



CREATIVE TECHNOLOGICAL, EDUCATIONAL, EFFECTIVE, AND SECURE SMARTNESS OF HIGHER EDUCATION INSTITUTIONS: THE PILOT STUDY OF THE PERSPECTIVE OF ESTONIAN STUDENTS

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Abstract. Since such a topic has not been investigated in Estonia before, the author decided to conduct a pilot study in preparation for the main study. The overall goal of the current pilot study is to gain first understanding of students' perspectives on both technological and educational technological applications in the context of a smart campus, as well as the privacy aspects of different solutions. The survey took place from 01.02.2024 to 10.06.2024. The link to the questionnaire was distributed through the student councils and communication offices of Estonian public universities and universities of applied sciences. A total of 286 students from all over Estonia answered the questionnaire.

Keywords: smart campus, smart technology, sustainability, effectiveness, security, privacy.

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1. Introduction

There is no consensus definition of a smart campus, around 70 definitions for smart campus and related terms can be found in the literature, but in general, the concept of a smart university is related to technological innovations, sustainability, learning strategies and stakeholder participation to promote changes in educational paradigms and learning and living conditions in higher education institutions (HEIs). For example, Silva-da-Nóbrega et al. (2022) concluded that a smart campus is a higher education ecosystem that uses technology to achieve sustainability (economic, environmental and social aspects) in a managerial, collaborative and adaptive learning model. It is related to the goals of sustainable development, namely economy, education, environment, living, mobility, governance, security and technology (Silva-da-Nóbrega et al., 2022). All these solutions make campus operation convenient and teaching efficient, but campus smartness is largely based on big data, so the biggest challenge in developing a smart campus is protecting student and employee data – security and privacy issues.

However, the question remains, what does a “smart city” mean? How do students perceive the different characteristics of such a “smart campus”? Do Estonian campuses at least partially meet the requirements of smart campuses? Do students perceive “smartness” as a security threat to their privacy, or do they value its energy efficiency, smaller footprint on the environment, and perceive it as an environment that unites the community? These are all issues that need to be addressed in collaboration with the people who are actually affected by the university's service – the students.

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2. Literature review

Most of the studies and works on the smart campus have mainly focused on technological aspects. From monitoring classroom occupancy and counting students in the classroom, which allows control of the occupancy of auditoriums (Conti et al., 2014) to more efficient use of campus space (Chen et al., 2013; 2011), security and privacy (Flauzac et al., 2015; Sánchez-Torres et al., 2018) and the design and implementation of a dormitory management system based on facial recognition (Zhou et al., 2021). Smart classrooms are an important process and a key link in the implementation of smart teaching, and the realisation of smart teaching depends on the creation and development of smart classrooms (Zhang & Feng, 2022). De Angelis et al. (2015) focused on the environmental aspects of the smart concept from the point of view of energy saving.

At the same time, attention has also begun to be paid to technologies that support education. Smart lectures reflect a shift towards an emerging field called learning experience design. The student does not waste time navigating the course but spends all his time learning. Both in the classroom and online, courses are engaging when they encourage active learning and allow students to meaningfully interact with the material (Ben-Naim, 2017). The new generation of lecturers should be masters of both hard (e.g. professional education for teaching the relevant profession) and soft skills (communication skills, creative thinking, time management, etc.), including their mastery in creating training courses for the latest e-learning platforms based on the main components of smart pedagogy (Gudkova et al., 2023). The use of new technologies has created opportunities to make educational life easier, and at the same time, with the help of new technology, it is also possible to influence the content of teaching – to make lectures and studies more interesting and the application of teaching methods more effective (Ibáñez et al., 2014; Kwok, 2015).

In a digital campus, technology can reduce operational costs, improve security, and provide tools for researchers, faculty, students, and staff. These benefits provide great added value to the university. At the same time, studies have also shown that the human element remains important in higher education, alongside all the smartness. In addition, a smart university should increase flexibility and efficiency and take into account the emerging needs of modern society and the labour market (Coccoli et al., 2014; 2015). The results of the Galego et al. (2016) study revealed that in addition to the development of the infrastructure and technology of the HEI, human feelings remain important when assessing the level of intelligence, e.g. motivation and needs.

“Smart” education would be a natural development, the framework of which is still in the formative stage, but definitely requires the preparation of education for digital transformation. The development of information and communication technology poses new challenges to teaching and learning. Considering the fields of the future, both lecturers and students should be ready to meet new demands.

The framework of this study builds on previous surveys conducted in various countries, examining smart campus concepts across higher education institutions as well as primary and secondary schools.

Přibyl et al. (2018) compared students' perceptions of smart campuses at the Czech Technical University and Thammasat University in Thailand. The findings showed that greater knowledge of smart city concepts led to more critical attitudes. Czech students, though familiar with smart cities, were skeptical about implementation and did not prioritize making their campus smarter. Thai students, on the other hand, perceived their campus as more advanced and desired further improvements. Key priorities included smart public transport, campus maps, and navigation tools, while smart parking was more valued in Thailand due to higher car use. Smart cards for building access were seen as most useful, while e-wallets and automatic attendance systems were least important.

Zhang et al. (2020) examined perceptions of smart technologies in Hong Kong primary and secondary schools among principals, teachers, and parents. The study found that technology adoption depended on users' understanding and that teacher training and well-being were often overlooked. It emphasized supporting teachers through professional development and reducing administrative workloads via smart tools. While sustainability was seen as less important, the study underscored the need for stronger knowledge of smart campuses to address privacy and cybersecurity concerns and to guide future policy and technology development.

Sanik et al. (2021) surveyed Malaysian university students to explore smart campus design as a step toward smart cities. After an educational video, students' understanding of smart concepts improved notably. Many respondents stressed that crisis management relies more on people than technology, cautioning against overinvestment in high-tech equipment. The authors recommend further open-ended surveys to deepen understanding of students' perceptions of smart campuses and cities.

In conclusion, previous studies show that awareness and understanding strongly influence how students and educators perceive smart campuses. Successful implementation depends not only on technology but also on user engagement, training, and support. Developing smart campuses therefore requires a balanced approach that combines innovation with education, practicality, and human-centered design.

3. Research methodology and sample characterisation

The questions of this study are based on three research projects (Přibyl et al., 2018; Zhang et al., 2020; Sanik et al., 2021), which were adapted to Estonian conditions. The level of knowledge was assessed on a 5-point scale.

Since the opinions of students in the context of a "smart campus" have not been studied before in Estonia, in this survey, many open-ended questions were also added, which included plenty of opportunities to express opinion and leave comments.

In total, 65% of female and 35% of male students answered the survey. By accommodation, 24% of the respondents live on campus and 76% live outside the campus. According to educational level, 36% of the respondents are in bachelor's studies, 49% are in master's studies and 14% are doctoral students. One respondent was a vocational student. By subject, 40% of respondents study technical sciences, 26% natural and exact sciences, 20% social sciences, 10% humanities, 3% medicine and 1% educational sciences.

4. Results

General awareness of the nature of a smart campus

Understanding students' level of knowledge about the smart campus is important because it affects their perceptions and attitudes towards smart education. Such knowledge can be interpreted as how familiar the respondents are with the smart campus, and five levels of knowledge are defined in the respondents' choice.

Figure 1 indicates a rather low and moderate familiarity with the smart campus and a lack of knowledge about the smart campus and its solutions among Estonian students. Notably, 41% have not come across any smart solutions. This shows the need to strengthen training and promote the smart campus. It is very possible that there are already so many "smart" solutions available that students consider them everyday, ordinary, and natural rather than smart solutions.

According to Figure 2, Estonian students generally do not perceive their university as a smart campus. Only a small number view their campus as fairly smart, and very few believe

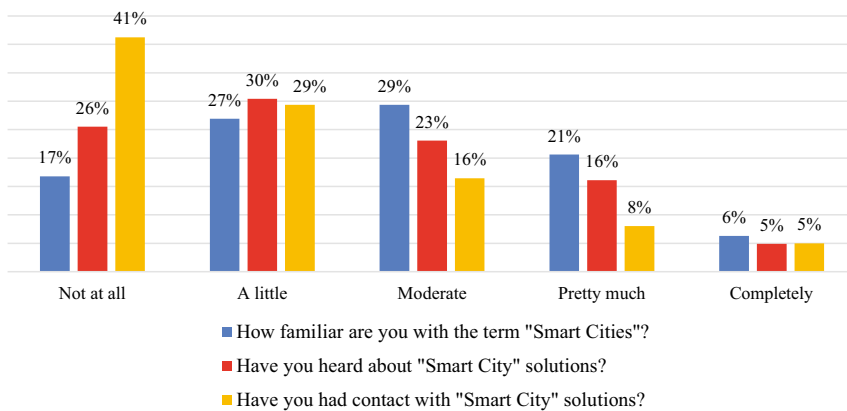


Figure 1. Respondents' familiarity with the term "Smart City" (source: created by author)

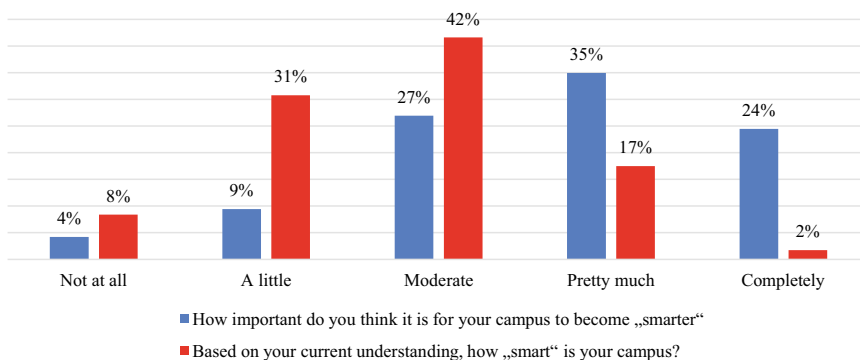


Figure 2. Current understanding of the "smartness" of the respondents' campus (source: created by author)

it is fully smart. In contrast, most students consider it important for their campus to become more intelligent and technologically advanced, with many emphasizing that this development is of high importance. From this, it can be concluded that there is currently a significant gap between the existing situation in Estonian higher education institutions and students' expectations of what a truly smart campus could be.

Table 1 shows how the responses to the question of what makes a campus smart were distributed. The majority of students agree with the proposed statements as important elements that would make the campus smart. On average, 34% somewhat agreed with the given statements, and the percentage of those who fully agreed was 48%. The overall most popular element is economic efficiency or savings. As expected, the next most popular element is convenience, followed by expectations that the HEI where you study would contribute to the achievement of green and environmentally sustainable goals and be a leader in innovation.

Table 1. The importance of becoming a "smarter" campus (source: created by author)

Statement	Strongly disagree	Somewhat disagree	Neither agree	Somewhat agree	Strongly agree
Convenience	2%	2%	9%	36%	51%
Economic efficiency	1%	2%	8%	42%	46%
Contributing to the achievement of green and environmentally sustainable goals	4%	4%	12%	33%	48%
My higher education institution must be a leader in innovation	3%	2%	20%	26%	49%
Average percentage	3%	3%	12%	34%	48%

The respondents highlighted the following aspects:

- *The university must be a leader in innovation – we just shouldn't lose sight of what really matters – in environmental preservation, the university must be a pioneer.*
- *A smart campus would give a better learning experience and would save students time and money, and provide safety.*
- *Convenience is always important because we all want to save our time and energy if we can. We must think about ecology in our times, because if not now, later can be too late.*
- *Universities should take the lead in showing how becoming energy efficient and comfortable aren't exclusive.*

Understanding the smartness of the campus

The elements of the smart campus are presented in Table 2. The level of importance of most of the elements was not important to the respondents at a higher level. The most important for students are smart lectures and lecturers, smart auditoriums, laboratories, buildings and smart mobility. Among other things, their preference was justified as follows:

- *Auditoriums and lecturers are overall more important if talking about studying so they are here also more important.*
- *Mobility, because it takes time to get from one faculty to another. Auditoriums/buildings – the place I will be spending my time, and try to study, hence good air quality, ambience and environment are important.*

- *A smart app could be the place that holds all the information a student might need: timetable, events, homework, etc. In my opinion, smart auditoriums and labs would have the biggest positive impact on studies.*
- *Smart lectures could make lectures more interactive and, for example, give introverted students an easy way to ask questions, but they could also lower the need for in-person lectures and social interactions.*
- *Smart places, like auditoriums and buildings, increase the comfort of the learning process. Smart courses make it possible for more people to participate, without losing efficiency.*

Table 2. Importance of the following “smart campus” elements (source: created by author)

Smart campus element	Not at all	A little	Moderate	Pretty much	Completely
Smart card	9%	15%	26%	29%	21%
Smart app	12%	15%	26%	27%	20%
Smart mobility	7%	9%	23%	30%	30%
Smart auditoriums/labs/buildings	4%	5%	19%	34%	39%
Smart courses/lecturers	4%	3%	18%	30%	46%
Average percentage	7%	9%	22%	30%	31%

Table 3. How important are the following on-campus mobility concepts for you? (source: created by author)

Mobility concept	Not at all	A little	Moderate	Pretty much	Completely
Parking with sensors that know where there is a free space in the parking lot	24%	19%	17%	22%	18%
Street lighting that turns on when a pedestrian approaches	7%	12%	19%	28%	34%
Waste management that sends information to the information collector when the rubbish bin is full	6%	12%	22%	27%	33%
Smart public transport management/tickets on student ID	7%	3%	16%	20%	54%
Campus map and navigation in smartphone	10%	10%	21%	22%	36%
A smart system to ensure the quality of the indoor heating and ventilation system, etc.	3%	5%	10%	27%	55%
Smart security and safety using the latest video surveillance technology	9%	11%	24%	27%	30%
The possibility of living and studying on a smart campus with services available 24/7, which increases the efficiency of time use	7%	8%	11%	26%	47%
Open and accessible Internet connection for everyone	1%	2%	4%	12%	81%
Average percentage	8%	9%	16%	24%	43%

Table 3 presents students' views on the importance of implementing smart campus mobile solutions. Although Estonia is known as an e-country, a small share of respondents did not consider any mobile solutions important. Most, however, valued them highly. The most

appreciated options were open campus Wi-Fi, smart systems for heating and ventilation, and intelligent public transport management, such as real-time departure screens and transport tickets linked to student cards. Students also valued 24/7 access to campus services that improve time efficiency. Parking sensors were seen as least important, likely because most students use public transport.

Among other things, the respondents justified their preferences as follows:

- *The public transportation possibilities better with the needs of the students would be nice, reducing unnecessary light pollution and unnecessary driving for waste when bins are not full is also important for me.*
- *Waste management would be a nice thing to have but not critical. The availability of a free and secure Internet connection for students and ways to increase the efficiency of time use would be massive benefits for the student body because it allows people to increase the efficiency with which they study. Increased video surveillance can be a controversial subject for people because even in a public space like the campus people still appreciate their privacy. Internet availability is very important.*
- *Students who arrive by car have to park their vehicle somewhere and it takes a lot of time when looking for a parking lot, which is why it's good to have parking sensors. Pedestrian visibility is crucial both for the pedestrian and the driver.*
- *I rely on public transit quite a lot so concepts that are related to that are very important to me, unlike parking sensors. Smart ways to make the campus more comfortable (e.g. ventilation) or make the environmental cost smaller (e.g. waste management) are also important to me.*

Knowledge of the "smart campus"

Figure 3 shows that, according to the respondents, the most important part of a smart campus is the regular monitoring of the satisfaction level of students and employees. The use of result-based "smart" teaching methodology follows. Monitoring the movement of vehicles and identifying the number plate in and out of the campus is not important for most students, because, as seen from the previous subsection, there are few students who enter the campus by car, as most of them use public transport.

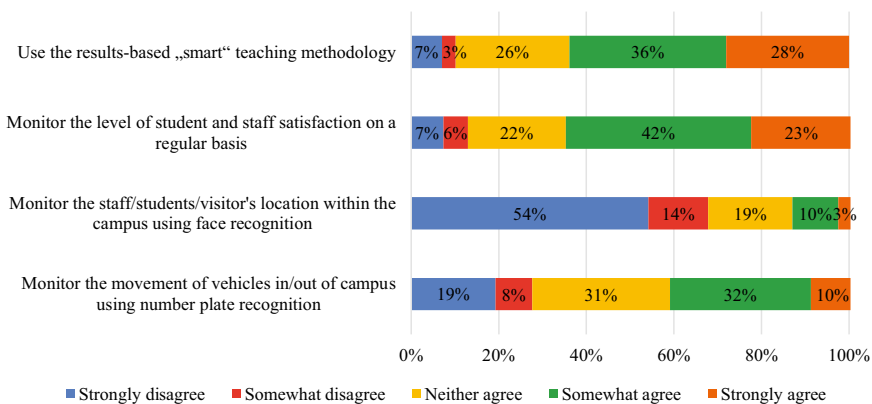


Figure 3. The solutions that "Smart Campuses" should have (source: created by author)

The least popular solution was using facial recognition to track the location of staff/students/visitors on campus. This statement brought a lot of responses and visibly emotional answers to the open question. These responses show that while security may be important in some situations, it must not intrude on the privacy of students and their guests:

- *If this identification camera was put in the hall of the dormitory, I would agree, because if there has been an "incident" in the dormitory and it is necessary to prove that someone has entered without permission, then this is an ideal means of ensuring security.*
- *Monitoring of students who are entering the campus can facilitate energy consumption for heating.*
- *It would be great if there were a monitor in the parking lot that displays the number of free spaces. Getting feedback on your overall daily well-being would help improve things. If these studies are done too rarely, people may not remember all disturbing or pleasant situations.*
- *People recognition would be a great threat to privacy. Result-based teaching would improve the quality of education.*
- *For new fields, old academic methods are outdated, so applying new methods is extremely important. Outcome-based learning would improve the quality of education.*

Table 4 explores how important students consider smart solutions for automated access on campus. Only a small number felt that such solutions were unnecessary. In contrast, the majority strongly supported their implementation. Students especially valued smart access to individual and group workspaces, library self-service machines, auditoriums, laboratories, and dormitories. The e-wallet feature was considered the least essential.

Table 4. The solutions students expect their campus should have (source: created by author)

My campus should have authorised:	Strongly disagree	Somewhat disagree	Neither agree	Somewhat agree	Strongly agree
<i>Access to auditoriums/classrooms/laboratories</i>	1%	2%	7%	28%	62%
<i>Access to the library's automated loan and return machine</i>	1%	1%	7%	22%	69%
<i>Access to individual and group work areas</i>	1%	0%	3%	14%	81%
<i>Entrance to the dormitory</i>	4%	3%	20%	20%	54%
<i>Automatic registration system for participation in the lecture</i>	8%	9%	22%	24%	38%
<i>Identity verification to enter the exam</i>	9%	7%	20%	29%	35%
<i>E-wallet feature to pay for meals, parking and other services on campus</i>	12%	9%	21%	25%	33%
<i>Average percentage</i>	5%	4%	14%	23%	53%

The respondents justified their opinions in free form as follows:

- *Access to different school rooms is important. An identity verification system sounds great and takes less time for lecturers to verify everybody. I don't think an extra wallet feature is needed.*
- *Students should be able to use individual and group work areas, and the library at all times – we need a quiet place to study even late at night (people often work late, the only time they can study is at night).*
- *Dormitories are homes for the few, not all, so authorised entry is fully justified.*

5. Conclusions

This study aimed to assess which smart campus applications and technologies are recognized and valued by students. The results of the study showed that smart lectures and lecturers, smart auditoriums, laboratories and buildings are the most important elements of a smart campus for students. Good air quality and environment are considered important for smart rooms and buildings because students spend most of the day there. Students do not consider their HE institution to be “smart”, although it is considered very important to become “smarter”. Old academic methods are considered to be outdated for new fields, so new methods are extremely important, and outcome-based “smart” teaching methodology would improve the quality of education. Tracking the location of employees/students/visitors on the campus using facial recognition is considered to be a breach of privacy, a restriction of freedom, and a data security issue. A stronger human element and lower levels of automation are preferred. Since students’ opinions on smart campuses have been relatively underexplored worldwide, this study conducted in Estonia aims to provide a broader context that can be generalized to European students, particularly in light of the General Data Protection Regulation (GDPR) that came into effect in 2021. Additionally, the freely expressed thoughts of students on various aspects of smart campuses, often presented in depth, add significant value to this article.

Future research should examine variations in students’ perceptions based on academic discipline, education level, and living arrangements, as these factors may influence attitudes toward specific technological solutions.

In conclusion, while smart campus technologies offer considerable potential to enhance learning, research, and operational efficiency, their adoption requires a balanced approach that weighs benefits against costs, ethical implications, and human-centered priorities. HEIs that successfully navigate these dynamics can serve as exemplars of innovation, sustainability, and student-centric development in higher education.

References

- Ben-Naim, D. (2017). *What makes a smart course ‘smart’?* <https://www.edsurge.com/news/2017-01-13-what-makes-a-smart-course-smart>
- Chen, Y., Li, X., Wang, Y., & Gao, L. (2011). The design and implementation of intelligent campus security tracking system based on RFID and ZigBee. In *The 2011 Second International Conference on Mechanic Automation and Control Engineering* (pp. 1749–1752). Hohhot. <https://doi.org/10.1109/MACE.2011.5987296>
- Chen, Y., Zhang, R., Shang, X. & Zhang, S. (2013). An intelligent campus space model based on the service encapsulation. In Z. Zhang, Zhang, R., & Zhang, J. (ed.), *Liss 2012* (ed. 127, pp. 919–923). Springer. https://doi.org/10.1007/978-3-642-32054-5_128
- Coccoli, M., Guercio, A., Maresca, P. & Stanganelli, L. (2014). Smarter universities: A vision for the fast changing digital era. *Journal of Visual Languages and Computing*, 25(6), 1003–1011. <https://doi.org/10.1016/j.jvlc.2014.09.007>
- Coccoli, M., Maresca, P., Stanganelli, L. and Guercio, A. (2015). An experience of collaboration using a PaaS for the smarter university model. *Journal of Visual Languages and Computing*, 31, 275–282. <https://doi.org/10.1016/j.jvlc.2015.10.014>
- Conti, F., Pullini, A., & Benini, L. (2014). Brain-inspired classroom occupancy monitoring on a low-power mobile platform. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops* (pp. 610–615). Columbus, OH, USA. <https://doi.org/10.1109/CVPRW.2014.95>

- De Angelis, E., Ciribini, A. L. C., Tagliabue, L. C., & Paneroni, M. (2015). The brescia smart campus demonstrator. Renovation toward a zero energy classroom building. *Procedia Engineering*, 118, 735–743. <https://doi.org/10.1016/j.proeng.2015.08.508>
- Flauzac, O., González, C., Hachani, A., & Nolot, F. (2015, March). SDN based architecture for IoT and improvement of the security. In *2015 IEEE 29th international conference on advanced information networking and applications workshops* (pp. 688–693). IEEE. <https://doi.org/10.1109/WAINA.2015.110>
- Galego, D., Giovannella, C., & Mealha, O. (2016). Determination of the smartness of a university campus: The case study of Aveiro. *Procedia - Social and Behavioral Sciences*, 223, 147–152. <https://doi.org/10.1016/j.sbspro.2016.05.336>
- Gudkova, S. A., Treshina, I. V., Malashchenko, M. V., Yakusheva, T. S., & Dayneko, M. V. (2023). The concept of new-generation lecturers for smart universities: Case study and trends. In V. L. Uskov, R. J. Howlett, & L. C. Jain (eds), *Smart Education and e-Learning – Smart University. KES-SEEL 2023. Smart Innovation, Systems and Technologies* (Vol. 355). Springer, Singapore. https://doi.org/10.1007/978-981-99-2993-1_13
- Ibáñez, M. B., Di-Serio, Á., Villarán-Molina, D., & Delgado-Kloos, C. (2014). Augmented reality-based simulators as discovery learning tools: An empirical study. *IEEE Transactions on Education*, 58(3), 208–213. <https://doi.org/10.1109/TE.2014.2379712>
- Kwok, L.-F. (2015). A vision for the development of i-campus. *Smart Learning Environments*, 2, 1–12. <https://doi.org/10.1186/s40561-015-0009-8>
- Příbyl, O., Opasanon, S., & Horak, T. (2018). Student perception of smart campus: A case study of Czech Republic and Thailand. In *2018 Smart City Symposium Prague (SCSP)* (pp. 1–7), Czech Republic. <https://doi.org/10.1109/SCSP.2018.8402669>
- Sánchez-Torres, B., Rodríguez-Rodríguez, J. A., Rico-Bautista, D. W., & Guerrero, C. D. (2018). Smart campus: Trends in cybersecurity and future development. *Revista Facultad de Ingeniería*, 27(47), 93–101. <https://doi.org/10.19053/01211129.v27.n47.2018.7807>
- Sanik, M. E., Zulkifli, N. M., Hussin, F. N. I., & Haekal, N. S. M. (2021). Feasibility Study of smart campus as downscaled smart city. *Multidisciplinary Applied Research and Innovation*, 2(2), 79–86.
- Silva-da-Nóbrega, P. I., Chim-Miki, A. F., & Castillo-Palacio, M. (2022). A smart campus framework: Challenges and opportunities for education based on the sustainable development goals. *Sustainability*, 14(15), Article 9640. <https://doi.org/10.3390/su14159640>
- Zhang, A., & Feng, X. (2022). The concept analysis of smart teaching. *Nurse Education Today*, 112, Article 105329. <https://doi.org/10.1016/j.nedt.2022.105329>
- Zhang, Y., Dong, Z. Y., Yip, C., & Swift, S. (2020). Smart campus: A user case study in Hong Kong. *IET Smart Cities*, 2(3), 146–154. <https://doi.org/10.1049/iet-smc.2020.0047>
- Zhou, Y., Sun, L., Hu, X., & Ma, L. (2021). Clustering and statistical analyses of electricity consumption for university dormitories: A case study from China. *Energy and Buildings*, 245, Article 110862. <https://doi.org/10.1016/j.enbuild.2021.110862>