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Submetido em: 30/09/2023
Aprovado em: 10/11/2023
Avaliação: *Double Blind Reviewe*-
ISSN: **2316-2880**

SMART UNIVERSITY: PERSPECTIVES FROM EDUCATION AND TECHNOLOGY AND RECOMMENDATIONS FOR VIETNAM

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Abstract. This article evaluates the emerging concept of a smart university. The purpose is to present various perspectives on smart universities, hypotheses, and the conceptual framework of the terminology and characteristics of a smart university as published in scientific literature. Furthermore, it emphasizes the role of the Internet of Things (IoT) as a fundamental element in shaping and implementing projects and assisting traditional universities in understanding, defining, and assessing pathways for transformation into a smart university.

Keywords: Internet of ccccThings, Technology, Smart Campus, Smart University.

1. INTRODUCTION

As the concept of "Smart University" (SmU) continues to evolve, it presents a transformative opportunity for higher education institutions to embrace the potential of cutting-edge technologies and innovative practices. The introduction and ongoing development of related concepts such as smart learning environment, smart campus, smart education, smart e-learning, smart training, and smart classrooms have added new dimensions to the educational landscape (Neves-Silva et al., 2014; Uskov et al., 2015; Nguyen, H. S. 2019; Ministry of Education and Training, 2016).

One of the driving forces behind the rapid popularity of smart education in top universities is the integration of modern and sophisticated smart technologies, systems, and devices. These advancements create a unique and unprecedented environment that enables academic institutions to raise their standards and adopt innovative approaches in various areas:

Education, Learning, and Teaching Strategies: SmU enables the implementation of diverse and adaptable teaching strategies. From personalized learning pathways to data-driven instructional designs, educators can cater to the specific needs and preferences of their students.

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Aprovado em: 14/11/2023
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Unique Services for On-Campus and Remote/Online Students: Through smart education, universities can offer tailored services that cater to the needs of both on-campus and remote/online students. Seamless access to resources, academic support, and communication tools fosters an inclusive learning experience.

High-Tech Smart Classrooms: SmU facilitates the establishment of high-tech smart classrooms that promote collaboration and interaction between local and remote students. With advanced audio-visual capabilities and interactive tools, these classrooms facilitate engaging and dynamic learning experiences.

Rich Multimedia Learning Content: Leveraging the power of the Web, SmU allows the creation and delivery of rich multimedia learning content. Interactive presentations, video lectures, online quizzes, and web-based assessments provide instant feedback and enhance student engagement.

The outbreak of the COVID-19 pandemic in 2019 further accelerated the growth of smart education. Universities worldwide had to adapt quickly to remote and online learning, leading to an increased demand for digital solutions and innovative approaches (Dewar Rico-Bautista et al., 2019).

The global smart education and learning market has witnessed significant growth, as reported by "Markets and Markets." The market size surged from $105.23 billion in 2015 to $446.85 billion in 2020, representing a remarkable compound annual growth rate (CAGR) of 24.4%.

Given the dynamic nature of SmU, there is a pressing need for active research to gain a clear understanding of its key features, components, and technologies. Faculty and educators play a crucial role in this evolution, as they need to embrace innovative pedagogical methods that align with the smart education paradigm.

In conclusion, the concept of Smart University presents exciting possibilities for reshaping the future of higher education. By leveraging smart technologies and fostering a culture of innovation, universities can create immersive, inclusive, and future-ready learning environments for their students. However, continuous research and collaborative efforts are essential to harness the full potential of SmU and to address the evolving needs of learners in the near future.

2. PERSPECTIVES ON SMART UNIVERSITY

In recent times, researchers and innovative developers have been actively presenting their visions on the concepts and principles of Smart University (SmU). Here is a brief summary of some notable publications exploring these concepts:

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According to the research conducted by Tikhomirov and Dewar Rico-Bautista (Tikhomirov et al., 2015; Dewar Rico-Bautista et al., 2021), "Smart University is a concept related to the comprehensive modernization of all educational processes. ... Smart education can bring about a new university that integrates ICT and faculty, leading to an entirely new quality of education, research, commerce, and other university activities. The notion of intelligence in education entails the emergence of technologies such as smart boards, smart screens, and wireless Internet access from anywhere."

Smart Learning Environment: Hwang (2014) introduced the concept of a smart learning environment as follows: "... can be viewed as a technology-enhanced learning environment that adapts and provides appropriate support (e.g., guidance, feedback, suggestions) at the right place and time based on the individual learner's needs, which can be determined through the analysis of learning behaviors, performance, and the context of online and real-world settings they are in... (1) A smart learning environment perceives the context; meaning, the situation of the learner or the context of the real-world environment the learner is in is perceived... (2) A smart learning environment can offer immediate and adaptive support for learners by analyzing their immediate needs from different perspectives. (3) A smart learning environment can adjust the user interface (i.e., the way information is presented) and the course content to cater to individual factors (e.g., learning styles and preferences) and learners' learning status (e.g., learning outcomes)."

Smart Education: IBM (www.ibm.com) defines smart education as: "An intelligent, cross-disciplinary education system that puts students at the center, connecting schools, educational organizations, and workforce training, using (1) adaptive learning programs, (2) collaborative technology, and digital learning resources for educators and students, (3) computer-assisted administration, monitoring, and reporting to keep instructors in the classroom, (4) better insights into learners, and (5) online learning resources for students everywhere."

Smart Campus: Kwok (2015) identifies the smart campus (i-campus) as "...a comprehensive, limitless smart campus environment based on certain themes of smart campus intelligence, such as social networking and communication for work collaboration, sustainable information and green communication with intelligent sensor management systems, healthcare protection and prevention, smart building management with automated security control and clear campus administration and reporting."

Xiao (2013) envisions the smart campus as follows: "The smart campus is the result of the integration of cloud computing and the Internet. The application framework of the smart campus is the combination of Information and Communication Technology (ICT) and cloud computing based on high-performance computing and the internet."

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Smart Faculty: Abueyalaman et al., (2008) argue that "A smart campus depends on a comprehensive strategy that concerns humans, infrastructure, and effective technology use. A smart campus deploys smart faculty and provides them with intelligent tools and continuous support to perform their duties while evaluating their pedagogical effectiveness through smart evaluation forms."

Smart Learning Community: Adamko et al. (2014) describe features of smart learning community applications as follows: "Requirements for intelligent community applications include: (1) Reasonable environment; (2) Connectable through networked devices publishing information to the web; (3) Accessible, information published on the web is accessible to users; (4) Ubiquitous, users can access information through the web but, more importantly, on mobile devices anytime, anywhere; (5) Social, users can publish information through their social network; (6) Shareable, not only data but the subject itself must be accessible; (7) Display/enhance, making hidden information visible by adjusting the physical environment."

Smart Classroom: An overview of the first-generation smart classrooms and the requirements for second-generation smart classrooms is available (Uskov et al., 2016).

As the concept of Smart University continues to evolve, these perspectives shed light on the multifaceted nature of SmU, paving the way for future advancements and innovation in the field of smart education and learning environments.

3. FEATURES, COMPONENTS, AND SYSTEMS OF SMART UNIVERSITY

3.1. Characteristics of Smart University

The characteristics of SmU are presented based on the idea that SmU, as an intelligent system, should deploy and demonstrate significant developments in various levels of "intelligence" or smart features, including (1) adaptability, (2) perception, (3) reasoning, (4) self-learning, (5) anticipation, and (6) self-organization and restructuring (Table 1).

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Table 1: Differentiating Features of smU

Smart University (SmU) Intelligence Level	Details	Example Descriptions
Adaptation	SmU's ability to automatically modify functions, teaching/learning strategies, administration, safety, physicality, behaviors, and other characteristics to operate and perform better (teaching, learning, safety, management, maintenance, control, etc.).	- SmU easily adapts to new teaching/learning styles (e.g., experiential learning, flipped classrooms) or courses (open education or lifelong learning for adults). - SmU easily caters to the needs of students with disabilities (e.g., converting text to speech or speech to text). - SmU's network adapts to new technology platforms (mobile networks, tablets, iOS and Android mobile devices).
Perception	SmU's ability to automatically use various sensors to identify, recognize, understand, and/or perceive different events, processes, objects, phenomena, etc., that may impact (positively or negatively) SmU's operations, infrastructure, or operational status, including students, faculty, staff, resources, assets, etc.	- Different local subsystem sensors gather data on electricity usage, lighting, temperature, humidity, safety, security, etc. - Smart card readers (or biometrics) grant access to classrooms, computer labs, smart classrooms, and activate listed user features/software/hardware. - Face, speech, gesture recognition systems retrieve and process data on student class attendance and in-class activities.
Inference (Logical Reasoning)	SmU's ability to automatically draw logical conclusions based on raw data, processed information, observations, evidence, assumptions, rules, and logical reasoning.	- The system analyzes student performance to create or update individual profiles based on their interactions, activities, technical skills, etc. - Other inferences: Data analysis from multiple sensors and conclusions (e.g., activating the drive system and locking/unlocking doors in all buildings and/or labs within the campus, turning off lights, etc.) - Suggestions to administrators for proactive actions related to students.
Self-Learning	SmU's ability to automatically collect, absorb, or generate new knowledge, experiences, or behaviors or modify them to improve operations, functions, performance, efficiency, etc. (Note: Self-descriptive, self-discovery, and self-optimization features are part of self-learning).	- Learning from the active use of innovative software/hardware systems. Web-based teaching systems, lecture recording systems, replacement classroom systems, etc. - Learning from anonymous opinion mining systems. - Learning from various types of classes: open, blended, online, etc.

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Prediction	SmU's ability to automatically think or reason to predict what will happen, how to handle that event, or what to do next.	- Safety systems. To predict, identify, and take appropriate actions in case of various events within the campus. - Enrollment management systems to predict, forecast, and control student enrollment variables. - Whole university risk management system (rain, storms, tornadoes, heatwaves, power outages, etc.)
Self-Organization and Reconfiguration	SmU's capability to autonomously change its internal structure (components), self-renew, and self-maintain purposefully under appropriate conditions.	- Automatic system configuration, operation parameters, sensors, actuators, and features in smart classrooms based on faculty profiles. - Auto shutdown and recovery of online streaming servers in case of temporary power loss. - Auto reconfiguration of wireless sensor networks.

In Table 1, the study highlights some prominent features of Smart University, which demonstrate its differences from the characteristics of traditional universities. SmU brings notable advantages, especially its adaptability, which supports innovative teaching and learning methods, expanding the scope of learning to previously hindered groups in traditional universities. SmU optimizes the operations and activities of administrators, reducing significant manpower compared to traditional universities. The modern equipment of SmU enables automated operation and management, leading to efficiency and economic benefits. Additionally, SmU has the ability to make predictions and recommendations for administrators based on data analysis collected through sensor systems. SmU facilitates educators and learners through lesson systems built on new platforms that align with technology and user trends.

Therefore, it can be said that the aforementioned features of SmU help overcome many barriers that traditional universities encounter when information and communication technology is not as developed as it is today.

3.2. Main Components of Smart University

SmUs may have many components similar to those of a traditional university, but they must also have additional components to implement and maintain the special features described in Table 1. Based on the research obtained about SmU, the study should identify the main distinguishing components of SmU, including at least the components listed in Table 2.

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Table 2: Main Components of Smart University

SmU Components	Specialized Subcomponents of SmU
Software System	- Web-based lecture system (with video recording and computer screen sharing) for developing learning content for pre-class activities. - Smart classroom activity recording system. - Smart video recording software. - Continuous collaborative learning systems (for both local and remote students) in smart classrooms and sharing of learning content/materials. - Web-based one-to-one or multi-member communication and collaboration systems. - Systems to organize, participate, form, and evaluate group discussions (involving both local and remote students). - Automatic playback of recorded in-class activities and lectures for post-class review (for both local and remote students). - Digital learning content and online resource storage (Web), learning portals. - Intelligent learning analytics and teaching analytics system. - Voice/speech recognition system; Speech-to-text system; Text-to-speech synthesis system. - Face recognition system; Emotion recognition system; Gesture (activity) recognition system; Context (situation) awareness system; Automatic translation system (for some common languages). - Smart physical network space (for safety and security). - Power/light consumption monitoring software system, etc.
Technology	- Internet of Things (IoT) technology; Cloud computing technology; Web lecture technology; Collaboration and communication technology; Ambient intelligence technology; Intelligent data visualization technology; Virtual and augmented reality technology; Remote (virtual) laboratories; 3D imaging technology; Wireless sensor network technology; Location recognition technology (indoors and outdoors); Sensor technology (motion, temperature, light, humidity, etc.).
Hardware/Devices	- Panoramic video cameras; SMART boards and/or interactive whiteboards; Smart pointing devices; Microphones and digital speakers, smart controllers; Large connected displays or TVs; Interconnected computer systems; Smart card readers; Biometric-based access control devices; Control and robot drive devices.
Intelligent Curriculum	- Adaptive learning programs. Core and supplementary programs, focused programs, and certificates with changeable structures suitable for various student/learner groups, intelligent pedagogy methods, etc. - Adaptive courses, lessons, and learning modules with components and structures adaptable to various teaching formats: face-to-face, blended, online, student/learner groups, intelligent pedagogy methods, etc.
Students, Learners, and Instructors	- Students or learners with combined or flexible learning methods. - Students can learn in-person (or fully online). - Lifelong learners in open education. - Students with disabilities. - Intelligent instructors (intelligent guides).
Intelligent Pedagogy	- Flexible use of innovative pedagogical forms: Learning by doing (including active use of virtual laboratories); Cooperative learning; E-books; Learning analytics; Adaptive teaching; Student-generated content learning; Game-based learning; Flipped classrooms; Project-based learning, etc.
Smart Classrooms	- Smart classrooms equipped with corresponding technologies, hardware systems, software, and intelligent pedagogy methods for intelligent education.

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In Table 2, the study identifies some essential components/devices that SmU needs to have. It emphasizes certain components such as:

Software System: Clearly, SmU cannot function without intelligent software. It supports the entire teaching and learning process within the university, from lesson design and construction to the use of lectures during teaching, all are maximally supported by software, enhancing the effectiveness of lectures. Both educators and learners benefit from the software's supportive features, enabling the teaching-learning process to no longer be constrained by time, space, or geographical distance.

Technology/Equipment and Hardware: These components ensure the smooth operation of SmU. As SmU's teaching methods change based on the digital technology platform, the curriculum also changes, enhancing the application of technology in content development and presentation, as well as how users interact with it. Thus, students, learners, and instructors will develop their capabilities in applying information and communication technology, responding to the innovative trends in higher education.

Virtual Classrooms: Virtual classrooms are considered a top priority in realizing Smart University projects.

4. CURRENT STATUS OF IMPLEMENTING INTELLIGENT COMPONENTS IN SOME UNIVERSITIES IN VIETNAM

Based on the research findings from the scientific and technological project with code B2022-HVQ.04, titled "Managing Open Knowledge in Higher Education in the Context of Digital Transformation in Education," we have the following table:

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Table 3: Current Status of Implementing Intelligent Components in Some Universities in Vietnam

University Name	Intelligent Components	Level of Implementation
FPT University	Digitized Administrative Management System	Good
	Student Record Management System	Good
	Teaching and Learning Support System	Good
	Smart University Infrastructure and Facilities	Average
	User Capabilities	Lecturers and students possess appropriate skills to utilize the features of the smart university.
Hanoi National University of Education	Digitized Administrative Management System	Weak
	Student Record Management System	Average
	Teaching and Learning Support System	Weak
	Smart University Infrastructure and Facilities	Weak
	User Capabilities	Average
Ha Noi Metropolitan University	Digitized Administrative Management System	Weak
	Student Record Management System	Average
	Teaching and Learning Support System	Weak
	Smart University Infrastructure and Facilities	Weak
	User Capabilities	Average
National academy of educational management	Digitized Administrative Management System	Weak
	Student Record Management System	Average
	Teaching and Learning Support System	Weak
	Smart University Infrastructure and Facilities	Weak
	User Capabilities	Weak

In Vietnam, there are several barriers and challenges to implementing the Smart University model, specifically regarding the following components:

Digitized Administrative Management System:

Limited financial resources may delay the comprehensive digitization of administrative processes in universities.

Resistance to change and reliance on traditional approaches to administrative procedures can slow down the adoption of digital systems.

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Insufficient understanding and skills of administrative staff regarding digital technologies can hinder effective management and utilization of these systems.

Student Record Management System:

Concerns about data security and privacy may create hesitancy in fully digitizing sensitive student information.

Outdated or incompatible legacy systems in some universities can create difficulties in integrating modern record management technologies.

Lack of standardization and interoperability between educational institutions may hinder data exchange for student records.

Teaching and Learning Support System:

Limited access to technology and reliable internet connectivity in certain areas of Vietnam may restrict students and educators from fully utilizing digital learning platforms.

The shortage of qualified professionals and opportunities for teacher training can limit their effectiveness in using digital teaching tools.

Traditional teaching methods and resistance to adopting innovative educational approaches can delay the full integration of learning support systems.

Smart University Infrastructure and Facilities:

Limited financial resources for upgrading infrastructure and facilities to support the Smart University model may hinder the implementation of advanced technologies.

Lack of a cohesive national strategy and coordination between educational institutions may lead to uneven development of smart infrastructure across the country.

Shortage of partnerships from industry and technology providers can slow down access to advanced solutions for smart infrastructure.

User Capabilities:

Insufficient digital literacy and technology skills among students, faculty, and staff can create barriers to effectively utilizing the Smart University model.

Resistance from some faculty and administrators to adapt to new technologies may impede the successful integration of intelligent capabilities.

Inadequate opportunities for continuous professional development and training for users can delay their ability to fully leverage the potential of intelligent systems.

The concept of the SmU and its related intelligent components, such as the digitized administrative management system, student record management system, teaching and learning support system, smart university infrastructure and facilities, and user capabilities,

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present a promising vision for the future of higher education in Vietnam. Embracing and implementing the Smart University model can offer numerous benefits, including improved education quality, enhanced teaching and learning experiences, streamlined administrative processes, and increased accessibility for students.

However, the current state of Smart University implementation in Vietnam faces several challenges. Limited financial resources, resistance to change, and inadequate digital literacy among users are significant barriers that need to be addressed. To overcome these obstacles, a comprehensive and coordinated approach from government authorities, educational institutions, and industry partners is necessary.

Investing in technology infrastructure and providing relevant training and support to faculty, staff, and students are vital steps to ensure successful adoption of the Smart University model. Additionally, fostering partnerships with technology providers and encouraging innovation can accelerate progress towards creating truly intelligent and innovative learning environments.

As the world continues to progress in the digital era, embracing the Smart University model will be crucial for Vietnam's higher education sector to stay competitive, meet the evolving needs of learners, and prepare the workforce for the challenges of the future. By actively addressing the barriers and harnessing the potential of smart technologies, Vietnam can establish itself as a leader in providing cutting-edge and inclusive education for its citizens.

5. RECOMMENDATIONS FOR VIETNAM TO EMBRACE AND IMPLEMENT THE SMU MODEL

Policy and Funding Support: The Vietnamese government should formulate and implement policies that promote the development and adoption of smart technologies in higher education. Allocating adequate funding for research and development in smart education and providing incentives for universities to adopt SmU initiatives will be crucial.

Infrastructure Development: Investing in robust and reliable digital infrastructure, including high-speed internet connectivity and advanced hardware systems, is essential for supporting the implementation of SmU technologies and ensuring seamless interactions between students, faculty, and resources.

Capacity Building and Training: Facilitating training programs for educators and administrators to enhance their technological skills and pedagogical knowledge in using smart technologies effectively. Encouraging faculty members to embrace innovative teaching methods and adapt to the changing learning environment will be crucial.

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Collaboration and Partnerships: Encouraging collaboration between educational institutions, technology companies, and industry partners will foster the exchange of ideas and resources, accelerating the development and implementation of SmU initiatives.

Accessibility and Inclusivity: Ensuring that SmU initiatives are designed with inclusivity in mind, catering to the needs of students with disabilities and providing accessible learning resources. This will ensure that all learners can benefit from the advancements in smart education.

Research and Development: Encouraging and supporting research initiatives that focus on smart education, learning analytics, and the integration of emerging technologies in the educational landscape will lead to continuous improvement and innovation.

Pilot Projects and Evaluation: Implementing pilot projects in select universities or educational institutions to test the feasibility and effectiveness of SmU initiatives. Regular evaluation and feedback mechanisms will help in refining the approaches and addressing any challenges.

Public Awareness and Engagement: Raising public awareness about the potential benefits of SmU and its contribution to improving the overall quality of education in Vietnam. Engaging various stakeholders, including students, parents, educators, and policymakers, in the conversation will foster a supportive environment for SmU implementation.

Smart Education Standards and Frameworks: Establishing standardized guidelines and frameworks for SmU implementation, encompassing curriculum development, assessment methods, data privacy, and security, will ensure consistency and quality in smart education practices.

Future Readiness: Considering the dynamic nature of technology, it is vital for Vietnam to continuously monitor global trends in smart education and be proactive in adopting future-ready technologies to remain at the forefront of the digital transformation in education.

By actively embracing these recommendations, Vietnam can pave the way for a Smart University ecosystem that nurtures innovation, enhances learning outcomes, and prepares students for the challenges of the digital age.

6. CONCLUSION

In conclusion, the concept of "Smart University" (SmU) represents a paradigm shift in the field of higher education, integrating advanced technology and intelligent systems to create an innovative and adaptive learning environment. The emergence of SmU and related concepts such as smart learning environments, smart campuses, and smart education has opened up new possibilities for academic and educational institutions to enhance teaching and learning methods, improve student engagement, and optimize administrative processes.

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Throughout this paper, we have explored various perspectives on SmU and its key components, including adaptation, perception, inference, self-learning, and intelligent curriculum. These components collectively contribute to the creation of a dynamic and efficient educational ecosystem that caters to the needs of diverse learners and fosters continuous improvement.

Additionally, we have presented an overview of the main components of SmU, including software systems, technology, hardware/devices, intelligent curriculum, students and instructors, intelligent pedagogy, and smart classrooms. These components serve as the foundation for the implementation and successful integration of SmU in higher education institutions.

For Vietnam, embracing and implementing the SmU model holds great promise for transforming the landscape of higher education. By following the recommended strategies, including policy support, infrastructure development, capacity building, collaboration, inclusivity, research and development, and public engagement, Vietnam can harness the full potential of smart education to provide students with a cutting-edge and future-ready learning experience.

As the world witnesses rapid advancements in technology and its applications in education, Vietnam has the opportunity to position itself as a leader in smart education adoption. Embracing SmU will not only enhance the quality of education but also contribute to the nation's development by nurturing a highly skilled and technologically literate workforce.

In conclusion, it is crucial for Vietnam to embark on a journey towards establishing Smart Universities, where technology and pedagogy synergize to unlock the full potential of students and educators alike. By investing in SmU initiatives and leveraging the power of digital innovation, Vietnam can pave the way for a more inclusive, interactive, and forward-looking educational landscape that will propel the nation towards a prosperous future.

As we look ahead, the continued exploration and implementation of SmU concepts will remain pivotal in shaping the future of education, creating a truly transformative and learner-centric ecosystem.

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Submetido em: 30/09/2023
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Avaliação: *Double Blind Reviewe*-
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