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Smart campus: Designing a digital environment that supports students' psychological well-being

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ABSTRACT

Smart campus technologies have witnessed increasing interest in modern educational environments due to their role in the quality of educational services and the student experience. Psychological well-being is also a key indicator of the quality of university life. This study aims to examine the levels of smart campus technology implementation and psychological well-being among university students and reveal the nature of the relationship between them. It will also explore differences based on demographic variables and identify the extent to which these variables and the dimensions of the smart campus explain psychological well-being using Structural Equation Modeling (SEM). A descriptive correlational approach was applied. A sample of 200 male and female students participated in the study. The study relied on the Smart Campus Scale and the Psychological Well-being Scale. The results show that the level of implementation of smart campus technologies is moderate. The smart security and safety dimension ranked first, while the smart infrastructure dimension ranked last. In contrast, the level of students' psychological well-being is high. The results also show no statistically significant correlation between the smart campus and psychological well-being. Regarding differences, the results of the four-way analysis of variance reveal statistically significant differences in the implementation level of smart campus technologies attributable to gender (favoring females), the level of use of smart systems, and the number of days attended. Nevertheless, no differences are found based on the college. Moreover, no statistically significant differences are found in the level of psychological well-being attributable to any of the demographic variables. The structural equation modeling (SEM) results show that demographic variables explain a limited proportion of the variance in the smart campus dimensions. Gender and college have a significant effect on certain dimensions, while the number of days attended has no significant effect. Regression model results indicate that some smart campus dimensions have varying effects on psychological well-being. The smart safety and security dimension shows a significant positive effect, as does the smart mobility dimension, while the smart learning environment (and sustainability and smart environment) shows a significant negative effect. The remaining dimensions do not show statistically significant effects.

KEYWORDS: smart campus, design, mental health, psychological well-being, university students, structural equation modelling

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Introduction

The modern university campus is undergoing a rapid transformation towards digitization and digital transformation. These transformations are considered fundamental factors and essential criteria in developing the university's technological environment (Dong et al., 2020; Qurtubi, 2022; Wang et al., 2024). Contemporary universities reflect this global trend towards smart education by employing modern technologies and digital tools to enhance the outcomes and quality of the educational process (Al-Thani, 2025; Yip et al., 2022). In this context, universities strive to build effective partnerships with the industrial sector and the local community to support sustainable educational goals and to achieve a tangible social impact (Salma et al., 2025). The smart campus emerges as an integrated learning environment that empowers students, transforming them into active participants in the learning network. They participate in knowledge production and the development of educational content, and the continuous improvement of the learning system (AbuAlnaaj et al., 2020; Elbertsen et al., 2025). As education is no longer confined to the boundaries of the traditional university campus, it has expanded into open digital spaces that cater to the needs of diverse learners, aligning with the requirements of the sustainable learning model (Valks et al., 2021).

A smart campus is defined as an integrated university system comprised of interconnected buildings and systems. Hardware, software, services, and infrastructure work harmoniously to enhance the user experience (Hussein et al., 2024). This concept is based on boosting operational efficiency through the effective and targeted use of technology, focusing on meeting user needs rather than simply introducing advanced technological tools (Das et al., 2022; Marques et al., 2023). With the advent of the artificial intelligence era, the urgent need to develop an integrated IT infrastructure is paramount. This infrastructure enables universities to keep pace with global developments and adapt to next-generation technologies efficiently and effectively (Elbertsen et al., 2025; Silva-da-Nóbrega, 2022). A smart campus is an integrated system that employs modern technologies such as the Internet of Things, artificial intelligence, cloud computing, data analytics, and cyber-physical systems to build a more efficient, interactive, secure, and sustainable learning environment (Suster et al., 2025). This model focuses on improving the student learning experience, enhancing resource management efficiency, and supporting scientific research and innovation to achieve a tangible societal impact.

In this context, modern universities are complex institutions that offer a wide range of services, activities, and roles enabling students to interact effectively within their environment. These universities are often located on carefully designed campuses characterized by efficient organization and advanced infrastructure that support teaching and research (Hidayat & Sensuse, 2022; Marques et al., 2023). The traditional role of the campus has been to provide supportive learning environments, in which students' sense of support increases engagement and improves academic outcomes (Prandi et al., 2020; Aloufi et al., 2024). With the shift towards smart models, the role of the campus is no longer limited to providing physical infrastructure but has expanded to include designing integrated, user-centered learning experiences (Al-Thani, 2025). It extends beyond improving operational efficiency and developing the educational process to include supporting mental health and enhancing the quality of life within the university environment (Dionne & Pruneau, 2025). An integrated design that combines physical infrastructure with digital technologies helps reduce daily stress on students by facilitating access to services. It also provides flexible and comfortable learning environments and a sense of security and belonging (Khawngam & Savithi, 2026). In addition, it focuses on user experience and provides user-friendly technologies to minimize technological confusion. These technologies enhance feelings of control and adaptability and impact psychological well-being and academic motivation positively (Polin et al., 2024; Valks et al., 2021).

Therefore, adopting the concept of a smart campus from a user-centric perspective directly contributes to students' psychological well-being, a fundamental element in the success and sustainability of the educational process (Guo et al., 2023). The results of a study by Wang et al. (2024) show that smart campuses, through their digital platforms, promoted social responsibility among students and provided opportunities for community engagement based on their diverse interests. It also contributes to psychological well-being by fostering a sense of accomplishment and belonging, developing skills, and increasing student satisfaction (Shirawia et al., 2024). The results by Salma et al. (2025) indicated that designing three-dimensional spaces using smart materials and structures improves psychological well-being by providing comfortable and stimulating environments. These environments promote feelings of comfort and relaxation. They also support social interaction and belonging to campus, which positively impact student satisfaction, motivation, and overall mental health. A study by Guo et al. (2023) showed that a smart campus could strengthen students' psychological well-being by monitoring their mental health and detecting early signs of stress or anxiety. Furthermore, a study by Brogly et al. (2021) demonstrated that students reported higher psychological well-being when on campus compared to those off campus.

With the increasing use of smart technologies in universities, understanding the impact of smart campuses on students' psychological well-being has become essential. A university campus is not limited to academic education; it also encompasses creating a supportive environment that provides comfort, security, and opportunities for social interaction. By integrating physical infrastructure with digital systems and smart services, campuses can enhance students' mental health and improve their overall university experience. Therefore, studying the relationship between smart campuses and the psychological well-being of students at Ajloun National University is a crucial step in understanding how the modern university environment contributes to supporting mental health and motivating students to actively participate and engage in lifelong learning.

Methods

Research design

This study aims to investigate the relationship between smart campuses and the psychological well-being of university students by revealing the nature of the correlation between variables. It also seeks to determine the prevalence of both smart campus technology adoption and psychological well-being among students. In addition, the study aims to identify differences in these two variables based on demographic variables such as gender, college, level of use of smart university systems, and number of days attended university. The study determines the extent to which demographic variables contribute to explaining the variance in both smart campus technology adoption and psychological well-being using structural equation modeling. Finally, the study verifies the extent to which smart campus technologies predict the level of psychological well-being among university students. The research employs a quantitative design. The study is designed around a correlational model, which allows for the evaluation of relationships between the selected variables. Therefore, a descriptive correlational approach was applied to analyze the results, utilizing quantitative data obtained from participants. To ensure the accuracy and reliability of the measurements, a checklist was developed that includes relevant measures, including a smart campus technology scale and a psychological well-being scale. It was submitted to experts for validation to ensure its accuracy and applicability to the study sample.

Sample of the study

The study sample consisted of 200 male and female students from Ajloun National University in Jordan. Participants were selected using a convenience sampling method, with selection criteria aligned with the research objectives and the characteristics of the study sample. Demographic data were collected from respondents based on the following variables: gender, college, level of use of university smart systems, and number of days attended university, as depicted in Table 1. The study instruments were then distributed electronically through the students' university email using Google Forms. Given the non-probability sampling method and the geographical concentration in Ajloun city, the study results are primarily interpreted within the specific context of the participants. Consequently, the generalizability of these findings to a larger number of students in Jordan or other communities is limited. Nevertheless, the results offer valuable insights into understanding the phenomenon within a specific demographic and social group and can serve as a basis for more comprehensive future studies.

Table 1. Frequencies and percentages according to study variables

Variables	Group	Freq.	%
Gender	Male	77	38.5
	Female	123	61.5

Level of using the university's smart systems	Low	26	13.0
	Medium	130	65.0
	High	44	22.0
Number of days attended university	1-2	121	60.5
	3-4	38	19.0
	+5	41	20.5
College	Humanities	113	56.5
	Sciences	87	43.5
Total		200	100.0

Ethical Considerations

Participation in this study was entirely voluntary. Participants were provided with all the necessary information to help them make an informed decision on participation. Before data collection began, participants were asked to review and sign an informed consent form. They confirmed their agreement to participate after understanding the study's objectives, procedures, and any potential risks. It was also made clear that participation was entirely optional, and participants had the right to withdraw from the study at any time without any consequences. Confidentiality and data protection were guaranteed. All personal data and questionnaire responses were treated with utmost confidentiality and used solely for scientific research. No personally identifiable information was included in any resulting reports or publications. In addition, participants were informed of any potential risks associated with participation, such as experiencing psychological discomfort, and were assured of their right to withdraw at any time without any reasons or facing any repercussions. This study was conducted in accordance with the ethical standards approved by the Research Ethics Committee, ensuring full adherence to the ethical principles applicable to scientific research.

Tools of the study

First: Smart Campus Scale

The Smart Campus Scale designed by Min-Allah and Alrashed (2020) was utilized. The scale consists of 31 items distributed across seven dimensions as follows: Dimension 1: smart infrastructure (items 1-5), dimension 2: smart learning environment (items 6-10), dimension 3: smart management and services (items 11-14), dimension 4: smart security and safety (items 15-18), dimension 5: sustainability and smart environment (items 19-23), dimension 6: smart mobility (items 24-27), and dimension 7: interaction and digital services (items 28-31). Responses to the scale items were based on a five-point scale with the following alternatives: Always (5 points), Often (4 points), Sometimes (3 points), Rarely (2 points), and Never (1 point).

Validity and Reliability

To determine the construct validity of the scale, correlation coefficients were calculated for items and their total score, items and their corresponding domain, and domains and total score. The scale was administered to a pilot sample of 30 participants outside the main study sample. The correlation coefficients for each item with the instrument ranged from 0.43 to 0.85, and with each domain from 0.61 to 0.94. Table 2 below shows the correlation coefficients.

Table 2. Correlation coefficients between item, total score, and domain to which the item belongs for the Smart Campus Scale

Item	Correlation coefficients (domain)	Correlation coefficients (scale)	Item	Correlation coefficients (domain)	Correlation coefficients (scale)	Item	Correlation coefficients (domain)	Correlation coefficients (scale)
1	0.90**	0.74**	12	0.90**	0.78**	23	0.79**	0.80**
2	0.88**	0.78**	13	0.93**	0.85**	24	0.75**	0.78**
3	0.83**	0.67**	14	0.85**	0.75**	25	0.83**	0.69**

4	0.87**	0.76**	15	0.86**	0.75**	26	0.82**	0.56**
5	0.85**	0.82**	16	0.94**	0.74**	27	0.61**	0.43**
6	0.66**	0.44**	17	0.84**	0.63**	28	0.85**	0.75**
7	0.78**	0.65**	18	0.81**	0.81**	29	0.83**	0.56**
8	0.91**	0.74**	19	0.87**	0.77**	30	0.87**	0.81**
9	0.83**	0.75**	20	0.87**	0.79**	31	0.92**	0.77**
10	0.64**	0.75**	21	0.77**	0.62**			
11	0.92**	0.82**	22	0.86**	0.69**			

* Statistically significant at the 0.05 level.

** Statistically significant at the 0.01 level.

It should be noted that all correlation coefficients were of acceptable and statistically significant value; therefore, none of these items were removed. In addition, the correlation coefficient between the domain and the total score, as well as the correlation coefficients between the domains, were calculated and are shown in Table 3.

Table 3. Correlation coefficients between domains and the total score for the Smart Campus Scale

	Smart infrastructure	Smart learning environment	Smart management and services	Smart security and safety	Sustainability and smart environment	Smart mobility	Interaction and digital services	Smart Campus Scale
Smart infrastructure	1							
Smart learning environment	0.682**	1						
Smart management and services	0.854**	0.718**	1					
Smart security and safety	0.751**	0.617**	0.818**	1				
Sustainability and smart environment	0.693**	0.774**	0.659**	0.633**	1			
Smart mobility	0.581**	0.741**	0.593**	0.556**	0.817**	1		
Interaction and digital services	0.638**	0.619**	0.686**	0.863**	0.672**	0.603**	1	

Smart Campus Scale	0.872**	0.865**	0.887**	0.860**	0.880**	0.813**	0.831**	1

* Statistically significant at the 0.05 level.
** Statistically significant at the 0.01 level.

Table 3 shows that all correlation coefficients between the domains of the Smart Campus Scale were positive and statistically significant at the 0.01 level. The correlation coefficients were high and statistically acceptable. Correlation coefficients greater than 0.30 indicate a statistically acceptable correlation in educational and psychological studies, according to common statistical standards such as the Cohen-Jacob criterion. This criterion indicates that correlation values close to 0.50 or higher are relatively strong indicators of correlation in behavioral studies. These results demonstrate a high degree of internal consistency between the scale's domains and the total score, which reinforces the scale's construct validity.

Reliability

To ensure the reliability of the study instrument, a test-retest method was utilized. The scale was applied and then re-applied two weeks later to a group of 30 participants outside the study sample. Pearson's correlation coefficient was then calculated between their scores in the two applications. The reliability coefficient was also calculated using Cronbach's alpha for internal consistency. Table 4 shows the internal consistency coefficient, following Cronbach's alpha, and the test-retest reliability for the domains and the total score. These values were considered suitable for this study.

Table 4. Internal consistency coefficient (Cronbach's alpha) and test-retest reliability for the domains and total score of the Smart Campus Scale

Domain	Test-retest method	Internal consistency
Smart infrastructure	0.86	0.84
Smart learning environment	0.89	0.75
Smart management and services	0.90	0.82
Smart security and safety	0.85	0.77
Sustainability and smart environment	0.82	0.71
Smart mobility	0.86	0.79
Interaction and digital services	0.87	0.80
Smart Campus Scale	0.92	0.86

Table 4 shows that the study instrument has good reliability, with internal consistency coefficients ranging from 0.71 to 0.86 and test-retest reliability coefficients ranging from 0.82 to 0.92, indicating a high level of reliability.

The Warwick-Edinburgh Psychological Wellbeing Scale (WEMWBS)

The Warwick-Edinburgh Psychological Wellbeing Scale (WEMWBS) by Tennant et al. (2007) was used. This widely validated instrument consists of 14 items, positively worded to identify perceived psychological wellbeing. Responses to the items were scored on a five-point scale with the following alternatives: Always (5 points), Often (4 points), Sometimes (3 points), Rarely (2 points), and Never (1 point).

Validity of the psychological well-being scale

To establish the construct validity of the psychological well-being scale, item correlation coefficients with the total scale score were calculated using a pilot sample of 30 participants outside the main study sample. The item correlation coefficients with the total scale score ranged from 0.44 to 0.73, as shown in Table 5.

Table 5. Item correlation coefficients and total score of the psychological well-being scale

Item	Correlation coefficient	Item	Correlation coefficient	Item	Correlation coefficient

1	0.57**	6	0.57**	11	0.48**
2	0.67**	7	0.63**	12	0.68**
3	0.44**	8	0.71**	13	0.59**
4	0.44**	9	0.65**	14	0.73**
5	0.70**	10	0.68**		

* Statistically significant at the 0.05 level.
** Statistically significant at the 0.01 level.

It should be noted that all correlation coefficients were statistically significant and acceptable; therefore, none of the items were removed.

Reliability of the Psychological Well-Being Scale

To ensure the reliability of the psychological well-being scale, a test-retest method was used. The scale was applied and then re-applied two weeks later to a group of 30 participants outside the study sample. Pearson's correlation coefficient between their scores in the two administrations was then calculated and found to be 0.92. The internal consistency coefficient was also calculated using Cronbach's alpha. A value of 0.85 was considered adequate for this study.

Results

Question 1: What is the implementation level of smart campus technologies at the university from the students' perspective?

To answer this question, the means and standard deviations of the implementation level of smart campus technologies at the university, as perceived by the students, were calculated. Table 6 shows the results.

Table 6. Means and standard deviations of the implementation level of smart campus technologies at the university from the students' perspective, ranked in descending order by means

Rank	No.	Domain	Mean	Standard deviation	Level
1	4	Smart security and safety	3.89	1.00	High
2	7	Interaction and digital services	3.81	0.95	High
3	3	Smart management and services	3.47	1.13	Medium
4	6	Smart mobility	3.40	1.00	Medium
5	5	Sustainability and smart environment	3.34	1.04	Medium
6	2	Smart learning environment	3.29	0.99	Medium
7	1	Smart infrastructure	3.03	1.01	Medium
		Smart Campus Scale	3.44	0.88	Medium

Table 6 shows that the level of the study sample regarding the application of smart campus technologies at the university, from the students' perspective, was moderate, with a mean score of 3.44 and a standard deviation of 0.88. Regarding the different domains, the mean scores ranged from 3.03 to 3.89. The smart security and safety domain ranked highest with a mean score of 3.89 and a standard deviation of 1.00, indicating a high level. The smart infrastructure domain ranked lowest with a mean score of 3.03 and a standard deviation of 1.01, indicating a moderate level.

Question 2: What is the level of psychological well-being among university students?

To answer this question, the means and standard deviations of the psychological well-being of university students were calculated. Table 7 shows the results.

Table 7. Means and standard deviations of the level of psychological well-being of university students, sorted in descending order by means

Rank	No. of item	Mean	Standard deviation	Level
1	10	4.43	0.75	High
2	2	4.34	0.86	High
3	11	4.30	0.80	High
4	8	4.19	0.87	High
5	7	4.16	0.77	High
6	13	4.14	0.83	High
7	12	4.09	0.88	High
8	6	4.05	0.78	High
9	1	3.95	1.03	High
10	4	3.90	0.94	High
11	14	3.89	0.84	High
12	9	3.76	0.85	High
13	5	3.74	0.91	High
14	3	3.30	0.98	Medium
Psychological well-being scale		4.02	0.53	High

Table 7 shows that the level of psychological well-being among university students in the study sample was high, with a mean score of 4.02 and a standard deviation of 0.53. Regarding the individual items, the mean scores ranged from 3.30 to 4.43. Item 10, “I feel confident,” ranked first with a mean of 4.43 and a standard deviation of 0.75, indicating a high level. Item 2, “I feel useful or have a role in life,” ranked second with a mean of 4.34 and a standard deviation of 0.86, also indicating a high level. Item 11, “I can make my own decisions,” ranked third with a mean of 4.30 and a standard deviation of 0.80, also indicating a high level. Item 3, “I feel relaxed,” was considered high. In last place, with a mean of (3.30), a standard deviation of (0.98), and a moderate level.

Question 3: Is there a statistically significant correlation ($\alpha \leq 0.05$) between smart campuses and students’ psychological well-being?

To answer this question, Pearson’s correlation coefficient was calculated for the relationship between smart campuses and students’ psychological well-being. Table 8 presents the results.

Table 8. Pearson’s correlation coefficient for the relationship between smart campuses and students’ psychological well-being

		Psychological well-being scale
Smart Campus Scale	Pearson correlation coefficient (*r*)	.061
	Sig.	.387
	No.	200

* Statistically significant at the 0.05 level.
** Statistically significant at the 0.01 level.

Table 8 shows that there is no statistically significant relationship between smart campus technology and students’ psychological well-being.

Question 4: Are there statistically significant differences ($\alpha = 0.05$) in smart campus technology and psychological well-being according to the variables of gender, level of use of smart university systems, number of days attended university, and college?

To answer this question, the means and standard deviations were calculated for both the level of smart campus technology and psychological well-being according to the variables of gender, level of use of smart university systems, number of days attended university, and college. Table 9 presents the results.

First: level of smart campus technology implementation at the university from the students' perspective

Table 9. Means and standard deviations of the level of smart campus technology implementation at the university from the students' perspective according to the variables of gender, level of use of smart university systems, number of days attended university, and college

Group	Sub-group	Mean	Standard deviation	No.
Gender	Male	3.28	.981	77
	Female	3.53	.790	123
Level of using university's smart systems	Low	2.90	.842	26
	Medium	3.62	.846	130
	High	3.21	.808	44
Number of days attended university	1-2	3.39	.974	121
	3-4	3.68	.495	38
	+5	3.35	.816	41
College	Humanities	3.36	.964	113
	Sciencies	3.54	.735	87

Table 9 shows apparent variations in the means and standard deviations of the perceived level of smart campus technology implementation at the university, as perceived by students, due to differences in the variables of gender, level of use of smart university systems, number of days attended university, and college. To determine the statistical significance of the differences between the means, a four-way analysis of variance (ANOVA) was used, as shown in Table 10.

Table 10. Four-way ANOVA of the effect of gender, level of use of smart university systems, number of days attended university, and college on the perceived level of smart campus technology implementation at the university, as perceived by students

Source of variance	Sum of squares	df	Mean of squares	f-value	Sig.
Gender	2.755	1	2.755	4.065	0.045
Level of using university's smart systems	14.465	2	7.232	10.670	0.000
Number of days attended university	4.187	2	2.094	3.088	0.048
College	.342	1	.342	0.505	0.478
Error	130.823	193	.678		
Total	152.229	199			

Table 10 shows the following:

- There were statistically significant differences (α = 0.05) attributable to gender. The F-value was 4.065 with a statistical significance of 0.045, in favor of females.
- There were statistically significant differences (α = 0.05) attributable to the level of use of university smart systems. The F-value was 10.670 with a statistical significance of 0.000. To determine the statistically significant pairwise differences between the means, Scheffé's post-hoc comparison method was used, as shown in Table 11.
- There were statistically significant differences (α = 0.05) attributable to the number of days attended university. The F-value was 3.088 with a statistical significance of 0.048. To determine statistically significant pairwise differences between the means, Scheffe's post-hoc comparison was used, as shown in Table 12. No statistically significant differences (α = 0.05) were found attributable to the college effect. The F-value was 0.505, with a statistical significance of 0.478.

Table 11. Scheffe's post-hoc comparisons of the effect of the level of use of university smart systems on the level of application of smart campus technologies at the university from the students' perspective

	Mean	Low	Medium	High
Low	2.90			
Medium	3.62	0.72*		
High	3.21	0.31	0.41*	

* Statistically significant at the 0.05 level.

Table 11 shows statistically significant differences (α = 0.05) between the mean and both low and high scores, with the differences favoring the mean.

Table 12. Scheffe's post-hoc comparisons of the effect of the number of days attended university on the implementation level of smart campus technologies at the university from the students' perspective

Number of days attended university	Mean	1-2	3-4	+5
1-2	3.39			
3-4	3.68	0.29*		
+5	3.35	0.04	0.32*	

* Statistically significant at the 0.05 level.

Table 12 shows statistically significant differences (α = 0.05) between students with 3-4 and both students with 1-2 and students with 5 or more. The differences favored students with 3-4 days.

Second: level of psychological well-being among university students

Table 13 presents the means and standard deviations of the level of psychological well-being among university students according to the variables of gender, level of use of university smart systems, number of days attended university, and college.

Group	Sub-group	Mean	Standard deviation	No.
Gender	Male	4.04	.487	77
	Female	4.00	.554	123
Level of using university's smart systems	Low	4.02	.543	26
	Medium	4.02	.530	130
	High	4.00	.527	44
Number of days attended university	1-2	4.00	.548	121
	3-4	4.08	.519	38
	+5	4.01	.481	41
College	Huma-nities	4.07	.512	113
	Sciencies	3.95	.543	87

Table 13 shows apparent variations in the means and standard deviations of the psychological well-being of university students due to differences in the variables of gender, level of use of university smart systems, number of days attended university, and college. To determine the statistical significance of the differences between the means, a four-way analysis of variance (ANOVA) was used, as shown in Table 14.

Table 14. Four-way ANOVA of the effect of gender, level of use of university smart systems, number of days attended university, and college on the psychological well-being of university students

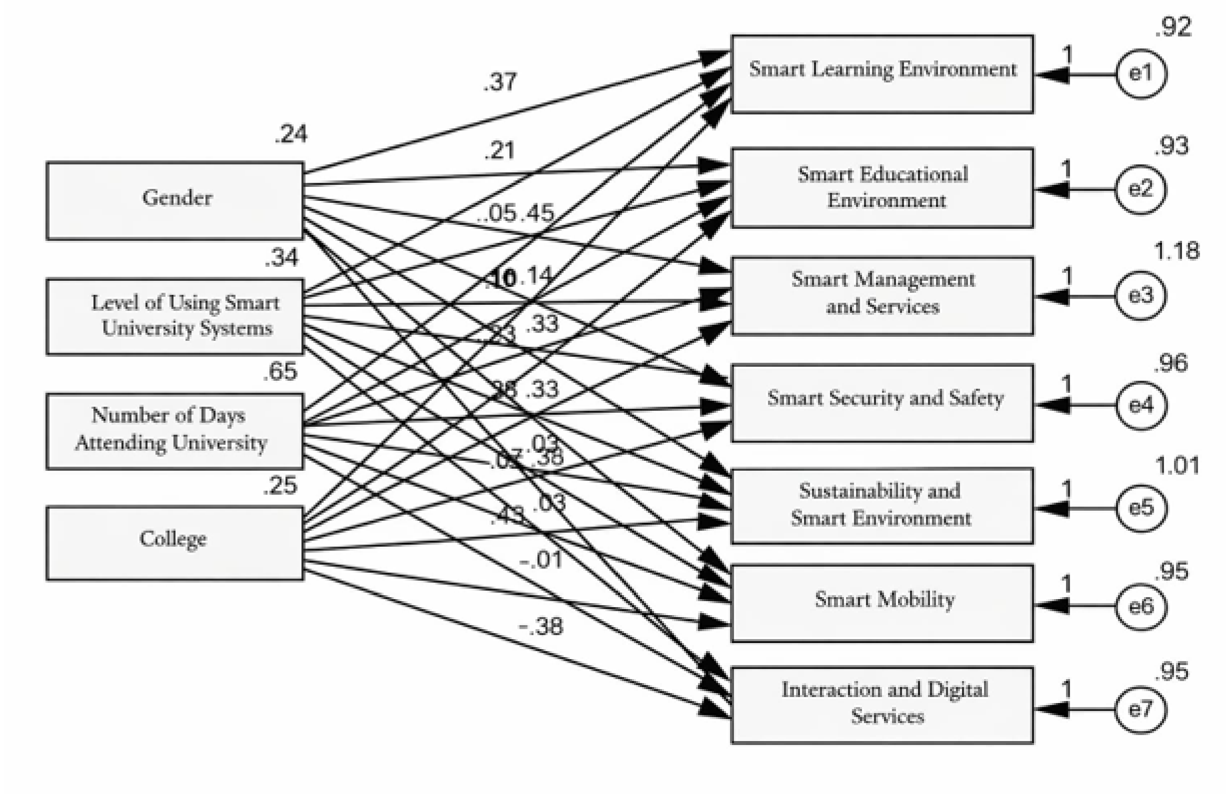
Source of variance	Sum of squares	df	Mean of squares	f-value	Sig.
Gender	.060	1	.060	0.215	0.644
Level of using university's smart systems	.110	2	.055	0.195	0.823
Number of days attended university	.267	2	.134	0.474	0.623
College	.818	1	.818	2.903	0.090
Error	54.364	193	.282		
Total	55.496	199			

Table 14 shows the following:

- No statistically significant differences (α = 0.05) were found attributable to gender, level of use of smart university systems, number of days attended university, and college.

Question 5: To what extent do demographic variables contribute to explaining the variance in both smart

campus technologies and psychological well-being through structural equation modeling (SEM)?



To determine the extent to which demographic variables—gender, level of use, number of days attended, and college—contribute to explaining the variance in the dimensions of the smart campus, structural equation modeling (SEM) was used using AMOS software.

Table 15 shows the values of the coefficients (B), standard deviation (S.E.), critical standard value (C.R.), statistical significance level (P), and the amount of variance explained for each dimension (R^2). This allows for the identification of the most influential variables in each dimension of the smart campus.

Impact factors of demographic variables on the dimensions of the smart university campus according to structural equation modeling (SEM)

Figure 1. SEM path diagram of the effect of demographic variables on the dimensions of the smart campus

Table 15. Effect coefficients of demographic variables on the dimensions of the smart campus according to structural equation modeling (SEM)

Domain	Demographic variable	B	S.E.	C.R.	P	R^2
Smart infrastructure	Gender	0.366	0.139	2.622	0.009	0.123
Smart learning environment	Gender	0.211	0.140	1.506	0.132	0.040
Smart management and services	Gender	0.451	0.158	2.849	0.004	0.069
Smart security and safety	Gender	0.140	0.143	0.978	0.328	0.027
Sustainability and smart environment	Gender	0.249	0.146	1.699	0.089	0.075
Smart mobility	Gender	0.286	0.142	2.010	0.044	0.050
Interaction and digital services	Gender	0.253	0.134	1.882	0.060	0.056
Smart infrastructure	Level of use	0.412	0.116	3.546	<0.001	-
Smart learning environment	Level of use	-0.046	0.117	-0.395	0.693	-
Smart management and services	Level of use	0.097	0.132	0.739	0.460	-
Smart security and safety	Level of use	0.103	0.119	0.866	0.387	-
Sustainability and smart environment	Level of use	0.253	0.122	2.078	0.038	-
Smart mobility	Level of use	0.052	0.118	0.436	0.663	-
Interaction and digital services	Level of use	0.034	0.112	0.305	0.761	-

Smart infrastructure	Days attended	-0.054	0.084	-0.636	0.525	-
Smart learning environment	Days attended	0.106	0.085	1.252	0.211	-
Smart management and services	Days attended	0.056	0.096	0.585	0.559	-
Smart security and safety	Days attended	-0.034	0.086	-0.395	0.693	-
Sustainability and smart environment	Days attended	-0.022	0.088	-0.255	0.799	-
Smart mobility	Days attended	-0.025	0.086	-0.293	0.770	-
Interaction and digital services	Days attended	-0.015	0.081	-0.180	0.857	-
Smart infrastructure	College	0.387	0.137	2.830	0.005	-
Smart learning environment	College	0.288	0.138	2.096	0.036	-
Smart management and services	College	0.370	0.156	2.382	0.017	-
Smart security and safety	College	-0.269	0.140	-1.915	0.055	-
Sustainability and smart environment	College	0.427	0.144	2.972	0.003	-
Smart mobility	College	0.344	0.140	2.461	0.014	-
Interaction and digital services	College	-0.376	0.132	-2.854	0.004	-

1. Gender

- Has a significant impact on infrastructure, management and services, and smart mobility, indicating a difference in student or faculty perception based on gender. The remaining dimensions were not demographically affected by gender, indicating that some dimensions of the smart campus are relatively independent of this demographic variable.

2. Level of use:

- Shows a positive impact on infrastructure, sustainability, and the smart environment, while the remaining dimensions are not statistically significant.
- This result suggests that experience or interaction with the smart campus enhances the perception of some dimensions more than others.

3. Number of days attended:

- No significant impact was shown on any dimension, meaning that the variation in smart campus dimensions is not clearly explained by the number of days attended.

4. College:

- Has a significant impact on most dimensions, such as infrastructure, learning environment, management and services, sustainability, and mobility, favoring science colleges.
- Some dimensions, such as security and digital services, showed a negative impact, reflecting a difference among colleges in the perception of smart campus dimensions.

Summary

- Demographic variables explain only a limited portion of the variation in the dimensions of the smart campus.
- The most significant influences are gender and college, while the number of days attended and the level of usage have a relatively limited impact.
- These results help guide smart campus development plans according to the characteristics of different student and faculty groups.

Question 6: Do smart campus technologies contribute to students' psychological well-being? (Through AMOS models)

The contribution of the university's smart campus dimensions to students' psychological well-being was examined using structural equation modeling (SEM) with AMOS software.

Table 16 shows the regression coefficients (B), standard deviation (S.E.), critical standard value (C.R.), statistical significance level (P), and the explained variance (R^2). Table 16 indicates which smart campus dimensions have a significant impact on students' psychological well-being.

Table 16. Regression coefficients for university smart campus dimensions in explaining students' psychological well-being

Dependent variable	Independent variable	B	S.E.	C.R.	P	R^2
psychological well-being	Smart infrastructure	-0.035	0.036	-0.982	0.326	0.123
psychological well-being	Smart learning environment	-0.092	0.037	-2.512	0.012	0.040
psychological well-being	Smart management and services	-0.017	0.032	-0.525	0.599	0.069
psychological well-being	Smart security and safety	0.191	0.036	5.250	<0.001	
psychological well-being	Sustainability and smart environment	-0.088	0.035	-2.535	0.011	
psychological well-being	Smart mobility	0.090	0.036	2.499	0.012	
psychological well-being	Interaction and digital services	0.003	0.038	0.089	0.929	

1. Smart infrastructure did not show a significant impact on psychological well-being (B = -0.035, P = 0.326), indicating that infrastructure quality alone does not explain differences in students' psychological well-being.

2. Smart learning environment had a significant negative impact on psychological well-being (B = -0.092, P = 0.012), which may reflect some students' feelings of stress or challenges associated with the intensive digital environment.

3. Smart management and services did not have a significant impact (B = -0.017, P = 0.599), indicating that smart management and services do not directly contribute to students' psychological well-being.

4. Smart security and safety showed a significant positive impact on psychological well-being (B = 0.191, P < 0.001), which is the most prominent dimension contributing to students' sense of comfort and security on campus.

5. Sustainability and smart environment has a significant negative impact (B = -0.088, P = 0.011), which may reflect concerns related to certain environmental policies or changes in the smart university environment.

6. Smart mobility had a significant positive impact on psychological well-being (B = 0.090, P = 0.012), indicating that smart mobility facilities enhance student comfort and reduce psychological stress.

7. Interaction and digital services did not have a significant impact (B = 0.003, P = 0.929), meaning that these digital services do not directly affect psychological well-being.

Discussion

The results of the first question indicated that the implementation level of smart campus technologies at the university was moderate from the students' perspective. This result shows that the university is moving towards digital transformation, but it has not yet reached the desired level of integration and comprehensiveness. This result can be explained by the fact that implementing smart campus technologies requires advanced infrastructure, significant financial investments, and long-term strategic plans. These factors may not be sufficiently complete in the current university environment. This result may also be due to the varying levels of technology implementation among different colleges or facilities within the university. This variation can lead to uneven student perception and affect their overall evaluation (Min-Allah & Alrashed, 2020). In addition, the novelty of the smart campus concept in some educational institutions may contribute to the slow implementation process, thus resulting in the moderate level observed.

Regarding the ranking of domains, smart security and safety ranked first. This result can be explained by universities' increasing focus on providing a safe learning environment, especially in light of contemporary challenges. In addition, the applications of this domain are often tangible and readily apparent to students, such as surveillance systems, access cards, and emergency systems, which enhances their perception of its effectiveness and positively influences their evaluation of it. In contrast, smart infrastructure came last in place. This result can be explained by the fact that this domain requires significant technical and financial resources and is less visible to students compared to other domains. Its components often operate in the background, such as smart networks and data management systems. Any weakness or slowness in internet services or digital systems can negatively impact students' evaluation of this field (Elbertsen et al., 2025; Shirawia et al., 2023; Tashtoush et al., 2025).

The result that university students reported high levels of psychological well-being suggests that they enjoy a good degree of psychological balance and satisfaction with their academic and personal lives. This result may reflect their ability to adapt to the demands of university life and their effective management of academic stress. It also indicates their possession of positive psychological skills such as optimism, resilience, and a sense of belonging. In addition, this result can be attributed to the relatively supportive university environment, whether through positive social relationships among students, support from faculty members, or the availability of counseling and psychological services within the university. This environment contributes to enhancing students' sense of psychological security and satisfaction (Ma & Liu, 2025; Zhang & Tsai, 2023).

The results of the third question indicated no statistically significant relationship between smart campuses and students' psychological well-being. This result suggests that the level of smart campus technology implementation did not have a direct or clear impact on the psychological well-being of the sample. This result can be explained by the fact that psychological well-being is a complex and multidimensional concept, influenced by personal, social, and academic factors that may be more influential than technological factors. Students may rely more on elements such as social support, interpersonal relationships, family stability, and satisfaction with their major to achieve their psychological well-being than on smart campus services or technologies (Azzahrah et al., 2025). Therefore, even with or without smart campus implementations, levels of psychological well-being may remain relatively stable.

In addition, this result can be explained by the fact that the level of smart campus implementation—which was moderate—did not reach the point of having a tangible impact on students' psychological well-being. In other words, the effect of these technologies may be limited or insufficient to reflect statistically significant improvements in psychological well-being. Moreover, the lack of a correlation may stem from students' limited awareness of the smart campus concept or their lack of understanding of its direct connection to their psychological lives, thus diminishing its perceived impact. Furthermore, some components of the smart campus, such as infrastructure or technological systems, operate invisibly, and thus students do not directly perceive their psychological effects (Sneesl et al., 2022).

The results indicated statistically significant differences in the level of smart campus technologies attributable to gender. These differences favored females, indicating that they scored higher than males. This can be explained by the fact that females often demonstrate a higher level of awareness and attention to aspects of university life or psychological well-being. This awareness is reflected more positively in their evaluations. This result may also stem from females' tendency to express their feelings and understand their psychological experiences more deeply. This understanding makes them better able to assess dimensions of psychological well-being or the university environment compared to males, who may tend to downplay emotional aspects. In addition, the differences could be attributed to the nature of their interaction with the university environment. Females may be more committed to or integrated with university activities and services, including guidance services or available technologies, which contribute to their higher levels of smart campus technology proficiency.

The results indicated statistically significant differences in the level of smart campus technologies attributable to the rate of use of smart university systems. These differences favored the moderate level of use. This result can be explained by the fact that moderate use of smart technologies achieves a better balance for students. They benefit from the advantages of these systems without experiencing the negative effects associated with excessive or limited use. Moderate use may allow students to efficiently access educational and administrative services, such as online registration and academic communication, thus facilitating their university life and enhancing their experience. Conversely, low use may not allow them to fully benefit from these systems. High use, on the other hand, may be associated with increased reliance on technology or exposure to digital stress. This result can also be explained by the fact that students with moderate use possess a better awareness of how to employ technologies effectively without overusing them (Min-Allah & Alrashed, 2020).

The results indicated statistically significant differences attributable to the number of days attended at university. These differences favored students attending 3–4 days a week. This result can be explained by the fact that this level of attendance represents a suitable balance between face-to-face learning and self-directed learning. It allows students to benefit from interaction with faculty and peers while simultaneously providing them with sufficient time to organize their studies and other commitments. Moderate attendance may enhance students' integration into the university environment and increase their sense of belonging. It also allows them to benefit from available university services and technologies, whether smart campus technologies or academic activities, which positively impact the variable under study (Zhang et al., 2022).

The results indicated no statistically significant differences attributable to the college variable in the impact of implementing smart campus technologies. This result shows students across different colleges have a similar perception of the level of application of these technologies. The result can be explained by the fact that smart services and technologies are generally and centrally implemented at the university level, rather than varying significantly from one college to another, leading to a similar student experience regardless of their major. It may also be attributed to the fact that most smart systems (such as administrative systems, e-services, and digital infrastructure) are managed at a unified level. Consequently, all students benefit from them to a similar degree, reducing the likelihood of college-related differences (Sneesl et al., 2022). In addition, the absence of differences may also indicate that the nature of students' use of smart technologies does not differ significantly between colleges. These technologies have become a common part of the university environment, used by all students to a similar degree, regardless of their major.

Moreover, the results indicated no statistically significant differences in psychological well-being attributable to gender, level of use of university smart systems, number of days attended university or college. This result suggests that students, regardless of their academic or personal characteristics, experience similar psychological well-being within the university environment. The result can be interpreted as meaning that psychological well-being is not directly affected by these apparent factors, but rather by deeper and more influential factors such as the nature of social relationships, level of psychological support, academic pressures, or students' personality traits (Ryan et al., 2022; Xie et al., 2024). The result may also indicate that university services, including smart systems, meet students' needs in a similar way, thus limiting the existence of differences among them.

The results indicated statistically significant differences attributable to gender in some dimensions of the smart campus, namely smart infrastructure, smart management and services, and smart mobility. These differences favored females, which may be attributed to their greater attention to the details of the university environment, such as the quality of facilities, ease of access to services, and the organization of movement within the campus. They also tend to be more sensitive to elements of comfort, safety, and organization (Asfour & Al-Mahdy, 2026; Abdulbaki et al., 2025; Hatamleh et al., 2025). In contrast, no statistically significant differences were found in the remaining dimensions, such as the smart learning environment, security and safety, sustainability, and digital interaction and services. This result suggests that these aspects are perceived similarly between males and females, and may reflect services that are available and equal to all students, regardless of demographic factors.

The results indicate that the level of use of university smart systems had a statistically significant positive impact on the dimensions of smart infrastructure and sustainability/smart environment. This result may reflect that students with high usage are more engaged with campus components in terms of facilities, equipment, and services related to efficiency and sustainability. Consequently, they have a higher awareness of these aspects as a result of their direct and frequent interaction with smart systems that contribute to improving infrastructure quality, reducing waste, and enhancing resource efficiency (Gao, 2022). In contrast, no statistically significant differences were found in the remaining dimensions, such as the smart learning environment, administration and services, security and safety, mobility, and digital interaction. The result suggests that these dimensions be similarly available and implemented for all students regardless of their usage level, or that the impact of usage is limited to aspects related to physical infrastructure and the environment rather than direct administrative or educational aspects (Elbertsen et al., 2025).

The results indicated statistically significant differences attributable to the college variable in most dimensions of the smart campus, such as smart infrastructure, the learning environment, smart management and services, sustainability and the environment, and smart mobility. These differences favored science colleges, which may be attributed to the nature of scientific disciplines that rely more heavily on technological applications, modern infrastructure, laboratories, and advanced equipment. This result leads to greater student interaction and engagement with the components of the smart campus, and consequently, a greater awareness of its efficiency and quality. In addition, the learning environment in science colleges is often more reliant on modern technologies. It reinforces students' higher evaluation of these dimensions compared to other colleges.

Conversely, this result may reflect differences in the nature of needs and experiences among colleges. Students in science disciplines have more infrastructure and technological requirements, while students in other colleges may have less reliance on these aspects, which explains the differences favoring science colleges (Hidayat & Sensuse, 2022).

The results indicate that none of the smart infrastructure, smart management and services, and digital interaction and services had a statistically significant effect on students' psychological well-being. This result suggests that while these dimensions are important for improving the quality of the university environment, they do not directly explain differences in psychological well-being. The result can be explained by the fact that psychological well-being is influenced by deeper and more complex factors than simply the availability of infrastructure or the quality of digital services, such as social support, academic pressures, personality traits, and the overall psychological environment within the university. It may also indicate that these dimensions are contributing factors to the overall university experience, but not directly related to students' psychological state, or their effect is indirect and manifested through other mediating variables. Therefore, improving psychological well-being requires considering psychological and social factors alongside technological and service-related factors within the university campus (Asfour & Al-Mahdy, 2026; Marques et al., 2023; Khasawneh et al., 2026).

The results indicate a statistically significant negative impact of both the smart learning environment and sustainability on students' psychological well-being. This result may reflect the fact that increased reliance on digital or smart learning environments can be accompanied by feelings of pressure among some students. This pressure can lead to burnout due to the intensity of technical demands or the difficulty of adapting to advanced digital systems. The negative impact of sustainability and smart environments can also be explained by anxieties or worries related to the constant changes in the university environment, environmental policies, and new technologies, which may negatively affect students' psychological state (Wei et al., 2025). Overall, these results suggest that some aspects of the smart campus, despite their role in development, may pose a cognitive or psychological burden on students if they are not designed or managed in a way that considers their needs and abilities. This necessitates striking a balance between technological development and providing psychological support for students.

The results indicate a statistically significant positive impact of both smart security and safety, and smart mobility, on students' psychological well-being. Smart security and safety are among the most prominent dimensions contributing to students' sense of security and stability on campus. This positively impacts their psychological state and increases their comfort and confidence in the university environment (Polin et al., 2024). Smart mobility, with its ease of movement and navigation within the campus, also contributes to reducing the effort and stress associated with moving between different facilities. Consequently, it alleviates daily pressures and enhances student comfort. Overall, these results demonstrate that the dimensions related to security and ease of movement are important factors in promoting psychological well-being; they address fundamental needs related to comfort and stability within the university environment (Chen & Wang, 2024; Ikrissi & Mazri, 2020).

In conclusion, the study results indicated that university students experience a high level of psychological well-being, while the application of smart campus technologies is at a moderate level, with significant variations across its dimensions. The results also revealed no statistically significant correlation between smart campuses and psychological well-being and thus suggest that the impact of these technologies on student well-being is not necessarily direct. In addition, structural equation modeling revealed that the impact of smart campus dimensions on psychological well-being varies depending on the dimension. Smart security and safety, and smart mobility emerged as significant positive predictors of psychological well-being. Conversely, the smart learning environment, sustainability, and smart environment showed significant negative impacts, while the remaining dimensions had no direct effect. Moreover. The results indicated that demographic variables contribute only to a limited extent in explaining the variation in smart campus dimensions, with gender and college showing a notable influence on some dimensions. These results suggest that improving students' psychological well-being within the smart campus context depends primarily on developing specific dimensions that enhance feelings of security and comfort, rather than relying solely on the general application of technologies. This highlights the importance of focusing on smart applications that consider the psychological needs of students within the digital university environment.

Study Limitations and Strengths

The study's main limitations include its reliance on a descriptive-correlational approach, which restricts the ability to interpret causal relationships between the study variables. Additionally, the sample was limited to a single university, which potentially affects the generalizability of the results to other universities. Moreover, the use of self-reported measurement tools may introduce response bias. However, the study's strengths lie in its use of standardized measures with appropriate psychometric properties. Furthermore, it addresses a contemporary topic that combines smart campus technologies with psychological well-being. Finally, the use of structural equation modeling (SEM) contributed to an advanced analysis of the relationships between variables and revealed the direct effects of smart campus dimensions on psychological well-being.

Recommendations

The study recommends directing university efforts toward developing specific dimensions of the smart campus, particularly those related to security, safety, and smart mobility, given their positive role in enhancing students' psychological well-being. It also recommends designing guidance and awareness programs within universities. They aim to promote psychological adaptation to the digital environment and mitigate the negative effects of certain dimensions, such as the intensive digital learning environment. In addition,. The study suggests conducting future research using longitudinal or experimental designs to investigate causal relationships between variables, expanding the sample size to include diverse universities and learning environments. Furthermore, it proposes investigating other mediating or moderating variables that may contribute to a more in-depth understanding of the relationship between the smart campus and psychological well-being.

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