SUTD Library Special Alerts

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Smart Campus

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The development of smart campuses is an integral part of the vision of developing a smart city. One of the key areas of smart campus initiatives is smart education, which is a new concept of digital-enabled teaching and learning. There are a range of campus facilities that could be transformed into smart spaces to provide novel experience. To enhance the experience, a robust foundation of information and communications technology support is needed. Building a smart campus requires decision-makings that are coherent with sustainable and integrated urban solutions to achieve higher levels of engagement and productivity, rather than merely setting up high-tech infrastructures.

Last year, Singapore set for itself a goal to become a Smart Nation to support better living, working, and interacting for all. A few institutions have joined the roadmap and are looking forward to contributing to the nation's vision. We have also explored some international campuses that aim to become the first few urban campuses of the future.

Contents

Overview

Why and how to transform a traditional campus into a smart campus

Kwok, L. (2015). A vision for the development of i-campus. *Smart Learning Environments, 2*(2).

Intelligent campus (i-campus) refers to a holistic intelligent campus environment, in which initiatives such as cloud and mobile-powered learning, RFID-based security management are established to support holistic e-learning, networking, and governance. The paper discusses the challenges faced by traditional campuses and envisions possible ways of developing an intelligent campus.

Mattoni, B., et al. (2016). A matrix approach to identify and choose efficient strategies to develop the smart campus. In *Proceedings of 2016 IEEE 16th international conference on environment and electrical engineering (EEEIC)*. IEEE.

A methodology for strategy selection to transform an ordinary campus into a smart campus was proposed, with focus on five smart fields that play significant roles in the transformation process - People and Living, Economy, Energy, Environment, and Mobility. For each of the smart fields, several actions were raised and evaluated according to a few factors, and finally the best solution was chosen.

Uskov, V. L., et al. (2016). Smart university taxonomy: Features, components, systems. In V. L. Uskov, R. J. Howlett, & L. C. Jain (Eds.), *Smart education and e-Learning 2016* (pp. 3-14). Springer International Publishing.

A report on an ongoing research project aiming at developing taxonomy of smart universities. The authors examined the distinctive features and main components of a smart university far outperform that of a traditional university, and also nominated a selection of software systems that could be employed by smart universities.

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Smart Education

Focusing on creating smart learning environments, providing smart pedagogical support and achieving desired learning outcomes

Gros, B. (2016). The design of smart educational environments. *Smart Learning Environments, 3*(15).

Creating smart learning environments needs to understand the characteristics of such environments, combine formal and informal learning, and take learners' perceptions and learning behaviors into

account, to exploit more effective learning methods and tools, and design space more appealing to personalized and autonomous learning.

Ip, H. H. S., Li, C., Wong, Y. W., Leoni, S., Ma, K. F., Wong, H. T., & Sham, S. H. (2016). Delivering immersive learning experience for Massive Open Online Courses (MOOCs). In D. K. W. Chiu, I. Marenzi, U. Nanni, M. Spaniol, & M. Temperini (Eds.), *Advances in web-based learning - ICWL 2016* (pp. 112-117). Springer International Publishing.

The traditional way of delivering Massive Open Online Courses could limit a learner's learning experience, especially when appreciating some tacit knowledge such as a unique culture and a roomy environment. The authors came up with smart phone enabled virtual reality educational content that can create immersive and better learning experience for online learners.

Kinshuk, Chen, N., Cheng, I., & Chew, S. W. (2016). Evolution is not enough: Revolutionizing current learning environments to smart learning environments. *International Journal of Artificial Intelligence in Education*, *26*(2), 561–581.

Smart learning environment is not simply about the application of technology, but more significantly enables the fusion of pedagogy and technology to create an ecosystem in which educators and learners are able to interact more efficiently and flexibly. The paper further discusses the need for pedagogical innovations to support smart learning as well as emerging technologies that offer endless learning opportunities.

Klimova, B. (2016). Teacher's role in a smart learning environment - A review study. In V. L. Uskov, R. J. Howlett, & L. C. Jain (Eds.), *Smart education and e-Learning 2016* (pp. 51-59). Springer International Publishing.

The rise of information and communication technologies in education has quietly changed the traditional role of teachers, with a shift of emphases towards an autonomous and innovative learning, and a fusion of diverse pedagogical methods and strategies. The paper investigates teachers' role in smart education environments and explores the pros and cons of such environments to the teachers.

Rozhkova, S., Rozhkova, V., & Chervach, M. (2016). Introducing smart technologies for teaching and learning of fundamental disciplines. In V. L. Uskov, R. J. Howlett, & L. C. Jain (Eds.), *Smart education and e-Learning 2016* (pp. 507-514). Springer International Publishing.

The article examines the effect of gaming technologies on the process of education. Gamification of educational process and such forms of active learning are considered to encourage students' motivation and creativity in learning, allow learners to customize their own learning pace, and enable teachers to assess students' learning outcome.

Yassine, S., Kadry, S., & Sicilia, M. (2016). Measuring learning outcomes effectively in smart learning environments. In *Proceedings of 2016 smart solutions for future cities*. IEEE.

Measuring the effectiveness of smart education is to measure the learning outcomes. The paper aims to find solution to more effectively and precisely measure the course learning outcomes in smart learning environment. It also highlights the crucial features need to be considered in developing analytics tools to assess students' performance in learning, including mapping learning activities, designing a dynamic course map, adopting open learning analytics etc.

Zhu, Z., Yu, M., & Riezebos, P. (2016). A research framework of smart education. *Smart Learning Environments*, *3*(4).

Smart education deals with better learning in digital age. A conceptual framework of smart education is proposed in the article, containing three essential elements: smart environments, as technological support; smart pedagogy, as methodological support; and smart learner, as the goal of smart education.

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Smart Facilities

A range of smart spaces offering intelligent services, venues for blended learning, and environments for research and development

Aguilar, J. (2016). The smart classrooms at the universities as one of the pillars of the e-society. In *Proceedings of 2016 third international conference on eDemocracy & eGovernment (ICEDEG)*. Information Systems Research Group, University of Fribourg.

The authors studied the impact of smart classrooms, a major role in building e-education system, on transforming universities to part of the e-society vision. The positive aspects include developing new talents, shifting education towards democracy, enabling learners to apply theoretical knowledge into practice, and boosting blended learning. However, there are some considerations as well, such as need for redefining educational models and ability to make use of the smart design.

Akinsiku, A., & Jadav, D. (2016). BeaSmart: A beacon enabled smarter workplace. In *Proceedings of Network operations and management symposium (NOMS), 2016 IEEE/IFIP*. IEEE.

In this paper, Bluetooth Low Energy beacon technologies are used to develop a mobile application that can turn a normal workplace into a smart Internet-of-Things ecosystem. The application can assist staff to locate items in a large stockroom, navigate employees or visitors to a specific office or cubicle, control room temperature, and push relevant notifications to users based on location tracking.

Antevski, K., Redondi, A. E. C., & Pitic, R. (2016). A hybrid BLE and Wi-Fi localization system for the creation of study groups in smart libraries. In *Proceedings of 2016 9th IFIP wireless and mobile networking conference (pp. 41-48)*. IEEE.

Presenting an approach to encourage group collaborations in smart libraries by creating study groups through a mobile application, locating the groups using hybrid Bluetooth Low Energy technology and Wi-Fi indoor positioning system, and recommending the groups to other students via a server-based infrastructure. A real-life scenario is described to show positive feedback of the approach.

Cao, L., Chen, W., Zhang, X., & Huang, K. (2014). A smart meeting management system with video based seat detection. In *Proceedings of international conference on internet multimedia computing and service (pp. 232)*. ACM.

Introducing a smart meeting management system designed for large-scale auditoriums that uses a cascade empty seat detection algorithm to generate seated data and relevant information of attendees during a meeting.

Farias, G., et al. (2016). Adding automatic evaluation to interactive virtual labs. *Interactive Learning Environments, 24*(7), 1456-1476.

This automatic evaluation technology enables lecturers to set up interactive virtual and remote laboratories and students' performance to be automatically assessed. Two case studies are presented to show positive impact of the program.

Fortino, G., Rovella, A., Russo, W., & Savaglio, C. (2016). Towards cyberphysical digital libraries: Integrating IoT smart objects into digital libraries. In A. Guerrieri, V. Loscri, A. Rovella, & G. Fortino (Eds.), *Management of cyber physical objects in the future Internet of Things* (pp. 135-156). Springer International Publishing.

With the emergence of Internet-of-Things, cyberphysical smart object, a new type of digital resources, will play a significant role in developing and delivering intelligent library services to the patrons. The proposed metadata model of including smart objects into digital libraries is able to provide effective discovery, management and querying of those items through typical digital library infrastructures, so as to establish cyberphysical digital libraries. A case study is presented to digitalize the smart objects in an office and make the items available for smart services to the users.

Pereira, E., et al. (2016). STARS: Enlightenment in the office space for behavioral change. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing (pp. 1640-1645)*. ACM.

To cope with workplace noise, the authors developed an ambient lighting system as a solution for reducing distractions in large offices. The ceiling system is able to visualize and highlight the increasing sound level to the person, who is the source of the noise, and deliver a message through a mobile app suggesting an available meeting room nearby to the person.

Sánchez, J., Zamora, J., & García, F. (2016). Virtual lab for digital systems. In *Proceedings of 2016 technologies applied to electronics teaching (TAEE)*. IEEE.

The paper introduces a Linux based operating system installed with specific software applications that creates a virtual lab environment, in which students can familiarize with the virtual machine, understand key concepts, learn about each tool, and get started in the development process.

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Smart Infrastructure

Employing emerging technologies and intelligent systems for smart education and optimized operation

Hentschel, K., Jacob, D., Singer, J., & Chalmers, M. (2016). Supersensors: Raspberry Pi devices for smart campus infrastructure. In *Proceedings of 2016 IEEE 4th international conference on future Internet of Things and Cloud (FiCloud)*. IEEE.

A prototype of a campus-wide supersensor network was developed and deployed around the campus of the University of Glasgow to support different groups of end users including staff, faculty, and students. The supersensors, sensors with powerful compute capability, are believed to empower more flexible data collection, processing and reaction.

Lazaroiu, G. C., Dumbrava, V., Costoiu, M., Teliceanu, M., & Roscia, M. (2016). Energy-informatic-centric smart campus. In *Proceedings of 2016 IEEE 16th international conference on environment and electrical engineering (EEEIC)*. IEEE.

The research introduces an ongoing implementation of an energy-informatic-centric smart campus infrastructure using information and communications technology to deliver various services and collect real time data on energy consumption and production, air quality and environmental conditions in the university. Finally, the optimized operation of smart campus in terms of energy and environmental impact could be achieved as the system is able to minimize the overall energy cost by increasing the efficient use of renewable energy.

Uskov, V. L., Pandey, A., Bakken, J. P., & Margapuri, V. S. (2016). Smart engineering education: The ontology of Internet-Of-Things applications. In *Proceedings of 2016 IEEE global engineering education conference (EDUCON)*. IEEE.

A continuous research on identifying the key features of the Internet of Things (IoT), its characteristics and functions, and how IoT can be implemented in smart education. A wide range of abilities of IoT-based smart learning system are listed to meet the requirements of usual and additional smartness

levels, from the system's self-adaptation to self-optimization, from its ability to learn new knowledge to extract content from generated data.

Voon, M. J., Yeo, S. M., & Voon, N. H. (2015). Campus access control and management system. In K. Lavangnananda, S. Phon-Amnuaisuk, W. Engchuan, & J. H. Chan (Eds.), *Intelligent and evolutionary systems* (pp. 395-404). Springer International Publishing.

The advanced Centralized Access Control (CAC) systems are widely used by institutions to monitor security and track movements on campuses. Here, a simpler CAC system was proposed, which not only controls access but also collects, manages and analyses data. Thus, the system is able to support various school activities, such as lecture attendance tracking, room availability monitoring, and more.

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Examples of Smart Campuses

Learn about the smart campus visions proposed by local and international pioneers

Singapore

▪ Temasek Polytechnic

Temasek Polytechnic. Temasek Polytechnic announces plans to develop Singapore's first smart campus platform. *Temasek Polytechnic*. Retrieved 2016, October 11.

Temasek Polytechnic (TP) is developing a Smart Campus Platform with the help of leading industry partners that integrates a comprehensive and robust IT infrastructure and innovative technologies to provide better services to improve the learning and working experience on campus.

▪ Singapore Polytechnic

Salim, Z. (2016, January 20). Singapore Polytechnic partners Cisco, NCS to create smart campus. *Singapore Polytechnic*. Retrieved 2016, October 11.

Singapore Polytechnic (SP) has announced its partnership with Cisco and NCS to cultivate a holistic smart campus that will benefit academia, operational and administrative staff, students and visitors. The initiative will be driven by three aspects - smart education, smart networks, and smart energy. To achieve these, sensors, devices, networks and data will be employed to provide innovative services to improve teaching, learning and operational efficiency.

▪ Republic Polytechnic

Basu, M. (2016, July 28). Inside Republic Polytechnic's smart campus vision. *GovInsider*. Retrieved 2016, October 26.

Republic Polytechnic envisions building a smart campus and providing personalized services to its students, even predicting their needs before they request. The proposed initiatives include adopting sensor technologies to collect and analyze data on students throughout the campus, using mobile applications to enhance the campus experience of students, staff and visitors, encouraging its own students to design and develop such applications and services, and creating an online education culture to digitalize learning, assignments, and examinations.

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Other Countries

▪ Cornell Tech

Cornell Tech. Campus: A place for discovery. *Cornell Tech*. Retrieved 2016, October 26.

Cornell Tech is a new campus of Cornell University, located in New York City. It is under construction at the moment, and opening soon in 2017. What makes Cornell Tech unique is its vision of becoming a new type of urban campus and integrating closely with the city. The projects unveiled so far include a Sustainability Program, supporting healthy living, renewable energy and water management; the Bloomberg Center, a learning hub encouraging interdisciplinary collaboration and academic-industrial partnership; the Bridge, a place culturing entrepreneurship and incubating prototypes; sustainable and innovative residential buildings; and the Verizon Executive Education Center, another venue breaking down the barriers between academia and industry.

▪ University of Glasgow

University of Glasgow. Smart campus: an opportunity. *University of Glasgow*. Retrieved 2016, October 26.

University of Glasgow sees its Smart Campus expansion plan a unique opportunity for the university to exploit in the fields of smart cities and explore areas such as urban innovation, city systems, big data, informatics, energy management, and transport policy. With the expectations from its students and staff, the industry, and the government, the new university quarter will have a large-scale and high-quality urban environment, equipped with first-class facilities and smart technologies.

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