Nothing is more important, certainly during these times of artificial intelligence, than our public education. And as it continues to grow and evolve, I think you and I know this is going to be critical that we are constantly training and retraining and creating these next-generation jobs.

Mr. Marc Benioff (Internet entrepreneur, born 1964)

Abstract  Education, especially public education using AI is more important than ever. This is because not only we need to reposition and upgrade our work skills, but more importantly, we should use this extraordinary technology to acquire knowledge, learn from others, and collaborate with all talents worldwide to acquire new knowledge. The richness of alliance is not only beneficial to us, but also to the overall mankind. This chapter begins with smart education progress in the past decades. Next, we examine the smart education model—a four-tier framework of smart pedagogies and key features of smart learning environment. Then, we study the two latest R&D AI-based smart education applications: AI language learning robots and VR-AR teacher to elaborate how AI technology we learnt in previous chapters such as machine learning, NLP technology, ontological knowledge base, VR, and AR can be integrated to provide a new age of smart education.

Mr. Marc Benioff’s statement is correct because education, especially public education using AI is more important than ever. This is because not only
do we need to reposition and upgrade our work skills, but more importantly, we should use this extraordinary technology to acquire knowledge, learn from others, and collaborate with all talents worldwide to acquire new knowledge. The richness of alliance is not only beneficial to us, but also to the overall mankind.

In this chapter, we explore an important AI topic in daily activities—*smart education*. First, we review its progress for the past decades. Then, we analyze its model—a four-tier framework of smart pedagogies and key features of the smart learning environment. Next, we examine two latest R&D on AI-based smart education applications: AI language learning robots and VR-AR teacher to integrate AI technology we learnt from previous chapters such as machine learning (especially on reinforcement learning), NLP technology, ontological knowledge base, VR, and AR to provide a new age of smart education.

11.1 Smart Education—An Introduction

With the advancement of technology, anything can be instrumented, interconnected, and integrated into intelligent design, as is education. In recent years, smart education has attracted widespread attention in projects carried out globally (e.g. Chan 2002; Choi and Lee 2012; Hua 2012; IBM 2012; Mäkelä et al. 2018; Zhu et al. 2016; Kobayashi et al. 2017).

Malaysia’s *Smart School Implementation Plan*, launched the first and the *Smart Education Project* in 1997 (Chan 2002). In this project, smart schools were implemented to improve the education system to meet the challenges of the twenty-first century.

Singapore implemented its *Smart Country Master Plan* (2010), in 2006, in which *smart education* was supported by various latest technologies such as IoT (Internet of Things), AI, and 5G (Hua 2012). Eight *smart schools* focused on creating diverse learning environments were established in the plan.

The *Finnish Board of Education* also implemented a smart education project in 2011, with a continuous system learning solution (SysTech). The project aims to promote learning in the twenty-first century through user-driven motivational learning solutions (Mäkelä et al. 2018).

The Australian government worked with IBM to design and implement an intelligent, multidisciplinary intelligent education system (IBM 2012), to connect all schools, higher education institutions, and vocational training institutions in 2012.
At the same time, South Korea government have also launched their smart education project (Choi and Lee 2012) and the United Arab Emirates (UAE) government launched their smart learning program, the so-called Mohammed Bin Rashid (MBRSLP), which aims to establish a new learning and cultural environment in national schools.

The New York Department of Education in the US launched the Smart School Program, in 2014, which aims to integrate the latest IT technology into the classroom (New York Smart School Committee Report 2014).

In Africa, the ICT Transformation Education Project (2019), was launched in 2015, with the aim to promote human and social development of African countries through the use of information and communication technology (ICT) for education. It is part of the cooperation between UNESCO and the Korea Trust Fund. The first phase of the project was implemented in Mozambique, Rwanda, and Zimbabwe from 2016 to 2019. The second phase will take place in Côte d’Ivoire, Ghana, and Senegal from 2020 to 2023.

Overall, the focus on smart education and development has become a new trend in global education.

### 11.2 What is Smart Education?

There is no clear and unified definition of intelligent education and intelligent learning. Intelligent education is a term describing education and learning in the new AI era and the digital age which has attracted the attention of many researchers. The goal of smart education (and smart learning) is to train smart learners by adopting the latest IT, communication, and AI technologies to meet the work and life needs of the twenty-first century.

Multidisciplinary researchers and education professionals are constantly studying the concepts of intelligent education and learning. Hwang (2014) believed that intelligent learning is ubiquitous learning with context awareness. Figure 11.1 shows the intelligent learning environment proposed by Hwang (2014).

The proposed smart education framework by Hwang (2014), consists of seven major components:

1. *Learning status detecting module*—to detect learners’ real-world status and environmental contexts.
2. *Learning performance evaluation module*—to evaluate and record learners’ performance by conducting online tests or in real world.
3. **Adaptive learning task module**—to assign learning tasks to learners based on learning progress, learning performance, personal factors, and learning objectives in all disciplines.

4. **Adaptive learning content module**—to provide learning materials to learners.

5. **Personal learning support module**—to provide learning support to learners based on learning needs.

6. **Database module**—to keep learners’ profiles, learning portfolios, learning sheets (i.e. the sheets that present the learning tasks for each subject unit or learning topic), learning materials, test items, and learning tools.

7. **Inference engine and a knowledge base**—to determine the value of candidate learning tasks, strategies, and tools as well as their possible combinations.

Kim et al. (2013) believe that intelligent learning that combines social learning with ubiquitous learning is a learner-centric and service-oriented education paradigm rather than focusing solely on the equipment use. At the 2010 *Korean Intelligent Learning Forum* (Noh 2011), the concept of intelligent learning was proposed as follows: First, it focused on humans and content, not devices. Secondly, it is an effective and intelligent tailor-made learning based on advanced IT infrastructure.

*MEST (The Korean Ministry of Education, Science and Technology)* defined smart education as **Self-directed, Motivated, Adaptive, Resource-enriched, and**
Technology-embedded education and learning systems. Their smart learning and education model so-called S.M.A.R.T. which consists of the following components:

S: Self-Directed means that the education system is progressing toward a self-learning system. Students’ roles transit from knowledge adopters to knowledge creators. Teachers become learning facilitators.

M: Motivated means education becomes experience centered and involves learning by undertaking creative problem-solving and individualized assessment.

A: Adaptive means strengthening education system’s flexibility and tailored learning for individuals’ preferences and career prospects.

R: Resource-enriched means that Smart Learning adopts ample content based on open market, cloud education services from both public and private sectors. In other words, it expands the scope of learning resources to include collective intelligence—Social Learning.

T: Technology-embedded means that in a Smart Learning education environment, students can learn anywhere, any time through advance technologies.

Figure 11.2 shows the holistic concept of SMART education in Korea (Kim et al. 2013; Middleton 2015). It also stipulates learner-centric aspects and how it benefits from using smart technologies. The personalized and smart
technologies make learners engage in learning and increase independence in a more open, connect, and augmented ways with distinctive ample contexts.

11.3 The Technology of Smart Education (TEL)

The basis of smart education is to use smart devices and smart technologies as a new educational paradigm (Kim et al. 2013). It is described as technology enhanced learning (TEL). TEL is used to provide flexibility in learning modes. They can be media or tools for content access (Daniel 2012), query, communication and collaboration, construction (Bruce and Levin 1997), expression (Goodman 2003), and evaluation (Meyer and Latham 2008).

Personalized technology has promoted mobile devices development. Mobile learning has become the main TEL mode. It focuses on learners’ mobility compared with the static traditional education style (Hwang et al. 2008).

Many studies have begun recently to focus on the importance of real activities that enable students to solve real-world problems (Hwang et al. 2008). It is very important to design a combination of real and virtual learning environments to put students in a real learning environment. Seamless learning overlaps with some aspects of mobile learning and ubiquitous learning. It is described as a one-to-one TEL model for learners to learn across time and locations. And it is easy to convert learning scenarios from one to another through smart personal devices to cover formal and informal learning, personal, and social learning (Chan et al. 2006).

Cloud computing, learning analysis, big data, IoT, wearable technology, and other smart technologies have promoted the emergence of smart education. Cloud computing, learning analysis, and big data focus on how to capture, analyze, and guide learning data to improve learning and teaching, and support personalized and adaptive learning development (Mayer-Schönberger and Cukier 2013; Picciano 2012). Multifunctional learning technology, the learning platform can respond to individual learner data and adjust teaching resources. It can use aggregated data across large-scale learners to gain an in-depth understanding of course design (NMC 2015).

The Internet of Things and wearable technologies also support contextual learning and seamless learning development. IoT connects individuals, objects, and devices. The smart devices that learners carry with them can benefit from various relevant information that the surrounding environment advertises to them (NMC 2015). Wearable technology can integrate location
information, motion recording, social media interaction, and visual reality tools with learning. Figure 11.3 illustrates the most frequently used IoT in smart classrooms including: interactive whiteboards, e-books, tablets, 3D printers, student smart cards, sound sensors, security cameras, temperature sensors, light sensors, smart HVAC systems, attendance tracking systems, and wireless door locks, etc.

11.4 Framework of Smart Education

Reference to smart education projects from different countries and the meaning of smart, a Smart Education Framework with three major components is proposed by Zhu et al. (2016), illustrated in Fig. 11.4:

1. Smart learners.
2. Smart pedagogy.
3. Smart learning environments.
The main theme of smart education is to create intelligent environments using smart technologies, so that smart pedagogies can facilitate personalized learning services and foster learners for better value orientation, stronger conduct ability, and talents of wisdom (Zhu et al. 2016).

These three components are interrelated. Smart education emphasizes the idea of pursuing better and/or smarter education to solve the needs of smart teaching methods as methodological issues and smart learning environments as technical issues to advance educational goals and train smart learners. Smart education may affect the smart environment seriously. Smart teaching methods and smart environments support smart learners’ development.

11.4.1 Smart Learners

Learning is defined as the process of acquiring competence and understanding traditionally. It brings a new ability to do things and an understanding of unknown things. Ability refers to having specific skills and knowledge. The twenty-first century requires individuals to possess skills and abilities to operate and live effectively. The purpose of smart education is to train smart learners to meet these needs.
There are many organizations that develop twenty-first century skills independently. The *Organization for Economic Cooperation and Development (OECD)* has organized 10 skills in the twenty-first century into four categories, including ways of thinking, working tools, working methods, and world lifestyles (Ananiadou and Claro 2009). *Partnership for twenty-first century* (P21 2015) proposes a framework for learning in the twenty-first century, indicating that students should master the following knowledge and skills: key themes in twenty-first century; learning and innovation capabilities; information, media, and technical skills; life and career skill. *The North Central Regional Education Laboratory (NCREL)* proposed that literacy, creative thinking, effective communication, and high productivity in the digital age constitute the twenty-first century skills (Burkhardt et al. 2003).

There are four ability levels in smart education that students should master to meet the needs of modern society based on these studies. These abilities are basic knowledge and core skills, comprehensive abilities, personalized expertise, and collective intelligence:

1. Basic knowledge and core skills refer to knowledge and skills in core subjects such as STEM, reading, writing, art, etc. Mastery of these core subjects is essential to students’ success (P21 2015). Jenkins (2009) also considered that the reading, writing, and mathematics are core capabilities of the twenty-first century.

2. Comprehensive abilities refer to abilities to think critically and solve real-world problem. Most of the twenty-first century skills frameworks raise the demands of thinking ways (Ananiadou and Claro 2009; Burkhardt et al. 2003; P21 2015). These abilities let the student use appropriate reasoning and comprehensive thinking in different complex situations. Students should solve different problems and produce better solutions based on analysis to make judgments and decisions.

3. Personalized expertise demands students to master information and technology literacy, creativity, and innovation skills. Information and technology literacy demand students to master ICT skills using different applications and combining cognitive abilities or higher-order thinking skills for learning (Ananiadou and Claro 2009). Creativity and innovation skills demand students to think and work creatively with others.

4. Collective intelligence refers to knowledge built up by a group of individuals via communication and collaboration. Students need to reflect about the ways to share and transmit results or outputs to others after the work with information and knowledge (Ananiadou and Claro 2009). They need to communicate in various ways clearly and effectively.
11.4.2 Smart Pedagogy

Learning methods become more and more flexible and efficient as technology advances. Cognitive science research shows that knowledge and skills are closely intertwined to enable learners to understand and put into practice. Critical thinking and learning skills are extremely important, but these skills cannot be taught independently, because some appropriate factual knowledge needs to be taught in a specific field and background (Ananiadou and Claro 2009). Using deliberate teaching or related learning strategies can develop knowledge and skills for learners.

Students acquire basic knowledge and core skills in the classroom. Every student’s goals and processes are the same. But students with different backgrounds have different preparation levels, interests, and learning characteristics. Every student should receive an equal education, supplemented by content and performance standards that enhance understanding (Tomlinson and McTighe 2006). The process should be customized according to learning requirements, background, interests, preferences, etc. (Sampson et al. 2002). Interest-driven personalized learning can cultivate intrinsic motivation and promote students’ personalized professional knowledge (Atkins et al. 2010).

In addition, whether it is in the classroom or online, usually need a group or team to achieve a common goal. The collaborative process enables students to develop comprehensive critical thinking and problem-solving skills (Stahl et al. 2006). Cooperative teams can retain knowledge by sharing information and discussions at a higher level of thinking to be responsible for their own learning (Totten et al. 1991).

Intelligence is the ability to get things done. Sternberg (1999) describes three basic aspects of successful intelligence including: analytical thinking, creative thinking, and practical applications. We provide students with the ability to solve problems, make decisions, creative thinking, and interest-driven learning so that they can generate intelligence. This is like transfer learning, or what we have learned to apply to other different related conditions in a specific situation (Barnett and Ceci 2002). Learning is a generating process. In this process, the learner is an active recipient of information, and he is committed to construct meaningful information found in the environment. Generative learning enables learners to apply what they have learned to a variety of relevant future situations (Fiorella and Mayer 2015).

The four instructional strategies proposed by Zhu et al. (2016), to foster learners’ performance is shown in Fig. 11.5. These strategies include class-based differentiated instruction, group-based collaborative learning,
individual-based personalized learning (interest-driven predominantly), and mass-based generative learning (through online interactions predominantly).

11.4.3 Smart Learning Environments

Individuals criticize the traditional learning paradigm for being too artificial, rigid, and unresponsive to today’s social needs (Kinshuk and Graf 2012). New technologies and new teaching methods developed in the digital age have attracted learners and promoted the learning of common phenomena. Piccoli et al. (2001) define and expands learning environment dimensions including space, place, time, technology, control mechanisms, and interactions. Therefore, it is possible to design a new learning environment technically and pedagogically.

From the technical point of view, ambient intelligence (AmI) is developing as a new research paradigm rapidly (Shadbolt 2003). In AmI environment, the device allows individuals to perform daily activities and tasks in a relaxed and natural manner from the network. It can interact and communicate independently without manual coordination, without making decisions based on a range of factors (including personal preferences and others in the surrounding area). Most students are digital natives who use smart mobile devices and digital resources for communication, learning, and entertainment every day (Bennett et al. 2008).

From the teaching perspective, the slanted analysis method enables institutions to support learners’ progress and enrich personalized learning (Siemens and Long 2011). The goal is to monitor the learning process and use data
analysis to predict students’ future performance to discover potential problems (Zhu and Shen 2013). Teachers can provide information feedback through virtualized dashboards and learning analysis and obtain an overall view of learner activities related to peers or other participants in the learning experience.

The technically supported intelligent learning environment should not only enable learners to use digital resources and interact with ubiquitous learning systems, but also provide the necessary guidance, support tools or suggestions in the right place, time, and form actively (Hwang 2014). There are many hardware and software technologies that can support reinforcement learning. The hardware includes tangible objects, such as interactive whiteboards, smartwatches, e-bags, mobile phones, wearable devices, smart devices, sensors using pervasive computing, cloud computing, environmental intelligence, IoT technology, etc. The software includes various learning systems, learning tools, online resources, educational games using social networks, learning analysis, visualization, and virtual reality.

The goal of smart learning environments is to provide abundant, accurate, personalized, and seamless (formal and informal) learning experience using learning analytics. Ten key features of smart learning environments are as follows (Zhu et al. 2016):

1. Location-Aware: Sense learner’s location in real time.
2. Context-Aware: Explore different scenarios and activities information.
3. Socially Aware: Sense social relationship.
4. Interoperability: Set standard between different resources, services, and platform.
5. Seamless Connection: Provide continuous service when any device connects.
6. Adaptability: Promote learning resource according to learning access, preference, and demand.
7. Ubiquitous: Predict learner’s demand until express explicitly, provide a visual and transparent way to access learning resources and service to the learner.
8. Whole Record: Record learning path data to mine and analyze deeply, then give a reasonable assessment, suggestion, and promote on demand service.
9. Natural Interaction: Transfer multimodal interactions such as position and facial expression recognition.
10. High Engagement: Involve in multidirectional interaction learning experience.
Figure 11.6 shows VR-AR technology application in medical training.

11.5 3D Holographic AI Teacher

As we can see, the existing Smart Education comprises of state-of-the-art technology covering IoT, wireless communication, VR, and AR. With the advance AI technologies studied in this book, future Smart Education should focus on how different AI technologies such as computer vision, machine learning, data mining, NLP, and ontological search engine can be integrated together to provide a comprehensive solution for Smart Education.

In the following two sections, we will introduce two innovative AI-oriented Smart Education applications: 3D Holographic AI Teacher and Language Chatbot Tutor which are part of UIC iCampus research project applications.

Imagine one day we attend a lecture on AI and neural networks. It is possible, technology speaking, to implement AR-VR with the integration of AR technology; to demonstrate the biological structure of the brain wearing VR-AR glasses as shown in Fig. 11.7. How about we see 3D AR graphic without glasses? Or, even the lecturer is only a 3D software agent image?

The answer is absolutely yes. With the Holographic Technology, it is technically feasible to visualize 3D AR images with the naked eye, akin to what you see in many sci-fi movies. The challenges nowadays are: whether we can incorporate with various AI technologies such as machine learning, NLP, and ontological knowledge base to implement a 3D holographic AI teacher—a software robot with ontological knowledge-based on a particular knowledge domain (e.g. AI in our case) with the appearance of a 3D holographic image.
(of a real teacher) to deliver lectures and interact with students ubiquitously. Such technology becomes extremely useful at the time of writing this book when many of the author’s colleagues are unable to conduct face-to-face teaching due to Covid-19.

### 11.6 Language Chatbot Tutor

Language learning is always a crucial task in education for foreign language(s) learning and oral practice. As revealed in Chap. 6 *Natural Language Processing (NLP)*, current NLP technology provides a feasible and practical solution to handle both Text-to-Voice and Voice-to-Text technology for frequently used languages with so-called *true human voice* synthesis. Today challenges are focused on how to integrate with other AI technology such as machine
learning, data mining and ontological knowledge base with search engine to implement a comprehensive Smart Education solution for language learning and practice. *Language Chatbot Tutor* is one of the major AI research topics in UIC iCampus research project. AI technology integration such as NLP, machine learning (particularly in reinforcement learning technology), ontological knowledge base and search engine technology. Language Chatbot Tutor aims at the implementation of a comprehensive AI-based English language chatbot agent that can be installed in any mobile device for teaching and learning foreign language(s) such as English.

In terms of AI function, *English Language Chatbot* provides three levels of English learning: (1) Syntactic Level; (2) Semantic Level; and (3) Pragmatic Level which corresponds to the three knowledge levels in natural language. In Syntactic level, the user requires to read text passage (or dialog) shown by the chatbot. It will compare it with the sample voice soundtrack and advise student pronunciation as shown in Fig. 11.8. Technically, is alike to have an accompanied language tutor to correct pronunciation mistakes in daily dialog. In Semantic Level, the chatbot tutor will base on a specific scenario, e.g. inside a restaurant to teach students converse, pronounce, language styles, and meanings. In the Pragmatic Level, also the highest level, the language chatbot tutor will have the so-called *free conversation* with students, check and response language pronunciation and correct use of the language. In fact, it is also a major challenge for AI chatbot.

### 11.7 Case Study: A New Era of Smart Education

In this chapter, we studied various aspects of Smart Education ranging from its framework to different models implemented at countries worldwide.

The integration of different AI technologies such as machine learning, data mining, computer vision, NLP, and ontological knowledge base system and search engine with *smart education* is definitely a future trend. As a student, which aspect(s) of academic life and study will be affected and/or benefited by such technologies and changes?

Form a group of 4–5 students:

1. Explore and discuss which aspects of academic life may change in this new era of smart education, such as attendance, study, assignment, and examination, etc.
2. For each aspect of teaching and learning activity, discuss how it can be changed and what AI technologies are involved.
3. For each aspect of teaching and leaning activity, discuss how we can get benefited from these smart education technologies.

4. What are the potential threats or problems that might arise from these smart education technologies or systems? (Fig. 11.9)
11.8 Conclusion

In this chapter, we explore one of the foremost applications of AI in our daily activities—Smart Education. Education today is not only restricted to students and youngsters. Every one of us is in the course of continuous education in the sense that we all need to improve and upgrade our knowledge even if we have completed studies and started careers.

As some might worry: *Will AI and robotics replace our work, says as professional educators?* The similar kind of worry occurred when we started to use a computer back in 1970s, as many were worried about the work will be replaced by computers.

The truth is, there might be some changes in shifting our work nature alike with the use of computers, some tedious and so-called mechanical work will be replaced by computers allowing us to work on more creative and non-tedious work. The same logic applies to situations today. AI adoption in various industries will somehow replace some jobs and tasks that can be done by AI machines or systems more effectively. But again, we can improve ourselves and work on more creative and knowledge-oriented work. That is why Smart Education is significant. The importance of education is not only for self-benefit, but also to others and our next generations. Thus, the importance of Smart Education is to use the latest AI and related technology effectively so that it can benefit more people worldwide. This is the sole nature of Smart Education.
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