SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Application of the Third Generation Crime Prevention Through Environmental Design on University Campuses

Zhang Ruirui[1], Khoo Terh Jing[1,*], Lei Hao[1], Jiang Xiao[1], Ha Chin Yee[1]

[1] Department of Construction Project Management, School of Housing, Building, and Planning, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia

PAPER INFO

Paper history:
Received 3 August 2023
Received in revised form 30 September 2023
Accepted 2 October 2023
Available online 22 October 2023

Keywords:
Third-generation CPTED; University campus; Security; Crime prevention; Environmental design

ABSTRACT

As a complex of material and spiritual, space and society, the university campus is a relatively complex environment. This paper investigated the effectiveness of the third generation of Crime Prevention Through Environmental Design (CPTED) in reducing crime and enhancing security within educational institutions. The third generation of CPTED emphasizes the integration of advanced technologies, such as access control systems, intelligent sensors and alarms, emergency communication systems, data analysis, and predictive policing, using advanced technologies to enhance security measures on university campuses. This paper aimed to explore the current security level of the university campus, interpret the principle of the third generation CPTED to reduce the crime rate on college campuses and propose a security strategy based on the third generation CPTED for the university campus. The research method of this paper was qualitative, conducting semi-structured interviews with campus security personnel, university administrators, university teachers, and staff of the Universiti Sains Malaysia, using NVivo software, and using thematic analysis methods for data analysis. The findings suggest that traditional campus security measures may not fully address the evolving security challenges facing modern universities. Participants expressed concern about inadequate lighting, limited surveillance coverage, and inadequate emergency response systems. The results of this paper emphasize the technical application of the third generation CPTED, thereby highlighting the practice of the third generation CPTED in university campus security, proposing the basic strategy of a smart campus, and establishing a mobile phone application on the terminal. Strong use of technology to facilitate real-time communications, incident reporting, and emergency response to enhance campus security and ultimately improve the overall security of the university campus.

1. Introduction

As a comprehensive area, the university campus has many studies and work, production and residence, entertainment and leisure, sports and entertainment, catering centers, and commercial spaces, as well as natural landscapes such as lakes and grasslands. Previous Research has shown that

* *Corresponding author.*
E-mail address: terhjing@usm.my

https://doi.org/10.37934/araset.33.1.406423

secure school environments tend to have higher levels of academic achievement and that security issues that exist on campus necessarily affect their educational function [1]. College students are still in the stage of vulnerable groups in society. It is the responsibility of school management and local governments to attach importance to campus security. Campus security is an important part of students' overall university experience [2].

While local governments emphasize the implementation of preventive measures on college campuses, campus security discourse often fails to capture the role of practical and proactive approaches to protecting campus facilities. One such practical approach is Crime Prevention through Environmental Design (CPTED), which entails developing environmental strategies that reduce opportunities for crime by manipulating the physical and social qualities of the environment [3]. At present, there are many specific application cases of CPTED theory on campuses around the world, and relevant design guidelines have been issued. For example, *Florida Secure School Guidelines* in the United States provide the application methods of natural monitoring, access control, field strengthening, activity support, goal strengthening, and management for various spaces inside and outside the school [4]. Compared with the previous two generations of CPTED the third generation of CPTED is still a new thing, and there is a lack of relevant literature at present. The new generation of theory is not so much a change of the existing CPTED as it is based on the concept of green and sustainable development. Under the guidance of the innovation of specific implementation methods of the CPTED strategy [5]. The Research on CPTED in the field of university campus security is the application of the first and second generation CPTED, and the third generation CPTED is still relatively new and less applied[6]. However, there is growing recognition of the potential benefits of applying third generation CPTED theory, which specifically emphasizes social interaction, inclusion and diversity, technology, environmental sustainability, and community engagement, to enhance campus security [7]. This is especially important in the current global context, where universities and colleges are facing new and emerging security threats that require a more holistic and proactive approach to campus security, one that goes beyond traditional security measures and focuses on building approaches to environmental design and management [3].

This paper aims to explore the use of third generation CPTED to enhance security on college campuses. By examining the challenges and opportunities of implementing third generation CPTED in a college campus environment, this paper helps advance the theory of third generation CPTED in this specific context. Theory and practice development. Based on the universality of this paper, take the third generation CPTED Research on a global scale as a perspective, focusing on the application in universities in Malaysia.

2. Literature Review

In his original writing on crime prevention through CPTED founder C. Ray Jeffery [8], coined the term Crime Prevention Through Environmental Design and called for the development of an interdisciplinary behavioural science of crime and prevention. The first generation of CPTED was limited to preventing criminal opportunities with an emphasis on territorial control of these areas through architectural and physical design and the prospect of guardianship of vulnerable areas achieved through such design. The second generation of CPTED expanded prevention strategies to social relations [8]. The broader CPTED model envisioned by Jeffery is not content with a theoretical reconstruction of the second generation CPTED, which currently refers to the evolution and synthesis of development as the third generation CPTED, which should include 21st-century advances in cognitive, behavioural, and environmental sciences, providing a new perspective on how people derive quality and satisfaction from their environment [7]. CPTED draws on environmental

psychology and behavioral psychology and focuses on the relationship between people and the environment. Environmental cues in architectural forms are perceived and decoded and can affect how people respond to the environment, making legitimate users of a space feel an element of security that deters unwanted behavior from unlawful users, working to incorporate natural strategies into human activities and spatial design [9]. As shown in Figure 1, CPTED focuses on design through seven key principles: geographical juxtaposition, territoriality, image management, surveillance, legitimate activity support, access control, and target hardening [10].

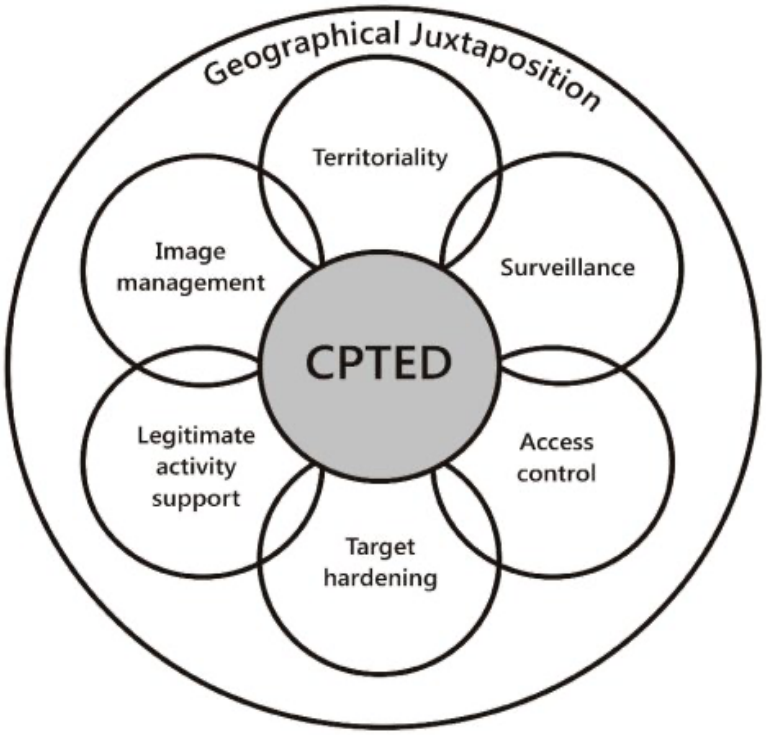

Fig. 1. The seven CPTED principles [10]

Crowe and Fennelly [11] proposed the third generation CPTED theory, which prevents crime through environmental design based on the previous two generations, emphasizing multidisciplinary approaches, situational crime prevention, and problem-oriented policing and the importance of using technology, and data analytics to create a securer and more secure environment. One of the main characteristics of the third generation of CPTED is the emphasis on community participation and participation in crime prevention efforts, which means that community members including residents, business owners and other stakeholders are actively involved in identifying crime hotspots, implementing preventive measures and cooperating with law enforcement address security issues; another feature is the use of technology for crime prevention, which includes the use of Closed-circuit Television (CCTV) cameras and other surveillance equipment to monitor public places and deter criminal activity, technology is also used to track criminal activity and identify law enforcement behavioral patterns to prevent future crime; sustainability and environmentalism are also integrated into the third generation of CPTED, which includes the use of energy-efficient lighting and building materials to promote green spaces and natural habitats, and the incorporation of natural elements such as trees, plants and water features public space design; another important aspect is the focus on creating secure and accessible public spaces that foster social interaction and community engagement, this includes public space design that encourages pedestrian movement and

discourages loitering and other undesirable behaviors [11]. The characteristics of the third generation CPTED are summarized in the following Table 1:

Table 1
Summary of characteristics of the third generation CPTED
(Source drawn by this paper)

	Features
Third generation CPTED	Emphasis on community engagement and participation in crime prevention efforts Using technology for crime prevention Sustainability and environmentalism Focus on creating secure and accessible public spaces that foster social interaction and community engagement

The third generation of CPTED is based on the premise that sustainable green urban environments are viewed as "secure" by its members and outsiders, focusing on sustainable green environmental design strategies and insisting on practical measures to cultivate people's security in urban spaces sense; the elements of the third generation CPTED are: solving the energy crisis, urban pollution, recycling and minimizing waste, redesigning physical space and materials according to consumption, online services, and network functions, going "green", using natural energy as energy, Solar lighting, and solar CCTV cameras, redesigning urban spaces, green and green spaces at city scale, and design strategies [12]. Fennelly and Perry [13] highlighted the potential future applications through CPTED, the same idea as the third generation CPTED. This papers argue that traditional CPTED approaches may not be sufficient to address the complex challenges of modern crime prevention and that the principles need to be adapted to address new security threats such as cybercrime, and terrorist incidents. They propose a "multilayered approach" for CPTED , which deals with combining technology, community engagement, and environmental design to create a comprehensive security plan, also discusses the importance of incorporating sustainability and green design into a CPTED strategy, providing examples of green design features that could be incorporated into a CPTED plan, such as rain gardens , green roofs, and bike lanes; another important aspect is a discussion of the role of technology in CPTED, this papers argue that advances in technology such as smart cameras and sensors can improve the effectiveness of traditional CPTED strategies, and provides how these technologies can be used to improve examples of surveillance, access control, and emergency response; finally, this chapter highlights the importance of community involvement in developing and implementing CPTED plans, and this papers argue that involving community members can help build trust, increase participation, and create ownership of security plans awareness, they provided examples of community-driven CPTED projects such as neighborhood watch programs, community gardens and public art installations [13].

Beyond that, the limitations of the third generation CPTED also need to be acknowledged. Abdullah *et al*., [14] describe limitations in the use of technical principles. This papers argue that due to the heterogeneous and dense nature of the communication environment, being able to deploy a large number of low-energy and wirelessly connected devices on campus, meeting security requirements is a problematic task, and the privacy of people on campus is an absolute requirement, the problem of ensuring that no one can abuse this system to violate people's privacy; adopting a security and security system on campus will result in the use of hundreds or even thousands of sensors, which is a huge burden to manually configure sensors, and the campus will face With financial difficulties, limited university resources; daytime only operation and some other operations,

the system may face strong opposition from campus and nearby residents because it invades their privacy [14]. A one-size-fits-all approach to designing a security system cannot be adopted due to the many external factors that affect campus security, such as campus location, the number of attendees, and the budgets of different universities, which are all external factors that contribute to campus crime cultures, such as student protests, poverty, and gender violence [15]. When CPTED functions fail, the local environment can lose its ability to control crime, which can occur through four processes: mismanagement of space, changing how space is used, growth and expansion, and degradation and contraction, therefore, good design cannot be expected to be the permanent solution [16].

As shown in Figure 2, based on the research theme of this paper, the independent variables are campus culture and environment, campus culture and environment, technology, social factors, and the dependent variable is crime rate in university campus. based on this, follow-up research will be carried out.

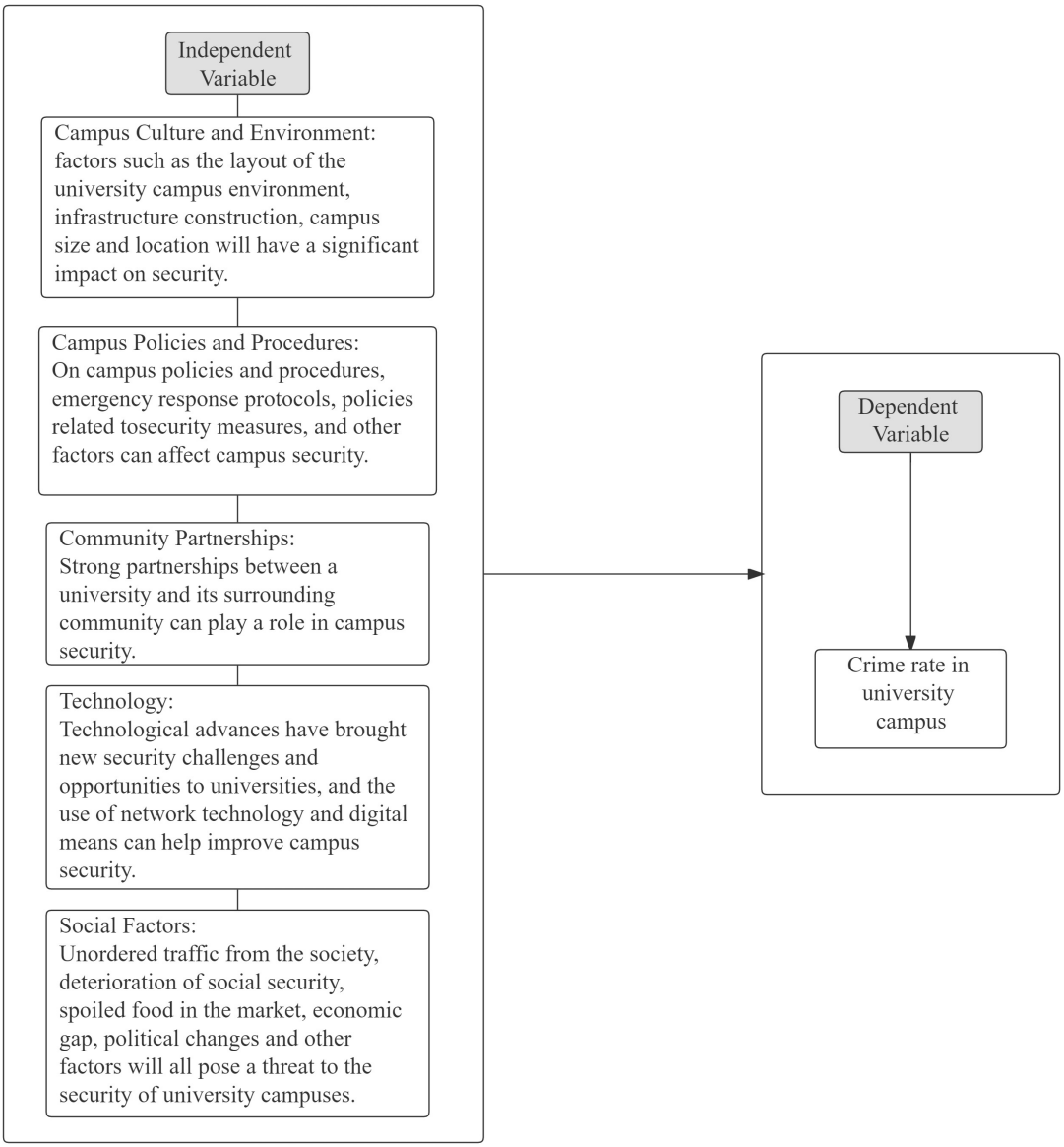

Fig. 2. Research framework (Source drawn by this paper)

As shown in Table 2, the relevant themes of the above independent variables are like those of many authors.

Table 2
Dependent variable source literature summary table
(Source drawn by this paper)

Item	Source
Campus Culture and Environment	[17,18]
Campus Policies and Procedures	[19-21]
Community Partnerships	[22-24]
Technology	[25,26]
Social Factors	[27,28]

3. Methodology

3.1 Research Design

The research method of this paper is qualitative analysis. Shariati [3] also applied qualitative analysis. The data for his research were collected during two field trips to Colorado Springs in April and June 2016. Subject protection policy, interviews for this paper were conducted under a promise of confidentiality. This research has three purposes: To explore the current security level of university campuses; To interpret the principle of CPTED theory to reduce the crime rate on college campuses; To propose a security strategy based on the third generation CPTED for the university campus. This paper aims to achieve these three purposes. To meet these three purposes, it is necessary to obtain some unknown information for future Research. In this research, semi-structured interviews were used as the primary method of data collection to gain insight into the perceptions, experiences, and perspectives of key stakeholders involved in the implementation and enforcement of campus security policies and practices.

i. Phase 1: Pilot Research

In the first phase, pilot research was conducted to refine the research questions and interview guidelines. The pilot research involved interviewing a small group of participants like the target population, to test the interview guidelines and refine the Research question. During this phase, a small group of participants, approximately 3 people, will be interviewed to provide feedback on the interview questions and to identify any potential issues in the data collection process. The pilot research will help ensure that the interviews are effective in obtaining the required information and that the quality of the data collected is high. The results of the pilot research are used to refine the Research questions and interview guidelines for the main research.

ii. Phase 2: Subject Research

The second phase of the main research involves semi-structured interviews with a larger sample of participants, approximately 10 people, during which the data collection process will be refined based on feedback received during the pilot research.

3.2 The Research Area

Due to the relatively stable national conditions in Malaysia, the common security issues of universities in its territory can represent the security issues of university campuses in most countries, and match the third generation CPTED principles, making this paper universal and bringing more reference value to readers. Therefore, the research area is selected as a university in Malaysia. It has

a large scale and a beautiful environment. The reputation of "Asia's Garden University" has been recognized by the Malaysian government as a top university. Most of the schoolteachers have American, British, Australian, and other frontier countries in the world's education and academic research background, there are more than 33,000 undergraduates and postgraduates; the USM main campus is the "soul" of USM [29]. The campus of USM is relatively open. These activities are also open to the public, attracting many people from the community to participate. USM's large campus area, open campus scene, and complex campus environment with various ecologies make it representative. Therefore, this Research is conducted on the main campus of USM in Penang, Malaysia, which is located on Penang Island. It is more suitable and can fit the Research question and research purpose of this paper. The map of the USM main campus is as follows Figure 3:

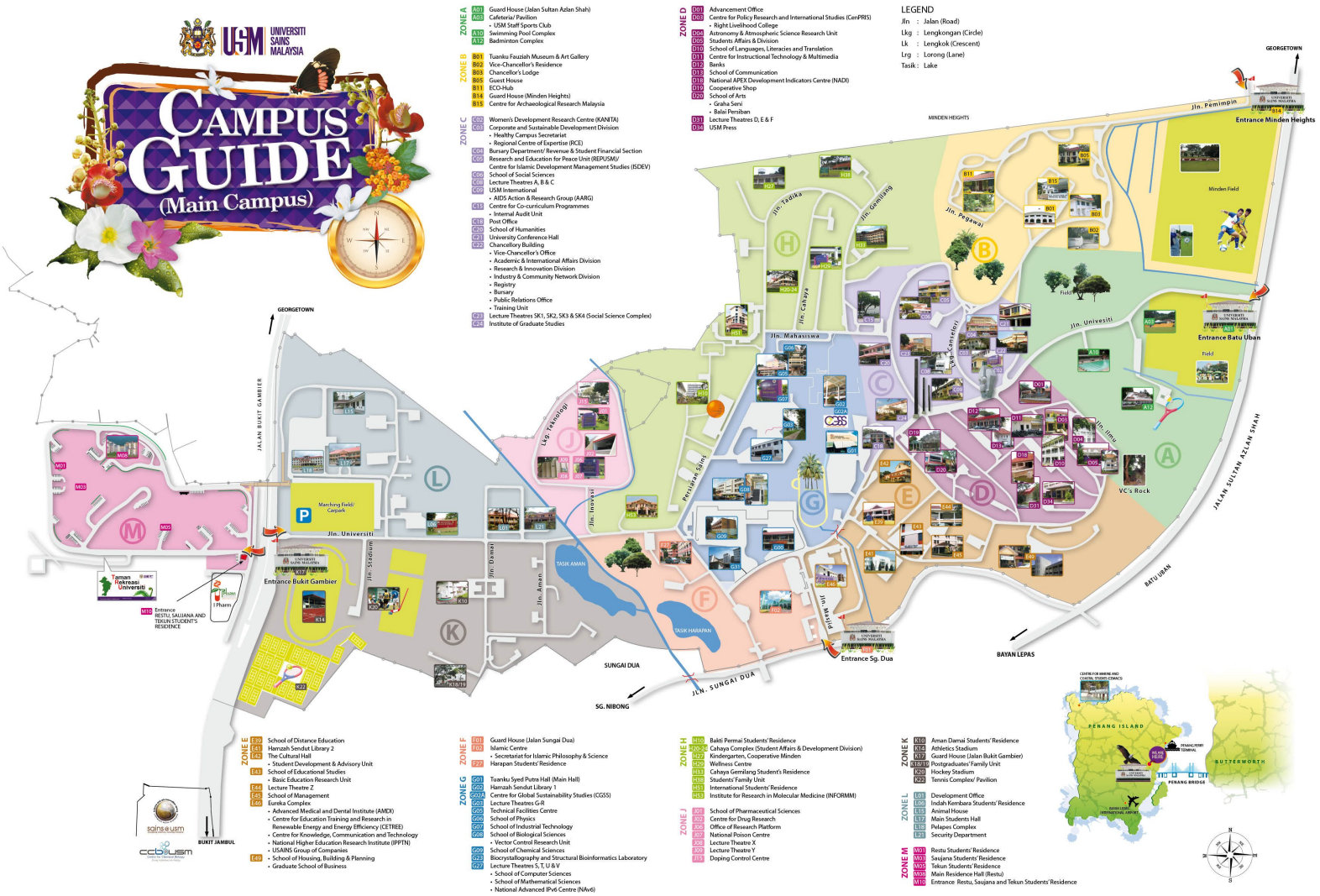

Fig. 3. USM Main Campus Map [29]

3.3 Data Collection

In the qualitative analysis research method, this paper uses the semi-structured interview method to collect data. Semi-structured interviews are an appropriate method of collecting data for this paper as they allow flexibility in the questioning process while still maintaining some structure

[30]. The research topic of campus security is complex and multifaceted, and the semi-structured interview method allows for an in-depth exploration of participants' experiences, attitudes, and perceptions of campus security policy and practice, and also allows for the inclusion of open-ended questions, which can provide rich and detailed data, can help uncover new insights and perspectives on campus security that may not have been considered before [3]. Combined with the benefits of semi-structured interviews for this research, the method of semi-structured interviews used in this paper is appropriate and necessary to achieve the research goals and fully understand campus security issues. The flow chart of the semi-structured interview research in this chapter is as follows Figure 4:

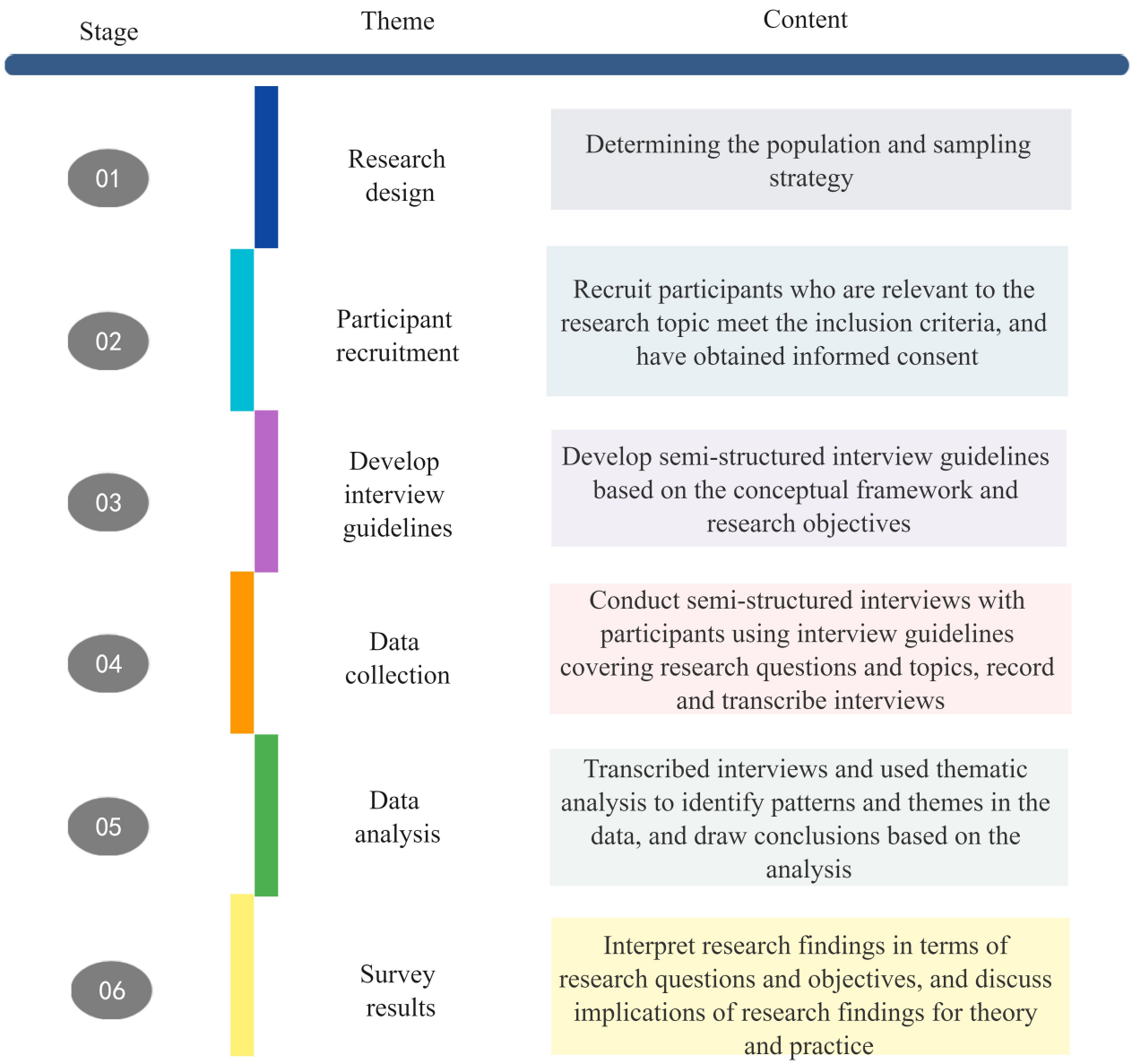

Fig. 4. Semi-structured interview flow chart
(Source drawn by this paper)

3.4 Sampling Method

The sampling method used in this paper is purposive sampling. As Arthur *et al*., [31] also chose the target sampling method in their research, choosing semi-structured interviews to examine and question their reasons for selecting targets, and whether intimidated by the environment or by physical features, the advantages of using qualitative Research in this particular research allowed the researchers to get an up-close look at the perpetrator's feelings, motivations, intentions, and often contradictory and detailed perspectives of the social world, all of which Difficult to capture quantitatively, this sample is purposeful and includes 12 active appointment muggers from a metropolitan area in Texas [31].

In this research, the target population was USM staff and students who participated in campus security measures or experienced campus security issues, and a purposive sampling method was used to select participants who met this criterion. This paper contacted potential participants via email, telephone, and face-to-face interaction, and explained the purpose and procedures of the research, then asked the participants if they would like to participate in the research and selected those who agreed as samples for data collection. Purposive sampling is useful in qualitative research when a researcher is trying to obtain in-depth and detailed information about a particular phenomenon. It allows the researcher to select participants who have first-hand experience with the subject being investigated, ensuring that the data collected is relevant to the research question. and meaningful, however, a limitation of purposeful sampling is that it may not be representative of larger populations and the results may not generalize to other settings [32]. Despite certain limitations, in this research, when some units are very important, targeted sampling is the only possible solution, so choosing targeted sampling is the appropriate sampling method in this paper.

Data saturation is the most commonly used concept for estimating sample size in qualitative research, and the broader term "data saturation" has been increasingly adopted over time for the question "How many qualitative interviews are enough", to reflect a broader application of the term and concept, in this broader sense, saturation is often described as the point of data collection and analysis when new incoming data yields little or no new information to address a research question [33]. Empirical studies addressing this issue began to appear in the literature in the early 2000s, with Morgan *et al*., [34] conducting a seminal methodological research using collected environmental risk data, who found that, the first 5 to 6 interviews yielded most of the new information in the dataset, and as the sample size approached 20 interviews gained little new information, and in four datasets, the first 10 interviews about 80% to 92% of all concepts [34]. Greg *et al*., [33] building on the principle of saturation, describe and validate an easily applicable method for assessing and reporting saturation in the context of inductive thematic analysis. Findings indicate that typically 6-7 interviews will capture most topics in a homogeneous sample, with 6 interviews reaching 80% saturation, and also suggest that 11 -12 interviews, following existing literature, show that 12 interviews are usually required to achieve higher saturation [33].Integrating the above mostly scholarly studies, to make the sample size of this research resilient, a sample size of 10 participants is considered sufficient to achieve data saturation for qualitative research, especially when the focus is on in-depth exploration and understanding of personal perspectives.

3.5 Ethical Considerations

Ethical considerations in this paper are an important aspect of the research methodology, to ensure that the rights and privacy of the participants are protected. First, informed consent was obtained from all participants before conducting semi-structured interviews. Participants were

informed of the purpose of the research, the nature of the research, the potential risks and benefits of participation, and their right to withdraw at any time without consequence. Consent forms are written in plain language and provided in English to accommodate the participant's language preference. Second, use pseudonyms rather than real names to ensure confidentiality when referring to participants in research reports. Recordings of the interviews were stored on a password-protected computer that was only accessible to this paper, and only this paper's authorization was required to transcribe and analyse the data. Finally, this paper maintained professional boundaries throughout the research by avoiding any personal relationships with the participants, and this paper also refrained from sharing any personal information with the participants that were not relevant to the research. Ethical considerations for this research were taken seriously to ensure that the rights and privacy of participants were protected throughout the research.

3.6 Limitations of Research Methodology

The use of qualitative analysis in this paper, is important to acknowledge the limitations associated with these methods: qualitative and thematic analyses, prioritizing deep understanding in specific contexts over-generalizations to larger populations, findings are contextually limited and may not be applicable in other settings or populations [35]. In semi-structured interviews, this paper's presence and questions may influence the responses of participants, who may provide answers they perceive as socially desirable or in line with this paper's expectations [36]. In this paper, this paper builds rapport, creates a comfortable environment, and employs exploratory techniques to encourage participants to express their authentic experiences and perspectives. Qualitative analysis involves conducting interviews and analysing data, which can be time-consuming and resource-intensive [37]. This paper carefully manages time and resources to ensure an appropriate sample size and depth of analysis within the constraints of the research project. With purposeful sampling, the aim is to capture diverse perspectives and experiences, but with limited sample sizes, it can be challenging to achieve data saturation where no new information or themes emerge [38]. In this research, this paper will be cautious about whether the sample size is sufficient, and if it is not saturated, additional recruitment should be considered. By acknowledging these limitations, in this research, this paper demonstrates transparency and critical reflection on the potential implications of findings and interpretation, by applying appropriate strategies, ensuring rigor in data analysis, and reviewing data from multiple sources. These limitations were addressed by triangulating the data to strengthen the credibility of the findings.

4. Results

4.1 Data Analysis and Findings

This paper first consulted relevant experts for the specific content of the interview questionnaire and then selected three participants to conduct pilot research on the interview questionnaire. The three participants were students, faculty members, and security guards. This paper adjusted individual questions in the interview questionnaire. This paper then conducted face-to-face and online semi-structured interviews with current or former USM students, faculty, and other staff who met the above criteria. When interviewing the 10th participant, this paper observed that the results of the interview were highly like those of the previous interviews. Based on the theory of data saturation, this paper terminated the semi-structured interview after the interview with the 10th participant. This paper summarizes the statistics of the interviewees in the following Table 3:

Table 3
Statistical table of respondents (Source drawn by this paper)

Participant ID	Gender	Years in School	Identity	Transportation
001	Male	1 year	Student	School bus, Walking
002	Male	4 years	Student	School bus, Walking, Motorcycle
003	Female	2 years	Student	School bus, Walking, Scooter
004	Female	1.5 years	Student	School bus, Walking
005	Male	5 years	Security personnel	Drive, Walking, Motorcycle
006	Male	8 years	Staff	Drive, Walking
007	Male	7 years	Staff	Drive, Walking
008	Female	2 years	Librarian	Drive, Walking
009	Male	4 years	Maintenance staff	Walking, Motorcycle
010	Female	6 years	Campus Store Clerk	Walking, Motorcycle

In this research, after the semi-structured interviews were conducted and recorded, a data-cleaning process was initiated to prepare the data for further analysis. Just as Shariati [3] used the data analysis method for the CPTED-based rresearch on university campus security, the data collection continued until the saturation point was reached and no new data patterns appeared. The qualitative data analysis software Nvivo11.0 was used to analyze the collected data. Analysis, the data analysis process of thematic analysis mainly focuses on identifying and summarizing themes, encoding the data, sorting out themes, and inferring the relationship between themes by comparing and categorizing the data. Observation notes were uploaded and analyzed to NVivo following the same subject analysis and coding steps suggested by Braun and Clarke [39]. Theme analysis involves 6 different stages: familiarizing with data, generating initial codes, searching for themes, reviewing themes, defining, and naming themes, and producing the report. Based on the above 6 stages of theme analysis, it is applied in this research, as shown in Figure 5.

This paper adopts the combination of deductive and inductive methods to carry out thematic analysis. A deductive approach is used to analyze the data about the theoretical principles of the third generation CPTED. Employ inductive methods to emerge new themes and insights from data. A combination of deductive and inductive methods ensures a comprehensive and nuanced analysis of the data. The purpose of the first-level theme in the thematic analysis is to find the same or similar types from the collected original data and to name the types at the same time to determine the concepts and dimensions of the types [40]. Using the free coding function of NVivo, the collected interview data is coded and labelled word by word without any Researcher's presuppositions and prejudices, initial concepts are generated from the original data, and conceptual categories are discovered. This paper uses the first-level topic coding to obtain 53 initial categories, with a total of 269 nodes. Among them, the top ten with the most frequency is generally relatively secure, theft, lack of emergency response, secure geographical location, beautiful ecological environment, student card, and night lighting Dim, currently the school library only has access restrictions, other places can enter and exit at will, dormitories and teaching buildings can increase access restrictions, lack of communication channels, lack of emergency alarm systems.

Fig. 5. Braun and Clarke's [39] thematic analysis of the six stages of the use of the program diagram in this Research
(Source drawn by this paper)

In the open coding process of this Research, a total of 53 original sentences and concepts were generated, and on this basis, 13 main categories were obtained by using thematic induction, which are security, main security issues, personal emergencies, geographical juxtaposition, territoriality, image management, surveillance, legitimate activity support, access control, target hardening, community engagement, technology strategies, and interventions, integration with existing campus security measures. The coding hierarchy diagram created by NVivo below shows the hierarchy of codes and topics identified during data analysis, visually illustrating the relationship and organization of codes within the coding framework. As Figure 6 shows:

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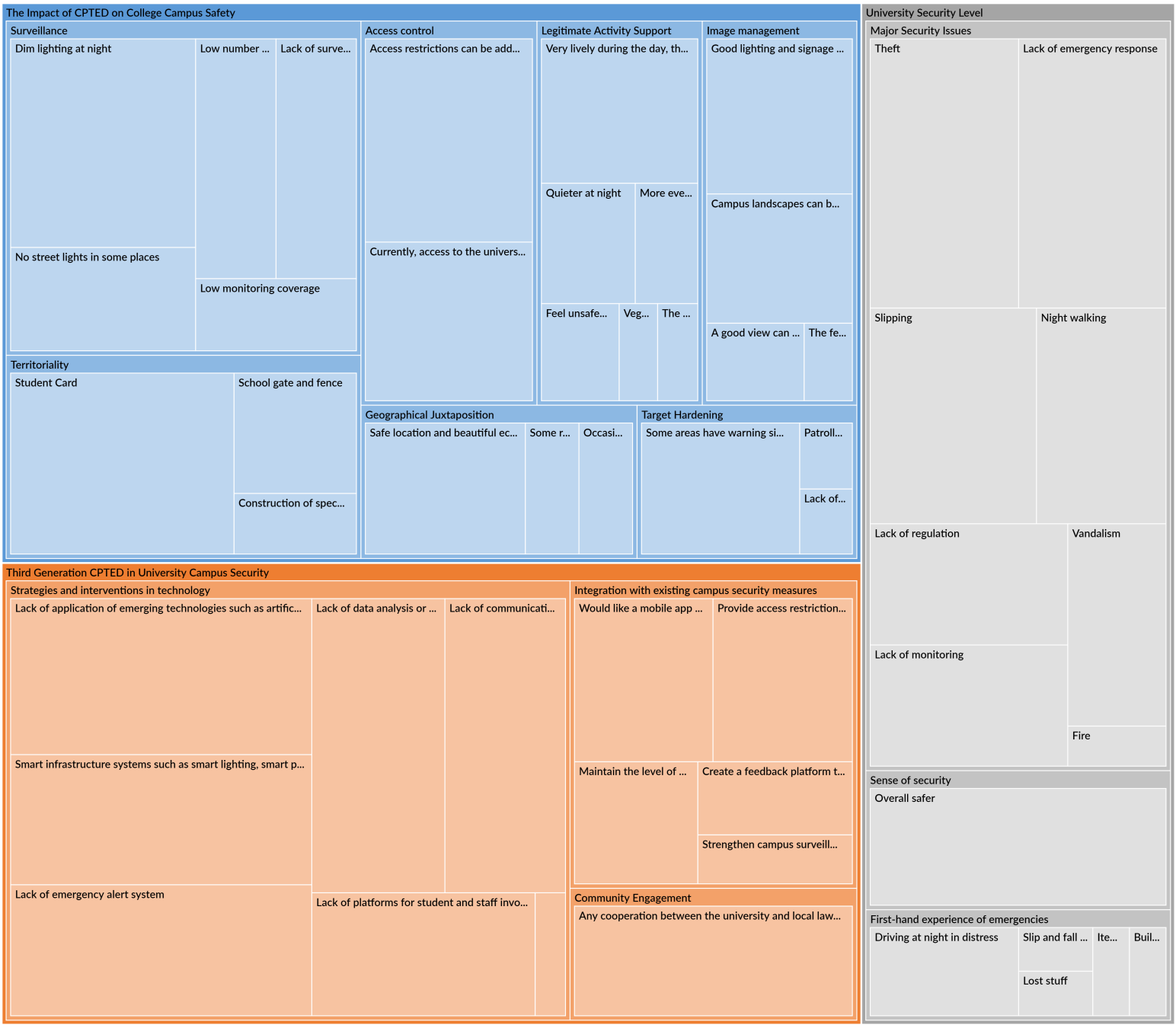

Fig. 6. Coding Hierarchy Diagram (Source drawn by this paper)

Due to the nature of dialogue-based semi-structured interviews, the results obtained from each interviewee may vary. In this research, however, several common themes and findings emerge from the analysis of the interview data. The results can be summarized as follows:

i. Perceived security concerns: Respondents expressed various security concerns about college campuses. These issues include poor lighting in certain areas, limited security personnel, lack of awareness of emergency procedures, and incidents of theft or property damage. Some respondents also cited concerns about late-night events or personal security in remote areas of campus.

ii. Satisfaction with campus security measures: Overall, respondents are satisfied with existing campus security measures. While some respondents acknowledged the existence of

security cameras, emergency call boxes, and security awareness campaigns, they also highlighted the need to improve the implementation and maintenance of these measures. Several interviewees emphasized the importance of regular security drills and training programs for students, faculty, and staff.

iii. Awareness of the reporting mechanism: Respondents showed varying degrees of awareness of the reporting mechanism for campus security incidents. While some respondents were familiar with reporting procedures and channels, others reported a lack of knowledge on how to report incidents or who to contact in an emergency. This finding points to the need for increased communication and education about reporting mechanisms to ensure prompt responses to security concerns.

iv. Suggestions for improving campus security: Respondents provided valuable suggestions for improving campus security. These include increasing the presence of security personnel, improving lighting infrastructure, implementing more frequent patrols, conducting security seminars and awareness campaigns, and establishing a more effective reporting system. Several respondents also emphasized the importance of fostering a sense of community and encouraging bystander intervention to create a securer campus environment.

4.2 Smart Campus Security System Based on The Third Generation CPTED

4.2.1 Technology Introduction

The intelligent campus security system is based on the general living environment security system, combined with the characteristics of colleges and universities with many buildings, dense and complex staff, and complicated environmental function subjects, making full use of information technology to monitor important places and public parts in the campus in real-time, take effective measures in time to make campus security management realize the combination of human defense, physical defense, and technical defense [41]. University campuses connect smart devices, applications, and individuals through common technical infrastructure, and combine emerging technologies such as 5G to realize intelligent campus security, such as setting intelligent alarms and energy-saving light controls in teaching buildings, and using detection technologies based on the Internet of Things (IoT)， when a disaster signal is detected, the system will automatically alarm, improving the rapid response ability of school security, which makes the campus securer and more secure for everyone who lives, works and studies there [42].

Emerging technologies in smart campus security systems are: IoT integration, IoT devices such as smart cameras, sensors, and beacons can be integrated throughout the campus to monitor and detect abnormal activities or potential dangers, this integration will enable real-time data collection and analysis to enhance incident response and preventive measures; facial recognition technology, which can be integrated with its incident reporting system to help identify individuals involved in suspicious activities, helps campus security personnel identify potential threats and address them more effectively events; Augmented Reality (AR) Navigation, AR navigation functionality can be integrated into apps to guide users through secure routes on campus, AR can highlight well-lit paths, emergency exits by overlaying real-time information on the user's field of view and secure areas, thereby enhancing real-time navigation; emergency response chatbots: using artificial intelligence-driven chatbots, can provide instant support and guidance in emergency situations, helping users obtain appropriate resources and assistance in a timely manner; mobile phone mobile applications: provide a Push-button emergency alerts, health monitoring and location tracking for increased security during campus events[43].

4.2.2 Design Strategy of Smart Campus Security System

Based on the principle of the third generation CPTED, the composition of the intelligent campus comprehensive security system mainly includes three main parts: information collection, information transmission and information processing. Through the design of data collection rules, data collection drivers, and online management of data collection equipment, various data collection and equipment management can be realized, and various information that is conducive to solving campus security problems can be transmitted to relevant functional departments in a timely manner, prompting relevant functional departments make correct security governance decisions and effectively handle various emergencies and disasters [44]. Information collection part: The function of the information collection part is mainly to obtain information on various personnel and events in the campus area for the first time. The content of the information collection is very extensive. Deploy control to obtain relevant information that is beneficial to security decisions. Information transmission part: After the information collection equipment receives various useful information, it needs to transmit this information to the information processing system in time, so that the decision-making equipment or organization can obtain correct information. The information transmission part plays a vital role in the function of the whole system. Information processing part: The information processing system is the core and heart of the entire comprehensive security system, which undertakes all the work of processing the collected information and provides the most direct information support for security governance decisions. The comprehensive security system based on the establishment of an intelligent campus includes not only the video surveillance system but also the perimeter anti-theft alarm system and fire alarm system, parking lot management system, access control system and public address system, and other important components:

i. Video surveillance system: The university campus is characterized by large area, scattered sites, numerous students, and complex surrounding environment. To reduce the difficulty of school security work, high-definition video surveillance points are built in specific places to cover the entire campus to ensure the personal and property security of teachers and students in the campus. At the same time, it can also strengthen teaching management and strict examination room discipline [45].
ii. Perimeter anti-theft alarm system: The purpose of this system is to establish a secure and reliable campus environment, strengthen the management of entrances and exits, prevent outsiders from entering the campus, and prevent illegal access to the campus through walls or windows, so that the campus can be securely guaranteed.
iii. Fire alarm system: According to the characteristics of the university campus itself, the campus fire system has established a mode of hierarchical monitoring, independent control, and centralized management. A general control center is set up in the entire campus to monitor and manage the entire fire alarm network, and a relatively independent subsystem integrating alarm control is set up in buildings that require key monitoring for single management.
iv. Parking lot management system: The main function of the system is to control the entrance and exit of the campus parking lot, and to effectively manage and control the vehicle entry and exit of campus personnel and outside personnel.
v. Access Control System: This system can arbitrarily set the use time and place of the card, and all the states of the portal are recorded in the computer. The system can also realize coordinated linkage between systems through hardware electric shock connection or gateway and closed-circuit monitoring, anti-theft, and fire alarm. An intelligent access control system with face recognition is installed in the dormitory building to strengthen

the management of student access and reduce potential security hazards. Or cooperate with the detection system of the smart camera, combined with the security detection model of artificial intelligence, if the students have an emergency, the management personnel will be notified in time to resolve the danger.

vi. Public address system: Set up sound playback equipment in squares, lawns, green spaces, road intersections, etc. on the campus, and are jointly controlled by the monitoring center and other relevant departments. In addition to playing music, notifications, and entertainment programs every morning, evening, and specific time, the monitoring center can forcefully switch to the emergency broadcast state when an emergency occurs and broadcast various disaster alarms or event messages.

Figure 7 shows a typical structure of a smart campus, with key technologies supporting operations:

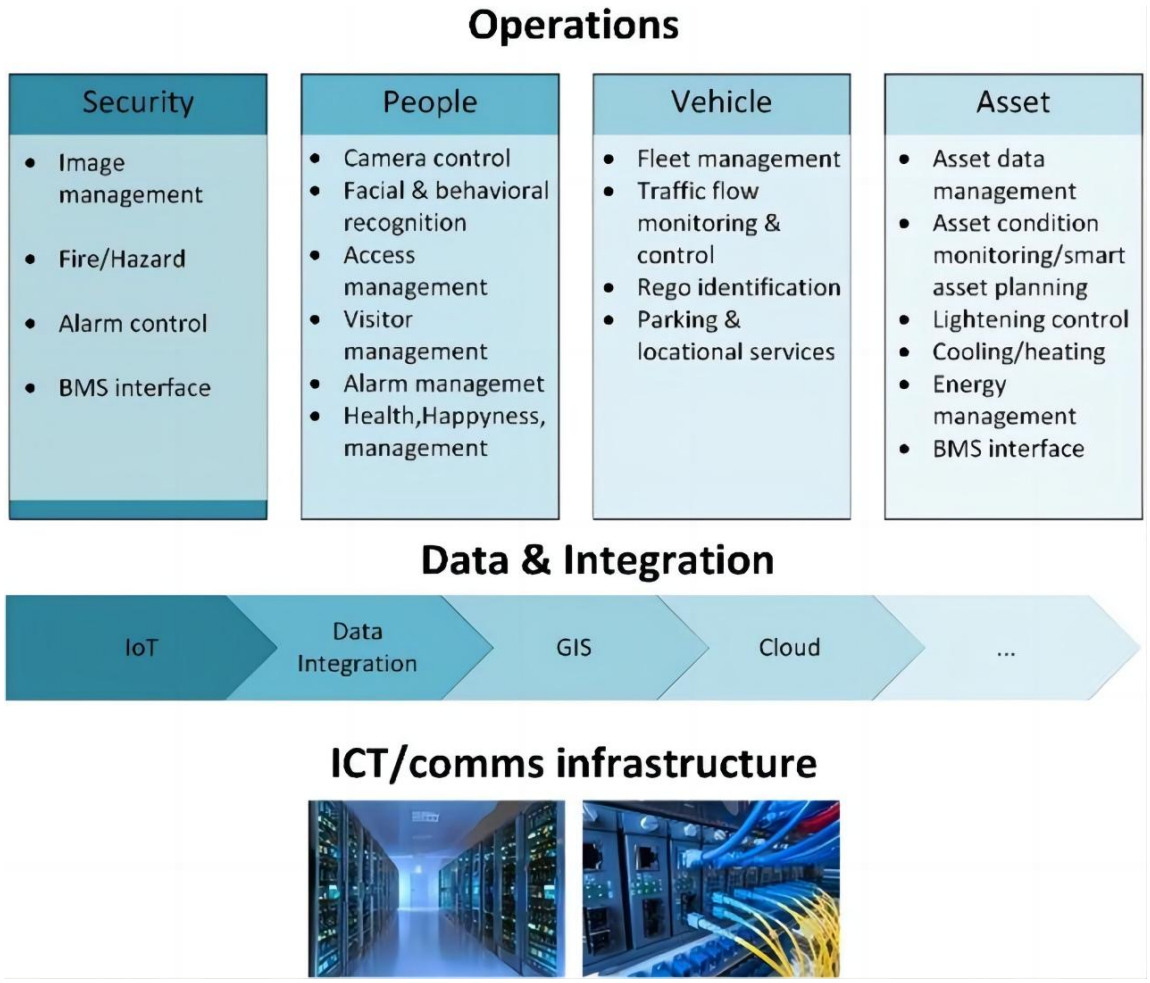

Fig. 7.Technology-driven Smart Campus Structure [43]

4.2.3 Mobile Phone Application Framework of Smart Campus Security System

In the proposed model, the terminals are smartphones, wearable devices, and AR/VR glasses with special applications for data visualization [38]. Combining the above design strategies of the smart campus security system, a mobile application for mobile phones is created as its terminal, aiming to be a secure companion for USM students, faculty, staff, etc., enabling them to report incidents, access real-time emergency services, navigate secure paths, and know the potential risks

and security measures. Based on the third generation CPTED, it will serve as a comprehensive, user-centered mobile application for campus security, creating a secure and secure environment for USM.

4.2.3a Design Principles of Mobile Apps for Mobile Phones

Put users at the center of the design process by understanding their needs, preferences, and pain points. Design the application's interface and functionality to be intuitive, easy to navigate, and accessible to users of all technical backgrounds. Embrace a minimalist design philosophy and maintain a clean and uncluttered user interface. Use clear and concise language to ensure users clearly understand the app's features and functions. Incorporate third generation CPTED principles into the design of the application to create a secure and secure campus environment. Prioritize features that facilitate visibility, natural surveillance, territorial hardening, and access control. Ensure a seamless and user-friendly onboarding process, allowing users to quickly create a profile and set the necessary preferences. Minimize the steps required to sign up and encourage the use of existing credentials. Use visual cues like color, size, and position to establish a clear hierarchy of information. Important actions such as emergency reporting and navigation should be highlighted for quick access. Create a sense of familiarity for users by maintaining consistency in design elements, icons, and color schemes throughout the app. This consistency will help improve ease of use and reduce the learning curve. Allows users to personalize their app experience by setting preferences, choosing notification settings, and customizing secure escort options. Personalization enhances user engagement and enhances a sense of ownership of their security journey. Make sure apps are inclusive and accessible to users of different abilities. Enable features such as voice commands and compatibility with assistive technology for users with disabilities. Enables real-time updates of incident reports, emergency notifications, and GPS tracking to provide users with accurate and timely information. Users should trust that applications provide up-to-date data and respond to their actions promptly. Prioritize the highest standards of data privacy and security to protect user information. Implement encryption protocols and comply with relevant data protection regulations to maintain user trust. Design applications with built-in error prevention mechanisms to minimize errors during critical operations. Also, provide clear error messages and recovery paths in case of unexpected operations. Facilitate user feedback and regularly monitor application performance to identify areas for improvement. The app is regularly updated with bug fixes, new features, and emerging security technologies to keep campus security at the forefront. By following these design principles, this terminal phone mobile application will provide the university user-friendly, reliable, and robust mobile application, enabling university campuses such as USM to enhance university campus security.

4.2.3b Framework for Cell Phone Mobile Application

The campus security mobile phone application framework based on the third generation CPTED theory is shown in Figure 3.2, and the specific content is as follows:

i. User registration and personalization:
   The app offers a seamless and user-friendly onboarding process for students, faculty, and staff, enabling them to create personalized profiles. In addition to basic information, the registration form includes fields for emergency contacts, medical information, and any specific security considerations to ensure the safety of users. To accommodate diverse user needs, the app provides language options, ensuring convenience and inclusivity for all.
ii. Real-time event reporting:

The app features an intuitive incident reporting interface, empowering users to quickly report any incidents on campus. Users can select the type of incident, its urgency, and provide the location details. To enhance the accuracy of reports, they can also attach images or videos as evidence. The app is seamlessly integrated with campus security and emergency services, allowing for an immediate and coordinated response to incidents reported, thereby ensuring a safer environment for everyone.

iii. Geospatial navigation:
Utilizing a map-based navigation system with geofencing, the app guides users through secure paths and areas on campus. High-traffic and well-lit routes are highlighted to increase natural surveillance, and designated security areas are identified to promote safety. Furthermore, the app alerts users when they enter potentially dangerous zones, providing an added layer of security and awareness.

iv. Security escort service:
For added security, the app allows users to request a campus security escort, particularly during late hours or in remote locations. Users can track the real-time location of the security escort through the app, ensuring peace of mind and a heightened sense of safety during their journeys.

v. Urgent notice:
In times of emergency, the app can instantly send out emergency notifications to all users. These notices include clear instructions, evacuation routes, and essential guidance to ensure users know what actions to take to stay secure and protected. By swiftly communicating critical information, the app plays a crucial role in emergency preparedness on campus.

vi. Security tips and education:
The app acts as a comprehensive repository of security tips, educational materials, and precautions to keep users informed about potential risks and best practices. Regular updates ensure that users are well-informed about the latest security measures and strategies, empowering them to actively contribute to campus safety.

vii. IoT monitoring integration:
The app integrates IoT devices, such as security cameras and sensors, to enhance campus surveillance. Users can access live feeds from security cameras through the app, improving situational awareness and promoting a sense of security.

viii. AI-driven event analysis:
By implementing artificial intelligence algorithms and machine learning models, the app can analyze event patterns and identify potential security risks. Leveraging historical data, the app can predict security issues, allowing for proactive measures to be taken in mitigating potential threats.

ix. Privacy and Security Measures:
The app prioritizes user privacy and security by adhering to strict data privacy standards and utilizing robust encryption protocols. This ensures that personal data and incident reports are kept secure and protected from unauthorized access.

x. Community Engagement:
To foster a sense of community and collective responsibility, the app encourages users to actively engage in security-related discussions through forums and participate in security awareness events. This collaborative approach enhances campus safety and reinforces the importance of reporting and vigilance.

xi. Continuous improvement:

The app is regularly updated with bug fixes, new features, and cutting-edge security technologies to ensure optimal performance and efficacy. User feedback is actively sought to identify areas for improvement, ensuring that the app remains a reliable and effective tool for campus security.

xii. Emergency preparedness:
The app provides comprehensive emergency response plans, evacuation procedures, and security protocols to prepare users for any potential threats. Regular security drills and training sessions are conducted for users and campus security personnel to enhance their preparedness and response capabilities.

xiii. Campus security analysis:
By leveraging data analytics, the app assesses its effectiveness in enhancing campus security, identifying trends, and informing security policies. Data-driven insights aid in resource allocation and planning, ensuring that security measures remain adaptive and responsive to evolving threats.

5. Conclusions

This research explores the application of third generation CPTED on university campuses, represented by USM. The findings suggest that traditional campus security measures may not fully address the evolving security challenges facing modern universities. These insights underscore the importance of taking an innovative and holistic approach to campus security. To address these challenges, this rsearch proposes the integration of emerging technologies, including IoT, 5G, and AR, to develop smart campus security systems and end-phone mobile applications. The smart campus security system aims to transform traditional campus security into a proactive and data-driven approach. By utilizing IoT sensors strategically placed throughout the campus, the system can monitor and analyze the environment in real-time. In addition, the terminal cell phone mobile application enables students and staff to actively participate in campus security. Through a user-friendly interface, the app allows users to report incidents, request immediate assistance, and receive real-time security updates. But it must be admitted that the proposed smart campus security system and terminal mobile application may face challenges during the implementation process. Factors such as cost, privacy concerns, and technical infrastructure may require careful consideration and planning.

This research highlights the potential of third generation CPTED combined with emerging technologies to create a securer and smarter university campus environment. By engaging stakeholders and implementing the proposed smart security system, the university can proactively address security concerns and foster a secure and conducive learning environment. Future research efforts may focus on assessing the long-term effectiveness and impact of implemented smart campus security systems. As technology continues to evolve, further exploration of cutting-edge technologies and their integration into campus security measures is critical to staying ahead of potential security threats.

Acknowledgment

This research was funded by School of Housing, Building and Planning, Universiti Sains Malaysia.

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