Chapter 1
Innovations in Smart Universities

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Abstract This chapter provides a brief overview of current innovative research in Smart Universities area, including projects on smart technologies, software/hardware systems for Smart Classrooms, and Smart Pedagogy.

Keywords Smart university · Smart technology · Smart systems · Smart pedagogy

1.1 Introduction

Fast proliferation of smart phones, smart devices, smart systems, and smart technologies provides academic institutions, students, faculty, professional staff, and administration with enormous opportunities in terms of new highly technological approaches to increase the quality of teaching strategies and learning outcomes. In addition, these technological advances provide remarkably effective management and administration of the main functions and services of colleges/universities.

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The concept of a 'Smart University' is an emerging and fast evolving area that represents the creative integration of innovative concepts, smart software and hardware systems, Smart Classrooms with state-of-the-art technologies and technical platforms, Smart Pedagogy based on modern teaching and learning strategies, Smart Learning Analytics and academic analytics, and various branches of computer science and computer engineering. The papers presented at the KES annual international conferences [1–4] on Smart Education and e-Learning (http://www.kesinternational.org/) clearly show that, in the near future, Smart University concepts, Smart Classrooms, and Smart Pedagogy will be actively deployed and used by leading academic institutions and training organizations around the world.

As Albert Einstein said, "We cannot solve our problems with the same thinking we used when we created them". We need to develop new conceptual models and identify unique features, systems and technologies for the next level of university's evolution—*a Smart University*. This is probably the main reason that multiple researchers and research teams around the world are actively working on the design, development, testing, and implementation of various innovative smart technologies, software and hardware systems, and smart devices on their university campuses, providing the ability for integration into the educational processes utilized. For example, research projects on applications of smart technology in Smart Classrooms and on Smart Universities campuses mainly focus on (1) Internet-of-Things technology, (2) cloud computing technology, (3) Radio Frequency Identification (RFID) technology, (4) ambient intelligence technology, (5) smart agents technology, (6) augmented and virtual reality technology, (7) remote (virtual) labs, (8) location and situation awareness technologies (indoor and outdoor), (9) Wireless Sensor Networking (WSN) technology, (10) sensor technology (motion, temperature, light, humidity, etc.), as well as many other types of emerging and advanced technologies.

The current design and development projects aimed to provide advanced software/hardware systems for Smart Classrooms usually are focused on systems of the following types: (1) Smart Learning/Teaching Analytics (big data analytics) systems, (2) serious games and systems for gamification of learning/training process, (3) context (situation) awareness systems (including geographic location awareness, learning context awareness, security/safety awareness systems), (4) automatic translation systems (from/to English language), (5) speaker/instructor tracking—smart cameraman—systems (in the Smart Classroom), (6) conferencing systems for smooth one-to-many and many-to-many audio/video interaction/communication/collaboration between local/in-classroom and remote/online students/learners, (7) gesture/emotion/activity recognition systems, (8) face recognition systems, (9) intelligent cyber-physical worlds' systems (for safety and security in buildings and on campus), (10) smart software agents and smart robotics, as well as other advanced software systems [5].

Most of the current research projects being done in the area of Smart Pedagogy are focused on various innovative technology-based student-centered learning and teaching approaches such as (1) learning-by-doing (including active use of virtual labs), (2) collaborative learning, (3) adaptive teaching, (4) serious games- and

gamification-based learning, (5) flipped classrooms, (6) learning analytics and academic analytics, (7) context-based learning, (8) e-books, (9) personal enquiry based learning, (10) crossover learning, and other innovative strategies.

Despite the fact that multiple publications are available on the above-mentioned topics (most of those publications are listed in the References sections of chapters below, including references [6–8] of this chapter), we were not able to locate any published books on the topic of Smart Universities. As a result, we arrived with the idea that there should be a book with a well-thought collection of contributions—a book that covers concepts, models, smartness levels, features, components, systems, and technologies to be used by smart academic institutions. This is the main reason that we initiated the development of this pioneering book in the area of Smart Universities.

1.2 Chapters of the Book

This book includes 13 chapters grouped into 4 separate parts: Part 1—Smart Universities: Literature Review and Creative Analysis, Part 2—Smart Universities: Concepts, Systems and Technologies, Part 3—Smart Education: Approaches and Best Practices, and Part 4—Smart Universities: Smart Long Life Learning. A brief description of those chapters, each of which is a peer-reviewed contribution presented by various international research, design, and development teams, is given below.

Chapter 2 presents the outcomes of a systematic literature review and creative analysis of professional publications available in Smart Universities and related areas. The performed systematic creative analysis proved to be a useful approach to identify and briefly compare various professional publications with a wide range of proposed ideas and approaches, developed technical platforms, software and hardware systems, introduced smartness levels, best practices, etc. for Smart Universities. This could potentially help administrators, faculty, and professional staff at traditional universities to understand, identify, and evaluate various potential paths for a transformation of their university into a Smart University. This chapter describes the proposed and developed Smart Maturity Model for Smart Universities —a model that can be viewed broadly as Smart University level-by-level "smartness" evolution and improvement of its main functions.

Chapter 3 presents a comprehensive approach to conceptual modeling of Smart Universities. It is based on the modeling of smartness levels, smart software and hardware systems, smart technology, Smart Pedagogy, and several other distinctive features and components of a smart university. The obtained research findings and outcomes clearly show that main distinctive features, components, technologies and systems of a Smart University go well beyond those in a traditional university with predominantly face-to-face learning activities. This can be seen through examples such as the recommendation of multiple types of software systems for deployment at Smart Universities and in Smart Classrooms. Particularly, this chapter presents information about 100 + analyzed software systems that can support various

activities at a smart university; it also provides recommendations for specific software systems that could benefit both faculty and students at a smart university.

Chapter 4 discusses one of the most distinctive features of a smart university. This is its ability of adaptation to and smooth accommodation of special students, i.e. students with various types of disabilities including physical, visual, hearing, speech, cognitive, and other types of impairments. This chapter presents the outcomes of systematic identification, analysis, and testing of available open source and commercial text-to-voice, voice-to-text, and gesture recognition software systems. These systems could significantly benefit students with disabilities attending a smart university. Particularly, this chapter presents information about 70 analyzed software systems and provides recommendations for text-to-voice, voice-to-text, and gesture recognition software systems for possible implementation at a smart university.

Chapter 5 describes an excellent practice to build a smarter college. This is a practical approach used by National Institute of Technology, Gifu College (NIT, Gifu College). The main idea is that, in a smarter college, various components should be interconnected to achieve the college's most effective functioning. These include hardware, software, systems, faculty development, information sharing, and institutional policies such as admission policy, curriculum policy, and diploma policy. The presented Active Learning practice at NIT, Gifu College is characterized by intensive use of educational systems, information and communication technologies, and equipment. From this point of view, Active Learning, as developed at NIT, Gifu College, has almost the same meaning as smart education.

Chapter 6 provides a brief overview of several modern technologies that emerged in the last few years, including Big Data, Internet of Things (IoT), Future Internet, and Crowdsourcing. A smart university could potentially be a proper place where all of these technologies could be examined and applied continuously as a sustainable evolution. Based on the performed analysis done of software systems and related aspects of this evolution, this chapter presents an open architecture for easily extensible services. These services are responsible for providing the users with value-added information; as a result, it is expected that they will increase the smartness level of university campus. Particularly, three directions were investigated for this reason: IoT to involve sensing, cloud computing and ubiquitous computing to make services available everywhere, and the transformation of service consumers to content generators or data producers and/or developers for new data source connections. Additionally, Big Data is considered as a forthcoming addition to these designated technologies to enhance the analytical capabilities of smart communities.

Chapter 7 introduces a novel framework for a smart virtual university hospital. The experiences to develop and test the solutions for training interprofessional team communication and collaboration are also described. The main premise behind this approach is that establishing a smart virtual university hospital mirroring a real life hospital can prepare students for direct patient contact such as practice placement and clinical rotation. This could optimize and sometimes also increase students' time on task. Additionally, such a virtual arena will support student learning by

providing adaptive and flexible solutions for practicing a variety of clinical situations at the students' own pace. Based on multiple performed experiments and observed practices of student groups—medicine and nursing students, who worked in groups with the clinical scenarios in a virtual hospital using desktop PCs alone and with virtual reality goggles—it may be concluded that a smart virtual university hospital could be a feasible alternative for collaborative interprofessional learning.

Chapter 8 introduces an advanced approach to make mathematical education smarter on the basis of applying various information and communications technologies to mathematical education. It presents a developed innovative educational system—EdLeTS system—to support practical components of mathematical classes in various aspects. The distinctive features of this systems, such as support of personalization of education, the system's availability "at any time and from anywhere", and self-learning mode, are aimed at resolving some of the identified problems in math education.

Chapter 9 presents another progressive approach to make education smarter. In this case, it is based on a developed modular framework and an accompanying spiral design process that facilitates the design, development, and continued improvement of smarter serious games. The implementation of this framework has been systematically explored through an evolving serious game developed using the framework, which is a game focused on teaching precalculus at the college level.

Chapter 10 studies a challenging topic—the individual completion of programming exercises at higher education institutions. The problem is that, while some students can easily solve the programming problems independently, there are still many students who require a lot of additional time and/or efforts to solve the assigned programming problems. This chapter, in general, is focused on making initial computer science education smarter by developing a smart educational environment and by supporting instructors and teaching assistants in their provision of smart pedagogy for students. Particularly, this chapter presents the proposed novel support functions utilized to assess the learning conditions of a programming practicum. The goal of these functions is to reduce the burden on instructors by supporting the assessment of learning conditions in order to improve the quality of instruction.

Chapter 11 discusses the aspects of Smart Life-Long Education and continuous professional development. The developed approach is based on the idea that a smart university may facilitate self-regulated learning of learners through the introduction of a personal development e-Portfolio. This assists learners in planning their professional development path and reflecting upon their own learning outcomes. An implementation of the developed approach in the City University of Hong Kong shows a model combining training content in massive online open courses with clearly specified intended learning outcomes. This, combined with competence-based definitions and personalized training portfolios, may help professionals fulfill their continuous professional development and training requirements.

Chapter 12 describes an interesting case study of introducing smart technologies and approaches into the educational process at a traditional polytechnic university.

Particularly, it examines several techniques aimed at enhancing student motivation in terms of independent work and in relation to independent and lifelong learning. The following techniques are considered in this chapter: a "role reversal" methodology of education, e-learning and blended learning, involving the professional community into the educational process, and professional training in English. The applications of several innovative and smart techniques, such as training sessions, group teaching methods, role-playgames, the use of smart components, etc., are analyzed and tested with students majoring in Power Engineering. The chapter provides a lot of statistical data and findings relevant to this interesting case study.

Chapter 13 focuses on the meeting of Constructivism (as a learning theory) and Smart Learning. This, in turn, theorizes the idea of Smart Constructivist Learning with applications in smart learning environments. Relying on the phenomena of "meaning construction" and "meaningful understanding production" in the framework of smart constructivism, this chapter is focused on the analysis of Smart Constructivist Knowledge Building and analysis of Learning-and-Constructing-Together as a smart constructivist model. It is expected that the presented theory and models could support the development of innovative smart learning strategies.

1.3 Concluding Remarks

We believe this book will serve as a useful source of research data and findings, design and development outcomes, best practices, and case studies for those interested in the rapidly growing area of Smart Universities, including faculty, scholars, Ph.D. students, administrators, and practitioners. It is our sincere hope that this book will provide a foundation of further progress and inspiration for research projects and advanced developments in the area of Smart Universities.

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