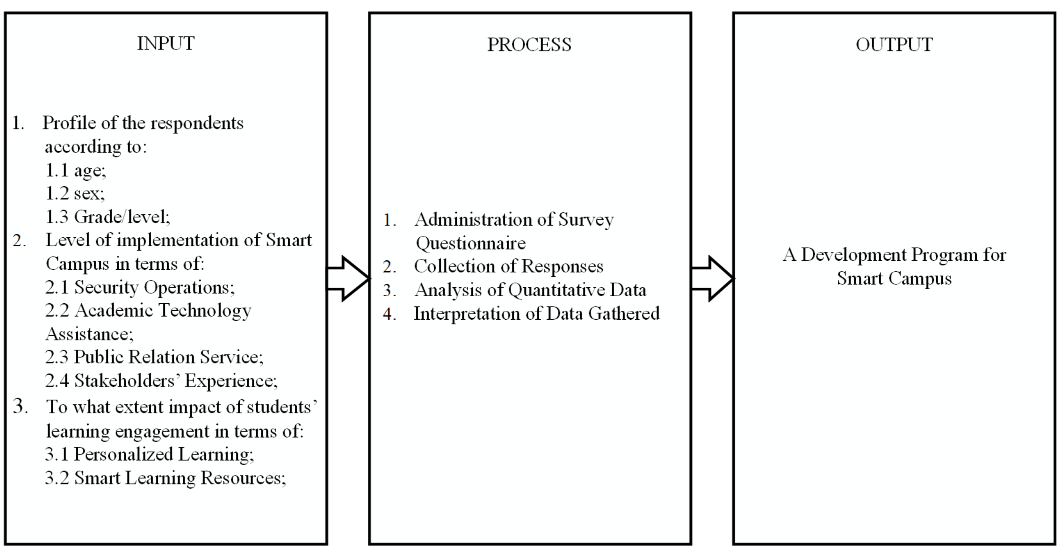
H7: The level of evaluation of stakeholders' experience significantly affects the extent of students' personalized learning.
H8: The level of evaluation of stakeholders' experience significantly affects the extent of students' use of smart learning resources.

We propose in this research eight hypotheses and establish a relevant conceptual framework illustrated in Figure 1, which depicts the I-P-O model.

## Participants

We conducted the study at Zhongshan College, which fully recognizes the importance of smart technology in improving education quality and providing intelligent services. The college utilizes the intelligent academic affairs support system to streamline academic operations and student information management, while providing students and faculty with a wealth of learning resources including software, books, and databases. In addition, the smart campus security system integrates surveillance cameras, face recognition, and advanced technologies to enhance campus security, enabling a swift response to potential risks and ensuring the safety of students and faculty.

**Figure 1. Conceptual paradigm of the study**



The study was composed of 277 students and 377 faculty members from Zhongshan College. The selection of participants followed the Raosoft sampling method. The researchers distributed questionnaires randomly to faculty and students. Teacher respondents were required to have at least one year of teaching experience at Zhongshan College, while student respondents must have been officially enrolled at the university. Among the student respondents, all participants fell within the age range of 19-22 years (100%); 216 were male (78%); 61 were female (22%). Only 88 students (31.8%) were juniors, while the rest (189, 68.2%) were sophomores. All of teacher respondents were above 30 years of age. The majority were male (303, 80.4%). Among them, a significant number had completed their master's degree program (57.3%), while 161 had finished a PhD program (42.7%).

## Instrument

We employed a self-made questionnaire with all items using Likert scales. The questionnaire targeted both faculty and students at Zhongshan College and consisted of three primary sections.

1. Demographic Profile.
2. Assessment of Smart Campus Implementation.
3. Extent of Learning Engagement.

The questionnaire's validity was established through the assessment of three expert validators from UPHSD Graduate School. Additionally, we used Cronbach's Alpha coefficient to validate the survey questionnaire's reliability. As an additional test for validity and reliability of the questionnaire, a pilot-test was conducted in at least one unit or group of administrators at Zhongshan College who were not involved in the study.

## Procedure

We conducted the study during the 2022-2023 academic year and followed a well-defined procedure to ensure the reliability of the data. The researchers distributed the questionnaire to the respondents in two ways, either through centralized offline completion or through the campus online network. The purpose of the survey was clearly explained to the participants, along with guidance on questionnaire completion. The researchers submitted to the standard operating procedures (SOPs) of the study by following the rules of quantitative analysis, ensuring a systematic and rigorous approach to data collection and analysis. By strictly implementing these steps, the research team worked to minimize potential errors and ensure the quality and credibility of the data.

## Data Analysis

To address the research questions and analyze the collected data, the following statistical tools were employed, and all analyses were conducted using SPSS 26.0.

Weighted Mean. This was used to determine the level of assessment of a smart campus. The weighted mean of the students' assessment is abbreviated as SWM and the weighted mean of the teachers' assessment is abbreviated as TWM.

T-test for Independent Samples. This was used to find out whether a significant difference exists in the level of assessment when grouped according to profile.

Pearson Correlation Coefficient. This was used to find out whether a significant relationship exists between two variables.

Regression Analysis. This was employed to explore the relationship between the dependent variable and one or more independent variables in the context of assessing a smart campus. The regression analysis aimed to identify and quantify the impact of various factors on the overall assessment of the smart campus.

# RESULTS

## Assessment of the Level of Smart Campus Implementation

### *Security Operations*

In Table 1, the overall weighted mean for teacher-respondents is 3.67 and 3.58 for student-respondents, reflecting both groups of respondents strongly agree with the all indicators related to security operations. They notably strongly agree with the smart campus's proactive stance in exploring privacy-enhancing technologies for safeguarding sensitive data (TWM=3.69, SWM=3.59) and fostering collaboration among various stakeholders (TWM=3.68, SWM=3.64). Moreover, they express strong agreement with the smart campus's vigilance regarding security implications of emerging technologies (TWM=3.67, SWM=3.50) and the implementation of a least privilege model for user

**Table 1. Security operations**

| Respondents | Indicators | Weighted Mean | Verbal Description |
|---|---|---|---|
| Teacher Respondents | 1. Stays vigilant about the security implications of emerging technologies such as artificial intelligence, blockchain, and internet of things (IOT) devices | 3.67 | Strongly Agree |
| | 2. Fosters collaboration and information sharing among different stakeholders within the smart campus ecosystem, including faculty, IT staff, security teams, and students | 3.68 | Strongly Agree |
| | 3. Encourages reporting of security incidents, vulnerabilities, or suspicious activities to facilitate timely response and remediation | 3.65 | Strongly Agree |
| | 4. Implements a least privilege model where users are granted the minimum level of privileges required to perform their roles and responsibilities | 3.66 | Strongly Agree |
| | 5. Explores the use of privacy-enhancing technologies, such as differential privacy or secure multi-party computation to protect sensitive data while still allowing for analysis and insights | 3.69 | Strongly Agree |
| | Overall Weighted Mean | 3.67 | Strongly Agree |
| Student Respondents | 1. Stays vigilant about the security implications of emerging technologies such as artificial intelligence, blockchain, and internet of things (IOT) devices | 3.50 | Strongly Agree |
| | 2. Fosters collaboration and information sharing among different stakeholders within the smart campus ecosystem, including faculty, IT staff, security teams, and students | 3.64 | Strongly Agree |
| | 3. Encourages reporting of security incidents, vulnerabilities, or suspicious activities to facilitate timely response and remediation | 3.61 | Strongly Agree |
| | 4. Students are granted the minimum level of privileges required to perform their roles and responsibilities | 3.56 | Strongly Agree |
| | 5. Explores the use of privacy-enhancing technologies, such as differential privacy or secure multi-party computation to protect sensitive data while still allowing for analysis and insights | 3.59 | Strongly Agree |
| | Overall Weighted Mean | 3.58 | Strongly Agree |

*Note.* The scale uses four different rating levels, each with a range of scores and corresponding verbal descriptions. *Strongly Agree: 3.26 - 4.00; Agree: 2.51 - 3.25; Disagree: 1.76-2.50; Strongly Disagree: 1.00-1.75.* SWM=students' weighted mean, TWM=teachers' weighted mean.

access (TWM=3.66, SWM=3.56), along with an encouraging approach toward reporting security incidents (TWM=3.65, SWM=3.61).

### *Academic Technology Assistance*

Table 2 reveals that both groups of respondents strongly agree with the indicators of academic technology assistance, as evidenced by the overall weighted mean of 3.97 for teachers and 3.89 for students. They strongly agree that the smart campus plans and manages technology to ensure that academic technologies and infrastructure are up to date (TWM=3.99, SWM=3.92). Teachers are in favor of conducting regular training sessions and workshops to educate faculty, staff, and students about the effective use of academic technologies (TWM=3.98), while students agree to attend regular training sessions and workshops to be educated about the effective use of academic technologies (SWM=3.90). In addition, the smart campus assesses hardware, software, and network infrastructure to identify areas for improvement and communicate with the officer-in-charge for necessary upgrades (TWM=3.98, SWM=3.87). It also provides support to the team that assists students with technical issues, troubleshooting, and questions related to academic technologies (SWM=3.86).

**Table 2. Academic technology assistance**

| Respondents | Indicators | Weighted Mean | Verbal Description |
|---|---|---|---|
| Teacher Respondents | 1. Establishes a dedicated help desk or support team that can assist users with technical issues, trouble shooting, and questions related to academic technologies | 3.95 | Strongly Agree |
| | 2. Conducts regular training sessions and workshops to educate faculty, staff, and students about the effective use of academic technologies | 3.98 | Strongly Agree |
| | 3. Assesses hardware, software, and network infrastructure to identify areas for improvement and plans for necessary upgrades | 3.98 | Strongly Agree |
| | 4. Plans and manages technology to ensure that academic technologies and infrastructure are up to date | 3.99 | Strongly Agree |
| | 5. Assists faculty and administrators in leveraging learning analytics and data to gain insights into student performance, engagement, and learning outcomes | 3.96 | Strongly Agree |
| | Overall Weighted Mean | 3.97 | Strongly Agree |
| Student Respondents | 1. Supports the team that can assist students with technical issues, troubleshooting, and questions related to academic technologies | 3.86 | Strongly Agree |
| | 2. Attends regular training sessions and workshops to be educated about the effective use of academic technologies | 3.90 | Strongly Agree |
| | 3. Assesses hardware, software, and network infrastructure to identify areas for improvement and communicate with the officer-in-charge for necessary upgrades | 3.87 | Strongly Agree |
| | 4. Checks the technology to ensure that academic technologies and infrastructure are up to date | 3.92 | Strongly Agree |
| | Overall Weighted Mean | 3.89 | Strongly Agree |

### *Public Relations Services*

In Table 3, faculty and students exhibit similar views when evaluating public relations services of the smart campus. Both groups of respondents strongly agree that smart campus establishes good media relationships, maintains close contact with news media, and promptly releases promotional information to major media outlets. Additionally, it communicates with students, parents, education industry practitioners, and other members of the public, responding to their concerns (TWM=3.52, SWM=3.77, SWM=3.76). Furthermore, the student respondents strongly agree that the smart campus actively promotes the students' achievements of the school to community (SWM=3.79), while teacher respondents concur that the smart campus actively promotes the development plan and construction of achievements of the school to community (TWM=3.49), as well as participates in policy formation and evaluation, provides professional advice and opinions to the government, and promotes the smooth progress of smart campus construction (TWM=3.47).

### *Stakeholders' Experience*

As observed in Table 4, both groups of respondents strongly agree with the indicators of stakeholders' experience. They acknowledge that the smart campus strengthens awareness and security in the application of existing information systems (TWM=3.98, SWM=3.89), and conducts an in-depth analysis of existing data in the system to discover greater value and secured data (TWM=3.97, SWM=3.93). Furthermore, all respondents strongly agree that the smart campus intensifies the

**Table 3. Public relations services**

| Respondents | Indicators | Weighted Mean | Verbal Description |
|---|---|---|---|
| Teacher Respondents | 1. Establishes good media relationships, maintains close contact with news media, and promptly releases promotional information to major media outlets | 3.52 | Strongly Agree |
| Teacher Respondents | 2. Communicates with students, parents, education industry practitioners, and other members of the public and responds to their concerns | 3.52 | Strongly Agree |
| Teacher Respondents | 3. Actively promotes the development plan and construction of achievements of the school to the community | 3.49 | Strongly Agree |
| Teacher Respondents | 4. Maintains close cooperative relationships with relevant enterprises and seeks support from technology and resources | 3.51 | Strongly Agree |
| Teacher Respondents | 5. Participates in policy formation and evaluation, provides professional advice and opinions to the government, and promotes the smooth progress of smart campus construction | 3.47 | Strongly Agree |
| Teacher Respondents | Overall Weighted Mean | 3.50 | Strongly Agree |
| Student Respondents | 1. Establishes good media relationships, maintains close contact with news media, and promptly releases promotional information to major media outlets | 3.77 | Strongly Agree |
| Student Respondents | 2. Communicates with other students, parents, education industry practitioners, and other members of the public and responds to their concerns | 3.76 | Strongly Agree |
| Student Respondents | 3. Actively promotes the student's achievements of the school to community | 3.79 | Strongly Agree |
| Student Respondents | 4. Maintains close cooperative relationships with relevant enterprises and seeks support from technology and resources | 3.75 | Strongly Agree |
| Student Respondents | Overall Weighted Mean | 3.77 | Strongly Agree |

**Table 4. Stakeholders' experience**

| Respondents | Indicators | Weighted Mean | Verbal Description |
|---|---|---|---|
| Teacher Respondents | 1. Supervises and improves the learning of the learners | 3.93 | Strongly Agree |
| | 2. Strengthens awareness and security on the application of existing information systems | 3.98 | Strongly Agree |
| | 3. Conducts an in-depth analysis of existing data in the system to discover greater value and secured data | 3.97 | Strongly Agree |
| | 4. Intensifies the safe operation and maintenance of basic resource systems | 3.96 | Strongly Agree |
| | 5. Promotes awareness and security on the application of existing information systems | 3.96 | Strongly Agree |
| | Overall Weighted Mean | 3.96 | Strongly Agree |
| Student Respondents | 1. Monitors and improves the learning of the learners | 3.86 | Strongly Agree |
| | 2. Strengthens awareness and security on the application of existing information systems | 3.89 | Strongly Agree |
| | 3. Conducts an in-depth analysis of existing data in the system to discover greater value and secured data | 3.93 | Strongly Agree |
| | 4. Intensifies the safe operation and maintenance of basic resource systems | 3.97 | Strongly Agree |
| | 5. Promotes awareness and security on the application of existing information systems | 3.95 | Strongly Agree |
| | Overall Weighted Mean | 3.92 | Strongly Agree |

safe operation and maintenance of basic resource systems and promotes awareness and security in the application of existing information systems (TWM=3.96, SWM=3.97). They also express strong agreement that the smart campus supervises and improves the learning of the learners (TWM=3.93, SWM=3.86).

## Level of Students' Learning Engagement

### *Personalized Learning*

Table 5 demonstrates the extent of learning engagement of the students in terms of personalized learning as assessed by the both groups of respondents. Results show that the students have a very great extent of learning engagement in terms of personalized learning as reflected in the overall weighted mean of 3.90 and 3.46 for teachers. The students have a great extent of learning engagement in terms of personalized learning since they have the freedom to choose learning activities that align with their interests and goals (TWM=3.50, SWM=3.92). They are encouraged to set personal learning goals and track progress toward achieving them (TWM=3.47, SWM=3.86). Furthermore, the students feel that their learning experiences are customized based on their strengths and weaknesses and receive personalized feedback and recommendations for further learning (TWM=3.45, SWM=3.91). Moreover, all respondents claim that the smart campus provides them with personalized learning pathways tailored to their individual needs (TWM=3.42, SWM=3.93).

### *Smart Learning Resources*

Table 6 illustrates the extent of learning engagement of students in terms of smart learning resources as assessed by the both groups of respondents. The results indicate that the students exhibit a high level of

**Table 5. Personalized learning**

| Indicators | Teacher Weighted Mean | Student Weighted Mean | Verbal Description |
|---|---|---|---|
| 1. I have the freedom to choose learning activities that align with my interests and goals. | 3.50 | 3.92 | Very Great Extent |
| 2. The smart campus provides me with personalized learning pathways tailored to my individual needs. | 3.42 | 3.93 | Very Great Extent |
| 3. My learning experiences are customized based on my strengths and weaknesses. | 3.45 | 3.91 | Very Great Extent |
| 4. I am encouraged to set personal learning goals and track my progress toward achieving them. | 3.47 | 3.86 | Very Great Extent |
| 5. I receive personalized feedback and recommendations for further learning. | 3.45 | 3.90 | Very Great Extent |
| Overall Weighted Mean | 3.46 | 3.90 | Very Great Extent |

**Table 6. Smart learning resources**

| Indicators | Teacher Weighted Mean | Student Weighted Mean | Verbal Description |
|---|---|---|---|
| 1. The smart campus offers a wide range of digital learning resources (e.g., online courses, interactive tutorials, e-books) that enhance my learning experience. | 3.42 | 3.89 | Very Great Extent |
| 2. I find it easy to access and navigate the smart learning resources provided by the campus. | 3.43 | 3.87 | Very Great Extent |
| 3. The smart learning resources effectively support my understanding and mastery of different subjects. | 3.42 | 3.92 | Very Great Extent |
| 4. The use of technology with the learning resources enhances my engagement and motivation to learn. | 3.43 | 3.93 | Very Great Extent |
| Overall Weighted Mean | 3.43 | 3.90 | Very Great Extent |

engagement in terms of smart learning resources (Overall Weighted Mean=3.43, 3.90). Respondents claim that the students find it easy to access and navigate the smart learning resources provided by the campus, and the use of technology with the learning resources enhances their engagement and motivation to learn (TWM=3.43, SWM=3.87, SWM=3.93). Furthermore, the teacher respondents believe that the smart campus offers a wide range of digital learning resources (e.g., online courses, interactive tutorials, e-books) that enhance students' learning experience, and the smart learning resources effectively support their understanding and mastery of different subjects (TWM=3.42, SWM=3.89, SWM=3.92).

## Differences in the Level of Assessment of the Smart Campus: Profile of the Respondents

To address Q2, we used the independent samples t-test to examine variations by determining the level of significance as 95% with age, gender, students' grade, and teachers' highest educational attainment as grouping variables, and the level of the four dimensions of smart campuses as correlating variables.

Table 7 portrays the computation of t-values used to evaluate the differences in the level of assessment of the respondents of the smart campus when grouped according to age. Since all the

Table 7. Grouped according to age

| Factors | Mean Level | | Computed t-value | α | p-value |
|---|---|---|---|---|---|
| | Over 30 | Under 30 | | | |
| Security Operations | 3.67 | 3.58 | 2.470 | .05 | 0.014 |
| Academic Technology Assistance | 3.97 | 3.89 | 4.559 | .05 | <0.001 |
| Public Relations Services | 3.52 | 3.77 | 7.141 | .05 | <0.001 |
| Stakeholders' Experience | 3.96 | 3.92 | 3.063 | .05 | 0.002 |

p-values are lower than 0.05, it can be concluded that a significant difference exists in the level of assessment of the smart campus when the respondents are grouped according to age. Furthermore, age can be considered as a determinant in assessing the level of assessment of the smart campus.

Additionally, when examining gender as a factor, no significant differences exist in terms of security operations, academic technology assistance, and public relations services. A notable difference occurs in terms of stakeholders' experience ($\alpha=0.05$, p-value=0.037), which ca be potentially attributed to the varying lifestyles and experiences of males and females (see Table 8).

Table 9 provides a summary of the computation of t-values used to assess the differences in the level of assessment of the teacher when grouped according to highest educational attainment. The results show that there is a significant difference in the assessment of academic technology assistance, public relations services, and stakeholders' experience ($\alpha=0.05$, p-value$<0.001$), while no significant difference exists in terms of security operations ($\alpha=0.05$, p-value=0.365).

Table 8. Grouped according to gender

| Factors | Mean Level | | Computed t-value | α | p-value |
|---|---|---|---|---|---|
| | Female | Male | | | |
| Security Operations | 3.62 | 3.66 | 0.711 | .05 | 0.478 |
| Academic Technology Assistance | 3.94 | 3.92 | 1.066 | .05 | 0.288 |
| Public Relations Services | 3.62 | 3.59 | 0.537 | .05 | 0.592 |
| Stakeholders' Experience | 3.95 | 3.91 | 2.104 | .05 | 0.037 |

Table 9. Teacher respondents grouped according to highest educational attainment

| Factors | Mean Level | | Computed t-value | α | p-value |
|---|---|---|---|---|---|
| | PhD | Master's Degree | | | |
| Security Operations | 3.69 | 3.65 | 0.908 | .05 | 0.365 |
| Academic Technology Assistance | 4.00 | 3.94 | 4.037 | .05 | <0.001 |
| Public Relations Services | 3.78 | 3.32 | 9.861 | .05 | <0.001 |
| Stakeholders' Experience | 3.91 | 3.99 | 5.548 | .05 | <0.001 |

When assessing by grade level of student respondents (see Table 10), a significant difference occurs in academic technology assistance (α=0.05, p-value<0.001), but no such difference exists among the other three dimensions.

## Relationship Between the Extent of the Impact of Students' Learning Engagement and the Level of Assessment of the Smart Campus

Tables 11 and 12 provide a summary of the Pearson r values calculated to examine the existence of the relationship between the assessment of the smart campus and students' learning engagement, particularly in the context of personalized learning and smart learning resources (Q3).

The results in Table 11 indicate a significant positive correlation between the evaluation levels of the smart campus in safety operations (α=0.05, p-value<0.001) and public relation services (α=0.05, p-value=0.016) and students' learning engagement in personalized learning. The higher the evaluation levels of the smart campus in safety operations and public relation services, the higher the degree of students' engagement in personalized learning. There is no significant correlation with the evaluation levels in academic technology assistance and stakeholders' experience. Thus, H1 and H5 are supported, while H3 and H7 are not supported.

In Table 12, all p-values are less than 0.05. This indicates a significant positive correlation between the evaluation levels of the smart campus in all four dimensions and students' engagement in the use of smart learning resources. As the evaluation levels of the smart campus improve, students' engagement with smart learning resource usage also increases. Therefore, H2, H4, H6, and H8 are supported.

**Table 10. Student respondents grouped according to grade level**

| Factors | Mean Level | | Computed t-value | α | p-value |
|---|---|---|---|---|---|
| | Sophomore | Junior | | | |
| Security Operations | 3.59 | 3.56 | 0.555 | .05 | 0.580 |
| Academic Technology Assistance | 3.83 | 4.00 | 6.604 | .05 | <0.001 |
| Public Relations Services | 3.79 | 3.73 | 1.069 | .05 | 0.287 |
| Stakeholders' Experience | 3.92 | 3.92 | 0.041 | .05 | 0.967 |

**Table 11. Personalized learning and the level of assessment of the smart campus**

| Factors | Pearson r | Degree of Relationship | α | p-value | Decision | Interpretation |
|---|---|---|---|---|---|---|
| Security Operations | 0.40 | Low Positive | .05 | <0.001 | Accept H1 | Significant |
| Academic Technology Assistance | 0.04 | Very Low Positive | .05 | 0.275 | Reject H3 | Not Significant |
| Public Relations Services | 0.09 | Very Low Positive | .05 | 0.016 | Accept H5 | Significant |
| Stakeholders' Experience | 0.04 | Very Low Positive | .05 | 0.252 | Reject H7 | Not Significant |

**Table 12. Smart learning resources and the level of assessment of the smart campus**

| Factors | Pearson r | Degree of Relationship | α | p-value | Decision | Interpretation |
|---|---|---|---|---|---|---|
| Security Operations | 0.32 | Low Positive | .05 | <0.001 | Accept H2 | Significant |
| Academic Technology Assistance | 0.12 | Very Low Positive | .05 | 0.002 | Accept H4 | Significant |
| Public Relations Services | 0.16 | Very Low Positive | .05 | <0.001 | Accept H6 | Significant |
| Stakeholders' Experience | 0.11 | Very Low Positive | .05 | 0.004 | Accept H8 | Significant |

## Regression Analysis of the Smart Campus and Students' Learning Engagement

The results of the regression analysis are consistent with the findings of the Pearson correlation analysis. Table 13 presents the regression analysis for evaluating the assessments of the smart campus as predictors of the significant impact on students learning engagement in terms of personalized learning. It is therefore concluded that of the four factors in the implementation of the smart campus, only the security operations and public relations services can significantly impact students learning engagement in terms of personalized learning.

Shown in Table 14 is the regression analysis for evaluating the assessments of the smart campus as predictors of the significant impact on students learning engagement in terms of smart learning

**Table 13. Regression analysis: Personalized learning**

| Factors | B | SE | α | p-value | Decision | Interpretation |
|---|---|---|---|---|---|---|
| Intercept | 5.073 | 0.461 | 0.05 | <0.001 | | |
| Security Operations | -0.385 | 0.034 | 0.05 | <0.001 | Accept H1 | Significant |
| Academic Technology Assistance | -0.020 | 0.073 | 0.05 | 0.786 | Reject H3 | Not Significant |
| Public Relations Services | 0.132 | 0.033 | 0.05 | <0.001 | Accept H5 | Significant |
| Stakeholders' Experience | -0.109 | 0.107 | 0.05 | 0.308 | Reject H7 | Not Significant |

**Table 14. Regression analysis: Smart learning resources**

| Factors | B | SE | α | p-value | Decision | Interpretation |
|---|---|---|---|---|---|---|
| Intercept | 2.244 | 0.488 | 0.05 | <0.001 | | |
| Security Operations | -0.340 | 0.036 | 0.05 | <0.001 | Accept H2 | Significant |
| Academic Technology Assistance | 0.254 | 0.077 | 0.05 | 0.001 | Accept H4 | Significant |
| Public Relations Services | 0.192 | 0.035 | 0.05 | <0.001 | Accept H6 | Significant |
| Stakeholders' Experience | 0.234 | 0.113 | 0.05 | 0.038 | Accept H8 | Significant |

resources. Since the all the p-values are lower than 0.05, it can be inferred that all four dimensions of the assessment significantly impact students' learning engagement in terms of smart learning resources. In conclusion, H1, H2, H4, H5, H6, and H8 are supported, while H3 and H7 are not supported.

## DISCUSSION

In this study, we addressed three key inquiries regarding the evaluation of Zhongshan College's smart campus and students' learning engagement. First, we assessed the construction level of the smart campus across four dimensions: 1) security operations, 2) academic technology assistance, 3) public relations services, and 4) stakeholders' experience (Q1). The results show high evaluations from both students and teachers across these dimensions, demonstrating strong endorsement of Zhongshan College's smart campus construction.

Additionally, we conducted a differential analysis to address Q2. The findings reveal significant differences in evaluations of the smart campus when grouped by age. Respondents aged 30 and above rate the smart campus higher in terms of security operations, academic technology assistance, and stakeholders' experience compared with those under 30. This divergence may be attributed to the older respondents, primarily teachers, emphasizing technological and academic aspects, acknowledging the role of security measures and academic support in instructional planning (Lambert & Gong, 2010; Ruggiero & Mong, 2015). Conversely, respondents under 30, mainly students, focus more on fostering student interactions and communication with the external environment (Johnson & LaBelle, 2016).

In terms of gender grouping, female respondents rate stakeholders' experience significantly higher than male respondents, indicating better alignment of smart campus services with female concerns and preferences. Female respondents may emphasize supervision of student learning, improvement efforts, and communication with parents (Ozmen et al., 2016), perceiving the smart campus as providing superior support in these areas.

Among the student population, there is a significant difference in the evaluation of academic technology assistance between sophomore and junior students, with junior students providing significantly higher ratings. As students advance in their academic journey, the demand for learning resources increases, and they develop a deeper appreciation for the academic technology support provided by the smart campus, resulting in higher evaluations.

In response to Q3, the study employed Pearson correlation analysis and regression analysis to explore the impact of the smart campus construction level across four dimensions on students' learning engagement.

First, the results indicate that the evaluation level of public relations services positively influences students' personalized learning and the use of smart learning resources. Prior research has demonstrated that maintaining positive relations with the media and timely dissemination of promotional information enhances the school's visibility and image, facilitating a deeper understanding of the school's educational resources by students and parents (Hori et al., 2015; Zhang et al., 2023).

Additionally, close cooperation with businesses and government entities, obtaining technical and resource support, and providing more learning opportunities and smart learning resources contribute to stimulating students' deeper engagement in learning. Furthermore, the evaluation levels of academic technology assistance and stakeholders' experience positively impact the extent to which students utilize smart learning resources. The introduction of academic technology ensures that students can access the latest tools and resources (Yang & Yu, 2015), actively influencing their interaction with smart learning technologies.

The maintenance and updates of relevant technologies troubleshoot issues, making students more likely to feel supported and confident in using these resources (Jeong & Hmelo-Silver, 2010). By monitoring and improving students' learning processes, stakeholders can better understand students' needs and challenges. This attention aids in providing personalized support, ensuring that students can use smart learning resources more effectively and purposefully, thereby enhancing their learning experience.

It is worth noting that the evaluation level of security operations has a negative influence on students' personalized learning and the use of smart learning resources. With the continuous enhancement of security operations in the smart campus, there might be increased scrutiny of learning resources, leading to certain limitations of learning resources and personalized learning pathways for students (Liu & Chen, 2018; Wang & Long, 2023). The reinforced security measures may result in varying levels of resource usage permissions for different individuals, with students potentially having lower permissions, adding complexity to the process of accessing learning resources and reducing students' motivation. The inconvenience in resource retrieval may pose obstacles for students in utilizing smart learning resources effectively, thereby influencing the depth of their engagement in personalized learning (Concepcion & Espino, 2023; Shang et al., 2008).

## CONCLUSION

In this research, we conducted an extensive investigation into the implementation of the smart campus at Zhongshan College, utilizing both descriptive statistics and quantitative methodologies. This study encompasses a series of sequential steps. First, researchers collected student respondents' and faculty respondents' evaluations of the smart campus from four perspectives: 1) security operations, 2) academic technical assistance, 3) public relations services, and 4) stakeholders' experience. Subsequently, we explored whether significant differences exist in the assessments of the smart campus among various respondent groups, stratified by age, gender, highest educational attainment, and grade level. Lastly, we employed two regression analyses to evaluate the significant influence of the smart campus on students' learning engagement, and we examined this influence from the dual perspectives of personalized learning and smart learning resources.

This study has yielded several significant conclusions, particularly regarding the relationship between the level of smart campus construction and students' learning engagement. The evaluation levels of security operations and public relation services significantly impact the degree of personalized learning. Additionally, evaluations of all four aspects of smart campus construction significantly influence the extent to which students utilize smart learning resources. These findings provide valuable guidance for school administrators. First, there is a need to enhance security operations to ensure the proper protection of personal information and learning data. Also, strengthening public relation services, including maintaining positive relationships with media, government, and businesses, is essential to promote collaboration and communication. Furthermore, optimizing academic technology assistance, timely integrating advanced teaching resources and facilities, and regularly maintaining and updating existing technologies and systems are crucial initiatives.

This study significantly enhances the understanding of smart campus implementation and digital technology utilization at Zhongshan College. We propose a novel evaluation framework for smart campuses, serving as a theoretical foundation for enhancing smart campus development in higher education institutions. This framework addresses existing research gaps related to the evaluation criteria for smart campuses. Current research predominantly focuses on value exploration and framework construction, lacking empirical studies and sufficient engagement from frontline personnel and smart campus users. Our study, distinct from existing approaches, conducts empirical investigations, prioritizes frontline personnel, and explores the evolving landscape of smart campuses in the rapidly advancing realm of internet technology. Our research provides in-depth insights into the relationship between smart campuses and learning engagement, contributing to the enrichment of pertinent research.

For students, the research promises improved adaptability to digital learning demands, facilitating easier resource access, academic interactions, and enhanced academic performance. Teachers benefit from transformative potential, gaining insights for personalized education to meet diverse student needs. Administrative leaders can gain practical guidance, optimizing digital technology for successful smart campus planning and management, contributing to modernized practices and enhanced competitiveness. The findings extend to other institutions, providing nuanced guidance on digital transformation that enhances the overall quality of education. The outcomes provide guidance for policymakers, technology companies, and governments, fostering collaborative efforts to advance smart campuses globally and promote educational equity and inclusivity.

This study still has limitations. Based on the literature study and the actual level of smart technology application in Zhongshan College, this study developed a total of four dimensions and 20 questionnaire questions to assess the level of smart campus construction. In addition to these four dimensions, the evaluation system may cover other dimensions. The research primarily focuses on Zhongshan College, which may limit the generalization of the findings to a wider scope. Future research should further explore the dimension and indicator selection for the evaluation of smart campuses. By conducting extensive literature reviews and on-site investigations of different smart campuses, a more comprehensive and accurate evaluation framework can be established to meet the varying needs of different schools and educational environments.

The scope of future research on smart campuses should be expanded to include universities from different regions and cultural backgrounds. Given the significant disparities in global education levels, there may be substantial variations in the levels of smart campus development among different types and levels of higher education institutions. Conducting comparative studies on the impact of varying levels of smart campus development on learning engagement can enrich research findings and enhance their reliability.

Smart campus development is a dynamic and continuously evolving process that necessitates ongoing tracking and research. A sustained investigation into how smart campuses persistently influence students' learning engagement over time is essential for a comprehensive understanding of its long-term effects. The evaluation of smart campuses should extend beyond students and teachers as respondents to include parents, campus administrators, and other stakeholders. Incorporating diverse perspectives enables a more holistic understanding of the impact of smart campuses on the entire educational ecosystem.

## AUTHOR NOTE

Qingrong Li http://orcid.org/0009-0005-7651-1012

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*Shaobin Chen received a PhD in educational management from the University of Perpetual Help System-DALTA, Philippines. He is the Deputy Director of the Department of Logistics Management at the University of Electronic Science and Technology of China, Zhongshan Institute and holds the title of Engineer. His research is centered on educational management in higher education, with a focus on logistics management and the planning and implementation of smart campus construction.*

*Qingrong Li received a bachelor's degree in information management and information systems from the Southwestern University of Finance and Economics (SWUFE), China. She is working toward a master's degree in business intelligence at the same institution. Her main research interests include data analysis and processing, machine learning, and image processing.*

*Tao Wang received the PhD degree in management information systems from Chungnam National University, South Korea. Currently, he is a professor at the Southwestern University of Finance and Economics, China. His research interests include the adoption and implementation of information systems innovations. He has published in Information Systems Journal, Online Information Review, Electronic Commerce Research and Applications, Behavior & Information Technology, Industrial Management & Data Systems, Journal of Business Research, and other venues.*