Semarak International Journal of Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.my/index.php/sijaset/index
ISSN: 3030-5314

Applications and Benefits of Geographic Information System (GIS) in Digital Campus Map: A Systematic Review

Che Norhayati Mohd Salleh[1,*], Siti Nur Aliaa Roslan[2]

[1] Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, Sedang Selangor, Malaysia

ARTICLE INFO

Article history:
Received 18 August 2025
Received in revised form 15 September 2025
Accepted 25 September 2025
Available online 6 October 2025

Keywords:
Geographic Information System; digital campus; map

ABSTRACT

The integration of Geographic Information System (GIS) technology in the development of digital campus maps has emerged as a significant advancement in higher education institutions. GIS technology enables the visualization, analysis, and interpretation of spatial data, offering enhanced navigational and informational support for students, faculty, staff, and visitors. Key applications include real-time location tracking, detailed information of campus facilities, route optimization, and integration with other platform. A review of the literature was therefore carried out to the applications and benefits of GIS in creating digital campus maps as well as the technologies used in this development. The articles were selected from SpringerLink, the IEEE Xplore digital database and Semantic Scholar using the keywords 'digital map', 'campus map', 'mobile application' and 'Geographic Information System (GIS)' and a total of 1870 articles were obtained and screened from the referenced databases. Finally, a total of 15 publications were chosen to evaluate information after inclusion and exclusion criteria in order to accomplish the primary goals of this research. The benefits of implementing GIS in digital campus maps are manifold: it provides a unified user experience, ensures consistent and up-to-date information, improves accessibility, and enhances data security. From the review finding, majority of researchers have increasingly focused on creating digital campus maps to provide essential navigational and informational support, making it easier for students, faculty, and visitors to navigate and utilize campus resources efficiently. However, these functions often remain distributed across various platforms and systems rather than being centralized in a single interface. Centralizing digital campus map functions offers numerous benefits, including a unified user experience, consistent information, streamlined management, and enhanced data security. By leveraging GIS technology, educational institutions can provide a more efficient and effective means of campus navigation and resource utilization, ultimately improving the overall educational experience for students, faculty, staff, and visitors.

1. Introduction

* *Corresponding author.*
E-mail address: gs67326@student.upm.edu.my

https://doi.org/10.37934/sijaset.7.1.113

In recent years, the integration of technology into various sectors has revolutionized how data is collected, analyzed, and utilized. One such technological advancement is the Geographic Information System (GIS), which has found applications in numerous fields including education sector, urban planning, environmental management, and disaster response. GIS is now invariability used to describe computerized systems, which comprise a digital map background and layers of additional information, which can be viewed in any desired combination and at any scale [1]. According to Restrepo [2] describe GIS is a system for management, analysis and visualization of geographic knowledge that it is structured in different sets of information and interactive maps, geographic data, geoprocessing models and data models. With the GIS technology it can enables individuals and even organizations to manage georeferenced data and ensures proper mapping of positions in an area such that organizations may make wise judgments and fully comprehend the life cycle of a facility with the use of GIS and mobile devices application for campus facilities [3].

Additionally, GIS is also provides a great opportunity to create intelligent maps that serve both spatial and attribute data about the geographical structures referenced to their physical locations like buildings, infrastructure and other assets [4,5]. Moreover, with the growth of the Global Positioning System (GPS), Location-based Service (LBS), and wireless communication, GIS has developed from desktop software to mobile application. These maps can be accessed and viewed on mobile devices, allowing field personnel to easily navigate the campus and locate specific assets.

The integration of GIS technology into digital campus map has significantly transformed the way educational institutions manage their physical spaces and facilitate navigation. GIS technology enables the collection, analysis, and visualization of spatial data, providing a powerful tool for creating detailed and interactive maps of campus environments. These digital maps serve multiple purposes, from enhancing campus planning and infrastructure management to improving the overall user experience for students, staff, and visitors.

This review paper aims to systematically evaluate the applications and benefits of GIS in digital campus map. By examining key studies and real-world examples, the paper will highlight how GIS technology is being utilized to create smarter, more efficient, and user-friendly campus environments.

2. Methodology

In this study, systematic literature review methodology is used to address the applications and benefits of Geographic Information System (GIS) in digital campus map and also review the various technologies used in the development of GIS-based digital campus map systems. A systematic literature review aims to address the problem by identifying, critically appraising, collecting and analysing data of all relevant studies addressing on a specific area to answer a specific research questions [6]. It emphasizes the importance of a replicable, scientific, and transparent process to achieve a synthesis of scientific research on a specific topic through a rigorous analysis of past and current studies [7]. By following a systematic approach, researchers can ensure comprehensive coverage of available literature sources and develop a scientific synthesis in response to specific research questions [8]. Moreover, systematic literature reviews offer significant advantages over traditional narrative approaches by minimizing bias through exhaustive searches of published and unpublished studies and providing an audit trail of reviewers' decisions and procedures [9].

2.1 Procedure

2.1.1 Identification

The area of this study is covered by the essential keywords, specifically, 'digital map', 'campus map', 'mobile application' and 'Geographic Information System (GIS)'. The search process is a manual search, researchers choose to restrict their search to the SpringerLink, the IEEE Xplore digital database of scholarly and technical literature and Semantic Scholar, the search focused on full-text articles, written in English, and published between 2007 until 2022. The reference list of all selected articles were hand-searched to obtain useful studies for the review. Some researchers used 'mobile application' and 'Geographic Information System (GIS)' synonymously. By neglecting the word 'mobile application' would not be in the best interest of enlightening the issue and could exclude some significant contributions.

2.1.2 Inclusion / exclusion criteria

The researcher formulates inclusion and exclusion criteria to choose appropriate and focused studies to answer the research questions. The process of defining inclusion and exclusion criteria is essential for maintaining the focus of the research and ensuring that the selected studies align with the research objectives. It helps researchers to systematically identify and select studies that are most relevant to the research questions, thereby enhancing the rigor and validity of the review process [10].

The following Inclusion Criteria (IC) were employed to determine which papers would be included in the review:

i. IC1: All studies published between 2007 and 2022.
ii. IC2: The studies are included which are published in the Journal.
iii. IC3: The studies are included which are written in the English language.

Excluding articles Criteria (EC) were also identified:

i. EC1: Studies were excluded if the content were book or systematic review
ii. EC2: If the language of the articles published other than the English language.

2.1.3 Study selection

Based on the research terms, 1870 articles were obtained in SpringerLink, the IEEE Xplore digital database and Semantic Scholar. A total of 236 of these were then selected according to the titles, abstracts, and keywords. After reading the selected articles (n=20), a total of 15 articles were chosen which met the inclusion and exclusion criteria (as shown in Fig.1).

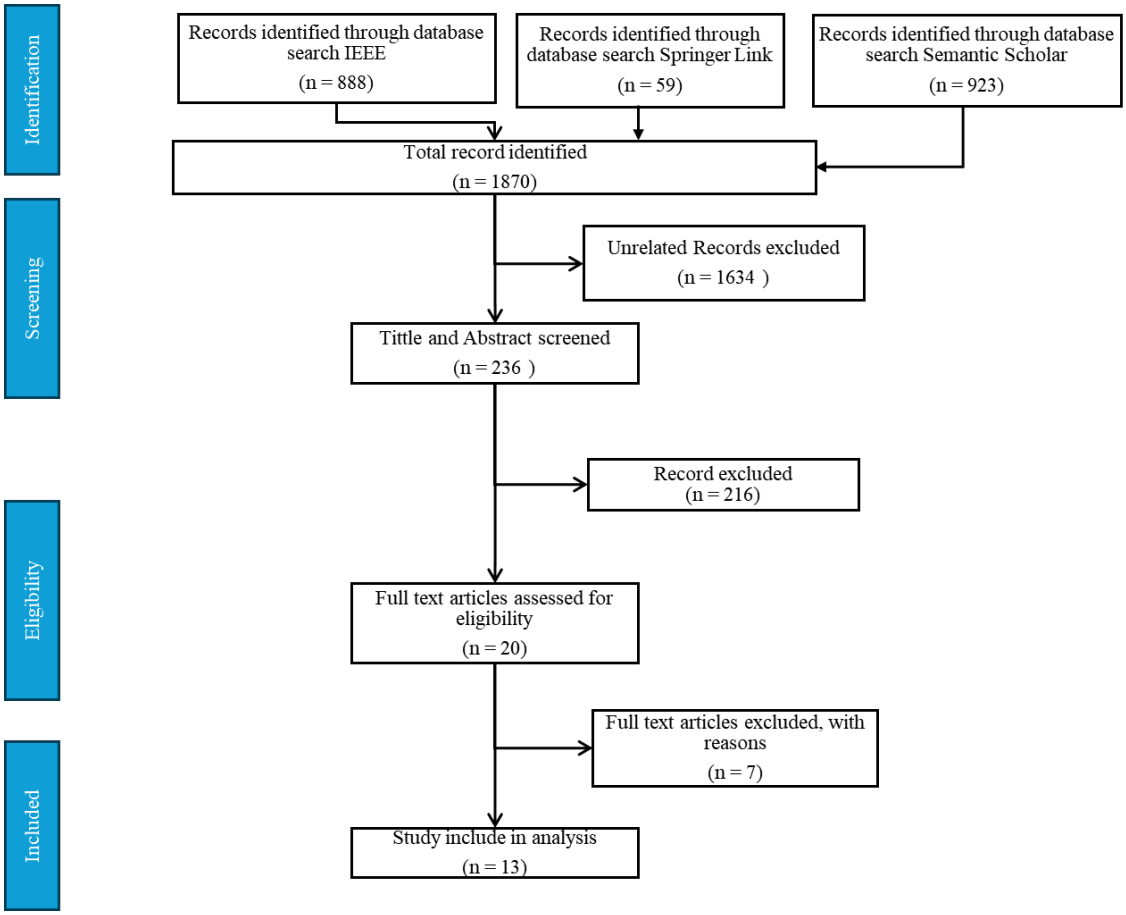

Fig. 1. Flow chart of study selection process

3. Findings

The summary report of the selected journals has presented on Table 1. The reviewed findings have been presented following the sequences such as the name of the authors, publication years, a sample of study and the findings to maintain the purpose of this paper.

Table 1
Summary of selected review

Bil	Study	Application	Technology	Benefits
1	Syafuan *et al.,* [1]	Developing Android and web apps for reporting damage at UPNM.	• ArcGIS 10.6.1 • ArcGIS Online (AGOL) • AppStudio for ArcGIS	• More efficient and effective reporting of infrastructure-related issues within the specified area.
2	Odekunle *et al.,* [11]	Smart Bosso map shows interactive mobile map creation on open source platform. Digital maps are essential for easy navigation and spatial understanding.	• ArcGIS, Google Earth Pro, and Android Studio. • Global Positioning System (GPS)	• The smart campus map can be accessed via mobile devices and web applications, making it convenient for users to get information anytime and anywhere, both within and outside the campus.

				• The map includes interactive elements such as real-time location tracking, route planning, and detailed information about campus facilities, which enhances the user experience and provides valuable insights.
3	Nurdin *et al.,* [12]	Develop a geographic information system (GIS) application using Google Maps API to accurately map the distribution of Bidikmisi scholarship recipients across Central Sulawesi, Indonesia, based on their region and economic geography	• Google Maps API	• It can helps universities and government bodies make better decisions by providing a clear map of where scholarship recipients are located, ensuring that aid reaches the most deserving students based on economic and educational criteria. • The system allows for easy integration and management of student data, making it simpler for university administrators to update and access information about scholarship recipients, thereby improving coordination among different university divisions
4	Ward *et al.*, [13]	Integrate Geographic Information System (GIS) and Building Information Modeling (BIM) data to help create a smart campus for the Faculty of Engineering at Cairo University, aiming to improve the educational environment, emergency response, and facilities management by managing, visualizing, sharing, and exchanging attribute and spatial data in a user-friendly way Develop practical applications, such as a 2D interactive map of the 5campus on the web and a6 smart building cellphone application using QR codes, to make campus information easily accessible and manageable in real-time	• Recap, AutoCAD, and 3DS Max • ArcGIS software • Structured Query .Language (SQL)	• The integration of GIS and BIM data helps in creating a smart campus, improving the educational environment by providing real-time geographic coordinates and building attributes through web and mobile applications.

5	Obediencia *et al.,* [14]	Developing a mobile app map directory with a web-based management panel to help users navigate the campus more easily	• Android Studio • Mapbox API	• The eMap app helps users easily locate buildings and rooms within the Eastern Visayas State University - Tacloban Campus, reducing confusion and saving time by providing the shortest routes to destinations. • It keeps users updated with the latest university news and events, enhancing the campus experience by ensuring they don't miss out on important activities.
6	Zhang *et al.,* [15]	To design and implement a mobile digital campus that extends the traditional digital campus by integrating mobile network technology to provide convenient, rapid, and personalized services to users	• WebKit engine • jQuery Mobile	• Users can access campus services and information anytime and anywhere using their mobile devices, which is not restricted to network and computer locations, making it highly convenient for students and staff
7	Ler and Zainon [16]	Develop an intelligent system for mobile phones that helps users find the shortest path between points of interest within the Universiti Sains Malaysia (USM) main campus, aiming to provide an optimal navigation solution that enhances the experience of route-planning and location-search for students, staff, and visitors	• Global Positioning System (GPS) • Dijkstra's shortest-path algorithm for route calculation.	• Making it easier for residents, students, staff, and visitors to find locations and plan routes efficiently.
8	Arenghi *et al.,* [17]	To develop a mobile application named UniBS4All, which helps people, especially those with disabilities, find accessible navigation paths within the urban university campus of the University of Brescia, avoiding architectural barriers and enhancing mobility for everyone	• Google Maps API and • Google Directions API	• The app UniBS4All makes it easier for people with disabilities to find their way around the University of Brescia by suggesting paths that avoid barriers, which is a big help for those who have trouble moving around or seeing. • By using Google Maps API, the app ensures that the navigation and wayfinding information is reliable and up-to-date,

				which means users can trust the directions they get.
9	Candy [18]	Create a computer program that helps people find their way inside buildings using their mobile phones or PDAs, showing them maps and directions based on where they are without needing to install any special software on their devices	• Map Server • PostgreSQL with the PostGIS. • RFID-equipped phone.	• By integrating RFID technology, the system can provide precise indoor locations, enhancing the user experience by offering accurate navigation inside buildings.
10	Liza *et al.,* [19]	To create a mobile application that helps users find the shortest path from one place to another within a school campus, aiming to improve accessibility and convenience for students and staff	• Android Studios • Tiled Map Editor • JSON files and MySQL	• The application provides the shortest path to specific locations on campus, saving users time and making navigation easier, which is a significant benefit for new students or visitors unfamiliar with the campus layout.
11	Liu *et al.,* [20]	To create a mobile service platform for schools that uses technology to make it easier for teachers and students to find their way around campus, keep track of each other, manage registration, and access personalized maps and services through their mobile devices	• Location-based services (LBS) and WebGIS . • ZigBee	• A mobile platform that integrates location-based services (LBS) and WebGIS, offering precise navigation, tracking, and personalized map services for campus environments, enhancing convenience for teachers and students.
12	Faustryjak *et al*.,[21]	To develop a web application that makes it easier for students, teachers, and visitors to navigate through the extensive and complex campus of Lodz University of Technology using GPS and OpenStreetMap, ensuring efficient management and display of a large amount of information on a multilayer map	• Global Positioning System (GPS) • OpenStreetMap. • ArcGIS software	• The application improves campus navigation by using GPS and OpenStreetMap, making it easier for users to find locations and events on the university campus.
13	Lin and Li [22]	To design a campus navigation system using GIS technology to help new students and visitors easily navigate the expanding and densely populated university campus, making it more accessible and understandable for everyone	• VB6.0 environment • SuperMap 6.0	• The system updates and unifies data in real-time, ensuring users access the latest campus information, making navigation efficient and user-friendly. • It includes a shortest path selection function, which simplifies finding locations on campus,

				making the system practical and easy to use for visitors. • By integrating GIS technology, the system provides a comprehensive view of the campus, including map queries, navigation, environment preview, and campus profiles, enhancing the overall understanding and experience of the campus.
14	Abd Elrahman, Sahar [23]	to create a geographical database for the College of Technology at Sudan University of Science and Technology using GIS, which helps in academic and administrative decision-making for the college	• ArcMap 10.3	• The digital map and its layers make it easy to access and query information about different features of the college, such as finding the nearest vegetation area for students to take a break, thereby enhancing the user experience.
15	B. Jagadeesha Pai *et al.,*[24]	to create a detailed database of various facilities such as academic buildings, hostels, ATMs, and dustbins inside the Manipal Institute of Technology campus using GIS technology	• ArcGIS Software	• The study created detailed maps of the Manipal Institute of Technology campus, making it easier for students, staff, and visitors to find various facilities like academic buildings, hostels, and recreational areas

4. Discussion

The objective of this research is to provide a comprehensive review of the existing literature on the applications and benefits of Geographic Information System (GIS) in digital campus maps as well as the technologies used in this development.

4.1.1 GIS in digital campus map

The rapid advancement of technology has significantly transformed various sectors, including education. One of the pivotal technological innovations in recent years is the Geographic Information System (GIS), which has revolutionized how spatial data is managed and utilized. GIS is a framework for capturing, storing, analyzing, and visualizing geographical data, offering a powerful tool for enhancing various aspects of campus life in educational institutions. By integrating GIS into campus operations, universities can create digital maps that provide a myriad of benefits, ranging from

improved navigation and accessibility to efficient infrastructure management and enhanced decision-making.

Digital campus maps by GIS technology have become essential in modern educational environments. These maps provide interactive, real-time information about campus facilities, enabling students, staff, and visitors to navigate the campus more efficiently [11-16][18-24]. Moreover, GIS-based digital maps support administrative functions by offering precise spatial data that can be used for planning, maintenance, and emergency response.

The significance of GIS in digital campus maps lies in its ability to integrate various types of data into a single, coherent system. This integration facilitates better coordination and communication across different departments within the institution. For instance, a GIS-based campus map can include layers of information such as building locations, emergency exits, parking areas, and accessibility routes, all of which are crucial for daily operations and long-term planning.

Furthermore, the application of GIS in digital campus maps extends beyond mere navigation. It encompasses various functionalities that improve the overall campus experience. For example, GIS technology can be used to develop applications that help report and manage infrastructure-related issues [1], visualize the distribution of resources like scholarships [12], and integrate with other technological systems such as Building Information Modeling (BIM) [13] to create smart campuses.

The integration of GIS in campus maps also addresses the needs of diverse user groups, including individuals with disabilities [17]. By providing accessible navigation paths and real-time updates, GIS ensures that all users can move around the campus safely and efficiently. This inclusivity is a crucial aspect of modern educational environments, where diversity and accessibility are highly valued.

Majority of researchers from this review have increasingly focused on creating digital campus maps to provide essential navigational and informational support, making it easier for students, faculty, and visitors to navigate and utilize campus resources efficiently. However, these functions often remain distributed across various platforms and systems rather than being centralized in a single interface. Centralizing digital campus map functions offers numerous benefits, including a unified user experience, consistent information, streamlined management, and enhanced data security. However, achieving these benefits requires careful planning and coordination. By assessing current systems and needs, defining clear objectives, selecting the right technology, developing a detailed implementation plan, ensuring data security and privacy, integrating with existing systems, providing user training and support, and fostering continuous improvement, educational institutions can successfully centralize their digital campus map functions. This approach ensures that the centralized system meets the diverse needs of the campus community and enhances the overall educational experience.

4.1.2 Technology for development digital campus map using GIS

Developing digital campus maps using Geographic Information System (GIS) technology involves several key components and processes. GIS technology allows for the integration of diverse geospatial data layers, including building locations, infrastructure details, and environmental features, into a comprehensive mapping platform. By utilizing GIS tools and techniques, institutions can generate detailed and precise representations of campus environments, facilitating efficient navigation and resource utilization. The capability to overlay multiple data sets and conduct spatial analysis within GIS enhances the functionality of digital campus maps, enabling the creation of customized mapping solutions tailored to specific campus requirements.

GIS software is the backbone of digital campus map. Tools like ArcGIS, QGIS, and SuperMap GIS are widely used for data collection, processing, analysis, and map creation. These software packages

provide a range of functionalities, including digitizing, editing, and attributing spatial data, as well as advanced spatial analysis and visualization capabilities [1,11,13,21-24]. For instance, ArcGIS 10.6.1 and ArcGIS Online (AGOL) have been used to develop Android and web applications for reporting infrastructure damage at Universiti Pertahanan Nasional Malaysia (UPNM), making the reporting process more efficient and user-friendly [1].

Additionally, ArcGIS Online and SuperMap iPortal, also can enable the creation of interactive web maps and mobile apps for campus navigation. These platforms allow users to access campus maps and related information through web browsers and mobile devices, enhancing accessibility and convenience. For example, the smart campus map developed using ArcGIS, Google Earth Pro, and Android Studio provides real-time location tracking, route planning, and detailed information about campus facilities, making it convenient for users to get information anytime and anywhere.

However, it is important to note that software tools like ArcGIS and SuperMap can be expensive and may not be accessible to all institutions or researchers, limiting their widespread use [11,22]. For educational institutions, the high cost of ArcGIS licenses can be a significant financial burden [13]. Many universities and colleges operate on tight budgets and may find it challenging to allocate funds for expensive software licenses. This financial strain can limit the ability of these institutions to implement comprehensive GIS solutions for campus management, navigation, and other applications. For example, the Lodz University of Technology utilized ArcGIS to integrate information across multiple systems, enabling a more coherent approach to managing campus operations such as public safety, health services, and facilities management [21]. While the benefits of such integration are clear, the initial and ongoing costs of maintaining ArcGIS licenses can be prohibitive for smaller institutions or those with limited budgets.

While commercial GIS software tools like ArcGIS and SuperMap can be expensive, there are numerous affordable and even free alternatives available. Open-source platforms like QGIS and GRASS GIS, educational discounts and grants, collaborative partnerships, free geospatial data sources, in-house expertise development, and cloud-based solutions provide viable options for developing digital campus maps. By leveraging these resources and strategies, educational institutions and researchers can access the benefits of GIS technology, enhancing navigation, accessibility, safety, resource management, and decision-making on campus. This approach ensures that GIS technology remains accessible and beneficial to a broader audience, fostering innovation and efficiency in campus management.

4. Conclusions

The application of GIS in digital campus map offers numerous benefits, including improved navigation, increased accessibility, enhanced safety, efficient resource management, and better decision-making. Despite their benefits, these functions often remain distributed across various platforms and systems, leading to fragmented user experiences and management challenges. Centralizing digital campus map functions presents a solution that offers a unified user experience, consistent information, streamlined management, and enhanced data security. However, achieving these benefits requires meticulous planning and coordination. This study outlines a comprehensive approach to centralizing digital campus map functions, ensuring that the system meets the diverse needs of the campus community and enhances the overall educational experience.

The first step in centralizing digital campus map functions is conducting a comprehensive needs assessment. This involves engaging with key stakeholders, including students, faculty, staff, and visitors, to gather insights on their needs and challenges. Stakeholder interviews, surveys, and focus groups can provide valuable information about the current state of digital map applications and

related systems. Additionally, a thorough system audit is necessary to review existing digital map platforms and identify strengths, weaknesses, and areas for improvement. This assessment should culminate in a gap analysis that identifies discrepancies between current capabilities and desired functionalities.

Once the needs assessment is complete, it is crucial to establish clear goals for the centralized system. Objectives should focus on enhancing accessibility, ensuring data accuracy, improving user engagement, and increasing operational efficiency. Accessibility and usability are paramount, ensuring that the system is user-friendly and accessible to all, including individuals with disabilities. Maintaining accurate and up-to-date information about campus resources and facilities is essential for providing reliable support. Integration with existing campus systems, such as student information systems and learning management systems, should be a priority to ensure seamless interoperability. Finally, robust data security and privacy measures must be implemented to protect sensitive information and comply with regulations.

Choosing the appropriate technology platform is critical to the success of the centralized digital campus map system. A unified platform that consolidates all digital map functions is essential for providing a cohesive user experience. Open-source GIS software such as QGIS and GRASS GIS provide robust functionalities comparable to commercial GIS tools without the associated licensing costs. These platforms support a wide range of data formats, offer comprehensive spatial analysis tools, and benefit from active community support. By adopting these open-source solutions, institutions can develop detailed, interactive campus maps while keeping expenses manageable.

Next, protecting sensitive information and complying with data protection regulations are paramount. Implementing encryption for data storage and transmission safeguards information from unauthorized access. Role-based access controls limit data access to authorized users, enhancing security. Regular security audits help identify and address vulnerabilities, ensuring ongoing protection. Compliance with data protection regulations, such as GDPR and FERPA, is essential to maintain trust and legal adherence.

Lastly, seamless integration with existing campus systems is vital for the success of the centralized digital map. Using APIs facilitates communication and data exchange, ensuring consistent and up-to-date information across all systems. Strategies for integrating or phasing out legacy systems without disrupting services should be developed. Data synchronization ensures that changes in one system are reflected across all integrated platforms, maintaining consistency and reliability.

By following this structured approach, educational institutions can successfully centralize their digital campus map functions, creating a cohesive, efficient, and user-friendly system that significantly enhances the overall educational experience and operational efficiency. This centralized system not only meets the immediate needs of the campus community but also adapts and grows to support future developments, ultimately contributing to a more connected and well-managed campus environment.

Acknowledgement
This research was not funded by any grant

References

[1] Syafuan, Wan Mohamed, Rospi Mat Husin, and Muhammad Faiz MD Fauzi. "Smart Campus Geographic Information System (GIS) Mobile Application Reporting System." In *IOP Conference Series: Earth and Environmental Science*, vol. 1019, no. 1, p. 012020. IOP Publishing, 2022.https://doi.org/10.1088/1755-1315/1019/1/012020

[2] Restrepo, Juan Manuel. "Geographic information system for the management of traffic in the medellin's mobility department." In *2012 IEEE Colombian Intelligent Transportation Systems Symposium (CITSS)*, pp. 1-5. IEEE, 2012. https://doi.org/10.1109/citss.2012.6365986.

[3] Asakpa, S. O., I. S. Olatinwo, N. O. Saliu, and H. O. Jimoh. "Development of a Mobile/Data Based Geographical Information System (GIS) for Federal Polytechnic Offa Main Campus." https://doi.org/10.35629/5252-0407718724.

[4] Türkmendağ, Gökçe. "Web based geographical information systems for Middle East Technical University campus." Master's thesis, Middle East Technical University (Turkey), 2009. http://etd.lib.metu.edu.tr/upload/12610592/index.pdf

[5] Gangadharan, A. "Mobile GIS - ARKives." Arkives.in, 2022. https://arkives.in/posts/04/2022/mobile-gis/.

[6] Azeem, Nazia, and Muhd Khaizer Omar. "Students 'interests in technical and vocational education and training (TVET) program: A systematic review." In *International conference on educational research and practice*, pp. 158-165. 2019. http://psasir.upm.edu.my/id/eprint/76800.

[7] Lee, In. "Service robots: a systematic literature review." *Electronics* 10, no. 21 (2021): 2658. https://doi.org/10.3390/electronics10212658

[8] Ourzik, Victoria Yousra. "Customer knowledge management: a systematic literature review and agenda for future research." In *European Conference on Knowledge Management*, vol. 23, no. 2, pp. 1384-1394. 2022.https://doi.org/10.34190/eckm.23.2.780

[9] Tranfield, David, David Denyer, and Palminder Smart. "Towards a methodology for developing evidence-informed management knowledge by means of systematic review." *British journal of management* 14, no. 3 (2003): 207-222. https://doi.org/10.1111/1467-8551.00375

[10] Newman, Mark, and David Gough. "Systematic reviews in educational research: Methodology, perspectives and application." *Systematic reviews in educational research* 64, no. 3 (2020): 3-22.https://doi.org/10.1007/978-3-658-27602-7_1

[11] Odekunle, Mary Oluwatobi, Isaiah Majin Sule, and Ademola Andrew Adenle. "Application of Geographic Information Systems in creating smart campus map of Federal University of Technology, Minna Bosso campus." Proceedings of the 2nd International Conference on Information and Communication Technology and Its Applications (ICTA 2018) 5th–6th September, 2018 School of Information and Communication Technology Federal University of Technology, Minna, Nigeria., 2018. https://doi.org/10.26634/jdp.6.3.156

[12] Nurdin, Nurdin, Sagaf S. Pettalongi, and Mansur Mangasing. "Implementation of Geographic Information System Base On Google Maps API to Determine Bidikmisi Scholarship Recipient Distribution in Central Sulawesi Indonesia." *Journal of Humanities and Social Sciences Studies* 3, no. 12 (2021): 38-53. https://doi.org/10.32996/jhsss.2021.3.12.

[14] Ward, Yousif, Salem Morsy, and Adel El-Shazly. "GIS-BIM data integration towards a smart campus." In *Joint International Conference on Design and Construction of Smart City Components*, pp. 132-139. Cham: Springer International Publishing, 2019. https://doi.org/10.1007/978-3-030-64217-4_16

[15] Obediencia, Dindo C., Jade Kristoffer Pedrero, Christian Villablanca, and Mark Aries Reyes. "eMap: Mobile App: Map directory of EVSU main campus with web-based management panel." In *2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, pp. 1-7. IEEE, 2019. https://doi.org/10.1109/HNICEM48295.2019.9073452.

[16] Zhang, Rui, Xiyan Wu, and Zhipin Dan. "Design and implementation of mobile digital campus based on mobile internet." In *Proceedings 2013 International Conference on Mechatronic Sciences, Electric Engineering and Computer (MEC)*, pp. 2598-2602. IEEE, 2013. https://doi.org/10.1109/MEC.2013.6885471.

[17] Ler, Shir Ni, and Wan Mohd Nazmee Wan Zainon. "Campus mobile navigation system based on shortest-path algorithm and users collaborations." In *Advances in Computer Science and its Applications: CSA 2013*, pp. 791-797. Berlin, Heidelberg: Springer Berlin Heidelberg, 2014. https://doi.org/10.1007/978-3-642-41674-3_113

[18] Arenghi, Alberto, Simone Belometti, Francesca Brignoli, Daniela Fogli, Fulvio Gentilin, and Nicola Plebani. "Unibs4all: A mobile application for accessible wayfinding and navigation in an urban university campus." In *Proceedings of the 4th EAI International Conference on Smart Objects and Technologies for Social Good*, pp. 124-129. 2018. https://doi.org/10.1145/3284869.3284900.

[19] Candy, J. "A mobile indoor location-based gis application." In *5th International Symposium on Mobile Mapping Technologies (MMT07), Padua, Italy*, pp. 1-5. 2007.

[20] Ramos, Anna Liza A., Kelly Leuther C. Matienzo, John Michael D. Casunuran, Carlo M. Nervida, Jose Mari S. Rosal, and Angelique V. Bederico. "E-Vision: A campus locator map mobile application using A* algorithm." *International Journal of Computer Science and Software Engineering* 7, no. 1 (2018): 6-11.

[21]Liu, Wenzhi, Zhaobin Liu, and Yan Zhang. "Interactive mobile campus based on position perception." In *2011 Fourth International Symposium on Computational Intelligence and Design*, vol. 1, pp. 147-150. IEEE, 2011. https://doi.org/10.1109/ISCID.2011.45

[22] Faustryjak, Damian, Michał Majchrowicz, and Lidia Jackowska-Strumiłło. "Application of the Layered Model Management System in an interactive map of the university campus." *Image Processing & Communications* 22, no. 4 (2017): 51. https://doi.org/10.1515/ipc-2017-0021

[23] Lin, Dagui, and Bin Li. "Application of GIS in Campus Navigation." In *8th International Conference on Education, Management, Information and Management Society (EMIM 2018)*, pp. 356-360. Atlantis Press, 2018.

[24] Mohieldeen, Sahar Ismael. "A Geographical Database for the College of Technology in Sudan University of Science and Technology using (GIS)." *Journal of Engineering and Computer Science (JECS)* 22, no. 1 (2021): 56-67.

[25] Pai, B. Jagadeesha, Hiya Chetia, Prathiksha Nayak, Raksha Shetty, and Ashwini Kumar Prasad. "Facility mapping for Manipal Institute of Technology, Manipal Campus." In *2022 International Conference on Maintenance and Intelligent Asset Management (ICMIAM)*, pp. 1-6. IEEE, 2022.https://doi.org/10.1109/ICMIAM56779.2022.10146869.