Chapter 2
What Is a Smart Classroom? a Literature Review

Yi Zhang, Xing Li, Lingmin Zhu, Xuemin Dong and Qi Hao

2.1 Introduction

In referring to the "smart classroom", there are other terms often used, such as "intelligent classroom", "future classroom", "technology-enhanced classroom", etc. At present, there is no unified definition of smart education. Most commentaries are mainly concerned with the aspects of technical configuration and function in the smart classroom. In China, the main perspectives are as follows. In the era of information technology, network technology, rich media technology and artificial intelligence, the classroom environment should be a kind of new classroom in which teaching content can be optimized to facilitate the acquisition of learning resources to promote classroom interaction, with situational awareness and environmental management functions—this classroom is called the smart classroom. The smart classroom is also a typical smart learning environment that has evolved from the traditional classroom (Huang, Hu, Yang, & Xiao, 2012).

Globally, this concept involves other perspectives. The "intelligent learning environment" is an environment based on the application of information and communication technology, is learner-centered and has the following characteristics: it can adapt to learners' different learning styles and learning abilities; it can provide support for learners' lifelong learning; and, it provides support for ongoing development (Chin, 1997). There are other definitions:

(1) The Smart Classroom is a fully integrated interactive system that allows users to seamlessly access media from a central point;

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(2) The smart classroom can be classified as a classroom with computers, projectors, multimedia devices (video and DVD), network access, loudspeakers, etc., and capable of adjusting lighting and controlling video streams;
(3) The Smart Classroom is a completely self-service environment that helps teach and learn in which teachers use resources in a simple, easy-to-use manner; and,
(4) The smart classroom allows users to interact with them as naturally as possible (Yao, 2015).

Thus, the smart classroom environment makes use of sensing technology, network technology, rich media technology and artificial intelligence technology as a whole, with pad, electronic schoolbag and other one-on-one mobile devices. It can monitor the learners' learning status in real time and collect the process data of student diversity, and can promote students' personalized learning, self-learning and cooperative learning, that support student 21st century skills (communication, critical thinking, creativity, and collaboration).

2.2 The Origin and Background of Smart Classroom

The origins of the smart classroom can be traced back to a presentation by Ronald Reichenio in 1988, but at that time due to the limitations of the development of science and technology, the ideas of a smart classroom had not been vigorously promoted. Chinese intellectual education in the information environment can be traced back to Qian Xuesen as early as 1997 when he began to advocate "Dacheng smart". He proposed the English name "Science of Smart in Cyberspace", where Cyberspace describes the total network interactive information space. "Dacheng smart" also refers to the network smart formed in the vast information space by Immersion (Zhu, 2016).

With the continuous development of information technology, we can use large-scale computer clusters and cloud computing technology to collect, analyze, model, and forecast large data, so as to maximize the use of resources, and get more advice and information to help people make better decisions. In 2008, IBM Chairman, President and CEO. Mingsheng Peng articulated a vision for a "smart earth: the next generation of leadership agenda" and outlined some strategic research for a Smarter Planet, including the smart medical, the smart grid, the smart traffic and smart education (Palmisano, 2008).

Smart education can be seen as an important concept within the context of "smart earth". More recently, Prof. Zhiting Zhu (2016) outlined a comprehensive exposition of smart education. For Zhu, "The essence of smart education is to build the integration of learning environment through a technology, so that teachers can display efficient instructional methods, so that learners can get a suitable personalized learning services and a good development experience, so that everything is possible

Fig. 2.1 Apple TV

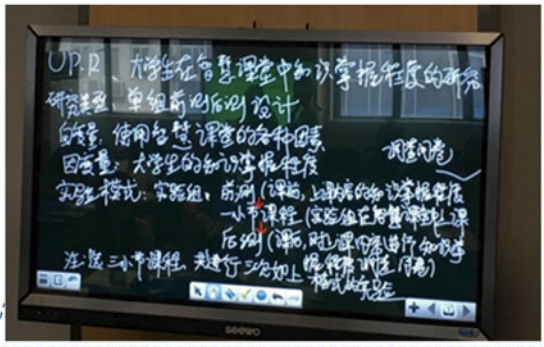
and powerful, so as to cultivate a good value orientation, strong action ability, better thinking quality, and deeper creative potential talents."

2.3 The Basic Equipment and Resources in the Smart Classroom

With the ongoing development of information technology, there will be more and more equipment and resources that can be applied to the smart classroom. Uskov et al. (2016) described software systems in the smart classroom including smart classroom in-class activities recording systems, smart cameraman software systems and systems for seamless collaborative learning (of both local and remote students), and sharing learning content/documents. Klimova and Simonova, (2015) discussed what study materials students prefer in smart learning environments, and showed that a rather large number of respondents welcomed having their study materials in electronic form. Smart devices, particularly smartphones, tablets, pads, etc., are generally understood as those connected to other devices or to networks via various wireless protocols (such as Bluetooth, Wi-Fi, 3G, etc.) and operating interactively, demonstrating a principle of ubiquitous computing (Li, Kong & Chen 2015a, b). Smart devices have been widely exploited for private purposes by learners of all age groups, and are naturally used for learning (Simonova, 2016).

There are some experimental schools with which our team cooperated in carrying out smart education, such as Primary School Affiliated to Central China Normal University, Primary School Primary Affiliated to Huazhong University of Science and Technology, Wuhan Economical & Technological Development Zone Experimental Primary School and Central China Normal University (Figs. 2.1, 2.2, 2.3 and 2.4).

Fig. 2.2 Dual interactive whiteboard



Content translation:
Research on the Knowledge mastery of college students in smart classroom
Study type: single group, pre and post test design
Independent variables: various factors in smart classroom
Dependent variable: knowledge mastery of college students
Research:
Pretest (conduct a pretest regarding knowledge level of learning content; one unit of the course, the target group studying in the smart class
Posttest (conduct a posttest regarding knowledge level of learning content)
Note: choose three units of courses and conduct more than three rounds.

Fig. 2.3 Touchable screen

2.4 Functions of the Smart Classroom and Its Promotion of Learning

Through connecting hardware and software and wireless networks, intelligent linking can be achieved in the smart classroom (Figs. 2.5 and 2.6), which can be a catalyst for subverting traditional classroom teaching habits, and to maximize the use of limited classroom time.

Experts have conducted research on the function of the smart classroom and the promotion to learning, with various points of focus.

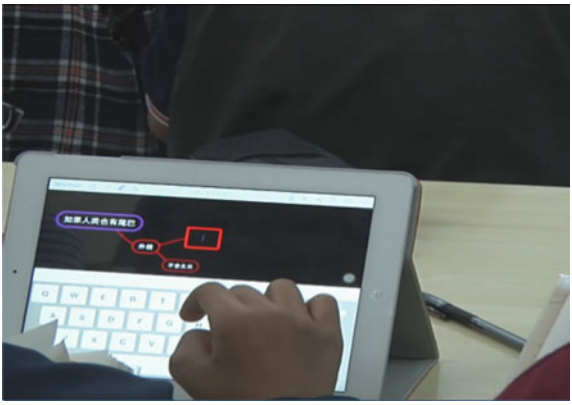


Fig. 2.4 iPad

Fig. 2.5 Panorama of the whole classroom at Central China Normal University

Fig. 2.6 Panorama of the whole classroom in K12 education

(1) *Integration of a diversity of technologies and devices*. Li, Kong and Chen (2015a, b) developed a smart classroom by integrating all kinds of interactive technologies, data analysis techniques, and context-aware technologies and devices to support the digital intelligence teaching and learning activities. Avdeeva, Omarova, and Taratuhina (2015) attempted to describe a possibility of an individual approach to learning within a multicultural electronic educational space and proposed a design of a prototype of a "smart educational environment" whose interface and content could be adjusted to a student's cultural-cognitive profile. Bitonto, Pesare, Rossano, and Roselli (2015) presented some solutions of smart learning environment in e-health domain that combines pedagogical approaches of social learning and game-based learning with technological approaches of the social network, combining recommender systems in order to provide engaging learning experiences.
(2) *Facilitated teaching.* The smart classroom has the ability to store, collect, compute, and analyze the massive data of learners to do the optimized pedagogical decisions (Li et al., 2015a, b).
(3) *Enhancing students' meaningful learning in practicing 21st Century Skills*. Students can practice 21st Century Skills regarding communication, information and ICT literacy supported by the intelligent environment. A smart learning environment not only enables learners to access digital resources and interact with learning systems in any place and at any time, but also actively provides the necessary learning guidance, hints, supportive tools or learning suggestions in the right place, right time, and right form (Hwang, 2014).

2.5 The Comparison of Smart Classroom to Traditional Classroom

With the rapid development of information and communication technology in recent years, traditional instruction has already been impacted and changed.

(1) *Transforming the teaching methodologies and learning strategies.* In Smart learning environments, there are some new learning methods, such as cyber synchronous learning, mobile learning, social learning, and ubiquitous learning (Kinshuk, Chen, Cheng, & Chew, 2016). Dabbagh and Kitsantas (2012) proposed that there is an increasing realization that learning can and does happen in any environment, interaction and conversation that the learners engage in.
(2) *Ubiquitous access to ICT improves the convenience and efficiency of learning and teaching.* Compared with traditional learning environments, smart learning environments facilitate just-in-time learning as they can provide various levels of adaptation and precision of diversified learning conditions (including curriculum, course content, strategy, support, etc.) for the learners (Kinshuk et al., 2016). Thus, "advanced data mining techniques can identify relevant patterns, such as where and when learners have difficulties and where their strengths lie"

(Kumar et al., 2014). So, the smart environment facilitates the implementation of teaching with teaching approaches changing to fit the needs of the learners and making it possible for the teachers to monitor an individual learner's learning process.

2.6 Theoretical Foundations

The primary exponents of the theory of constructivism are Piaget and Vygotsky (He, 2006), and after the nineties of the twentieth century reached support for these theories reached its peak worldwide. Swiss psychologist Piaget argued that the cognitive development of children is shaped by both internal factors and external factors formed by joint action, and proposed the concept of cognitive structure, that every child has their own cognitive structure. Children interact or interact with the external environment to expand or change their cognitive structure. Cognitive and social learning constructivist theories give strong support to the design of pedagogical and social activities, respectively (Wang, 2008). Cognitive constructivists acknowledge individual differences and believe individual learners can construct different knowledge even given the same condition.

2.7 Teaching Model in the Smart Classroom

Smart classroom often described as the technology-rich classroom, equipped with wireless communication, personal digital devices, sensors, as well as virtual learning platforms. (Hwang, Chu, Shih, Huang, & Tsai, 2010) The digital facilities enable smart classrooms to be an open learning environment and they provide opportunities for learners to learn in authentic learning context; explore in virtual learning environment as well as provide multichannel for learners to communicate, interact and cooperate (Yau et al., 2003). The environment of the smart classroom can stimulate learners' learning motivation and provide opportunities for learners to engage in individualized and social learning activities. Such an environment can also make visible individual and social learning activities demonstrating their own performance of tasks, routines, or objectives as well as those of the teacher.

Professor Zhang, Bai, and Li (2016) in Central China Normal University has finished some research based on the theory "APT model". As an informative teaching model, APT focuses on the integration of assessment, pedagogy and technology, which will transform the students' learning style into the independent cooperative and exploratory ones. It can also help to build effective classroom teaching activities, to improve students' learning, and to promote teachers' professional development.

This model advocates a scientific and diversified evaluation system. It not only attaches importance to summative evaluation but also pays more attention to process evaluation. Unifying the evaluation before class, in the class and after class, com-

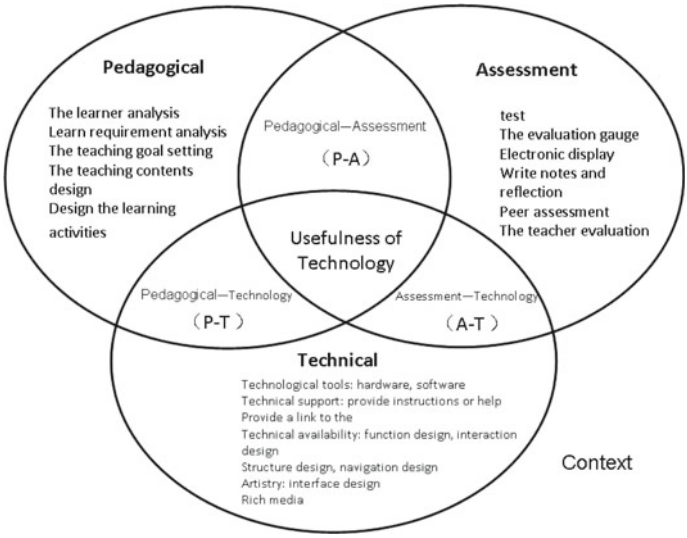


Fig. 2.7 APT teaching model for smart classroom

prehensive use of tests, gauges, teacher observation, learning contracts, real-time evaluation, e-portfolios, peer assessment, and other evaluation methods are all used together. Making full use of a variety of hardware and software tools, such as electronic whiteboards, electronic double boards, iPads, and other hardware, together with discussion forums, concept maps, office tools, email, QQ, and a variety of apps is very important to each teacher. Through the scientific and rational integration of evaluation methods, teaching methods and technical tools, we can transform students' learning as autonomous, cooperative, inquiry and ubiquitous learning methods, and create efficient classroom teaching and cultivate students' knowledge acquisition, sharing, construction and innovation ability, enhancing students' cooperation and innovation ability, active learning ability, information technology ability (Fig. 2.7).

2.8 Teaching activities in the smart classroom

Using a cloud classroom platform as an example, this chapter now describes the case of an elementary school mathematics classroom teaching based on the smart classroom environment of application and implementation and advantage.

Research was carried out to the conclusion that in the smart classroom environment in elementary school mathematics. A key advantage is the smart classroom can assist teachers in aligning characteristics of the students to an innovative design of teaching model, creating a real scene that stimulates student involvement and ability of thinking independently.

Another study focused on an English lesson. Conducted in a networked environment using tablets or electronic books in Hong Kong primary school grade 3 application in the English classroom. The study was concerned with the analysis of student perceptions and identified student learning methods and provided a comprehensive evaluation of electronic textbooks initiated by the Hong Kong education bureau support experiment plan. The English lessons have development of resources and design of teaching materials for different learning phases. In order to ensure that electronic books can be used more effectively in the classroom teaching environment, a primary school is responsible for the implementation of the plan.

Professor Yi Zhang has conducted research both in higher education and K12 education (Zhang, Chen and Li, 2016). There are some experimental schools with which her team cooperates are carrying out smart education and are implementing the smart classroom teaching model. These include the Primary School Affiliated to Huazhong University of Science and Technology, Primary School Affiliated to Central China Normal University, Wuhan Economic and Technological Development Zone Experimental Primary School, and Central China Normal University. In Prof. Yi Zhang's research, several activities were conducted based on the varied APT model at the primary school attached to Huazhong University of Science and Technology. One class was based on mobile learning, using the teaching model based on APT teaching model, while another class was the traditional classroom. For two parallel classes, a total of 100 people participated. From the first grade, the two classes taught by the same teacher began learning mathematics. Through the analysis at the end of the second grade, it was found that there was no significant difference between the two classes. Two classes were randomly assigned to the experimental group and control group based on the teaching environment of the APT teaching model. The students study resulted in significant differences with the traditional multimedia classroom teaching model, showing students' learning interest slightly higher than that of the traditional multimedia classroom, students' experimental cognitive load is higher than the control group, and the appropriate cognitive load was beneficial to the improvement of the students' grades.

In the fifth grade English teaching, the research shows that the electronic teaching materials based on APT model can facilitate the application and implementation of smart classroom instruction, providing a variety of supports for smart classroom learning (Fig. 2.8).

Another case is about the math lesson in the Primary School affiliated to Huazhong University of Science and Technology. The team constructed the mobile learning teaching model based on the APT teaching model, taking the fan-shaped statistical graph of primary school mathematics as an example (Fig. 2.9).

In that research, the following questions were the focus: *How to fully integrate evaluation, teaching, technology, and effective teaching, in the context of information technology environment? Is mobile learning based on APT teaching model superior to traditional classroom teaching?* The findings showed that classrooms based on the APT teaching model of iPad teaching environment, students' learning achievement demonstrated a significant difference to the traditional multimedia classroom. Based on the APT teaching model in the mobile environment, students' academic

Fig. 2.8 Teaching process of the English lesson

Fig. 2.9 Teaching process of the math lesson

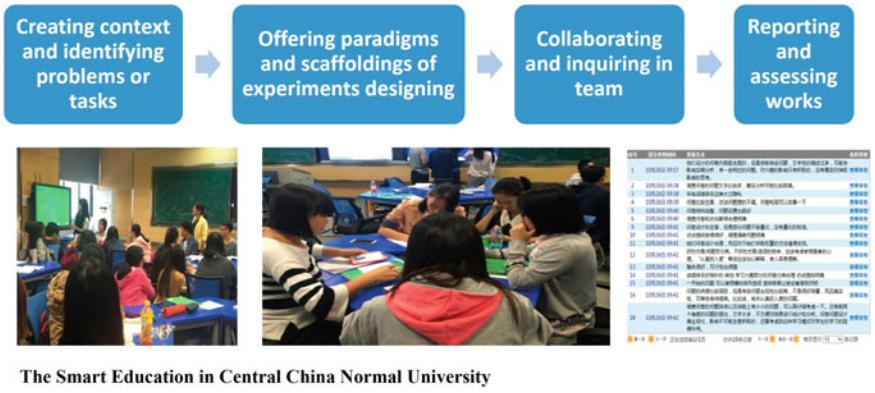


Fig. 2.10 Process of blended learning

achievement is superior to the traditional multimedia environment. APT teaching environment based on the iPad teaching model, students learning interest is slightly higher than the traditional multimedia class. Based on the APT teaching model, the cognitive load of students in mobile environment is higher than that of traditional multimedia environment, but in a certain range, the higher cognitive load is conducive to the improvement of students' academic performance. The progress of the teaching is as follows.

In addition, Prof. Yi Zhang's team applied the APT model in higher education. For example, a case study examined the effect of a scoring rubric on undergraduate students' inquiry skills in a technology-enhanced classroom. Technology included touchable screens for students' collaborative learning, a recording and broadcasting system, wireless network, a dual interactive whiteboard, as well as flexible desks and chairs. The pedagogy in this study included blended learning, problem-based learning, project-based learning, and inquiry-based learning. The formative assessment included teacher, self, and peer assessment (Fig. 2.10).

In this study, two teaching activities were conducted based on the APT model, one with first-year undergraduate students enrolled in Educational Technology Research Methods at Central China Normal University. A class used a scoring rubric, and the other didn't use it before class. For two parallel classes in the present study, a total of 83 people, two classes were taught by the same teacher. The study period is a whole semester. The course is a core component in a degree in Educational Technology. The main objective of the course was to familiarize students with the application of scientific procedures in Educational Technology and cultivate their inquiry skills. In addition, the science course designed in the Primary School affiliated to Central China Normal University, the teacher is better integrated the scientific inquiry into the Electronic schoolbag for science teaching and learning (Fig. 2.11).

Another teacher offered students the scientific background and assigned scientific tasks to the students for them to conduct experiments collaboratively, and then use tablets for searching information on the internet to obtain supportive evidence for the

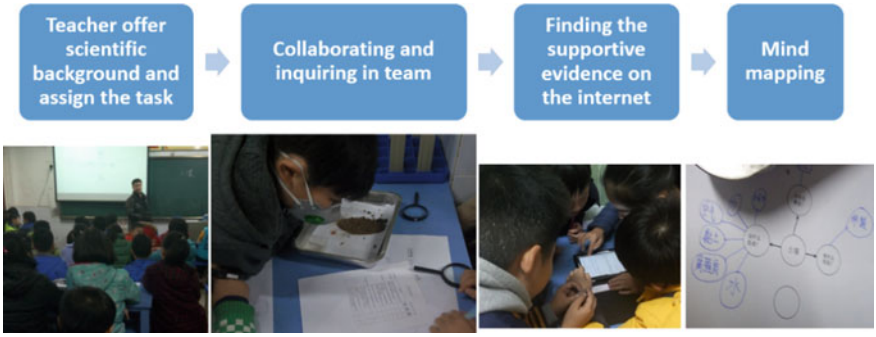


Fig. 2.11 The smart Education in Primary School Affiliated to Central China Normal University

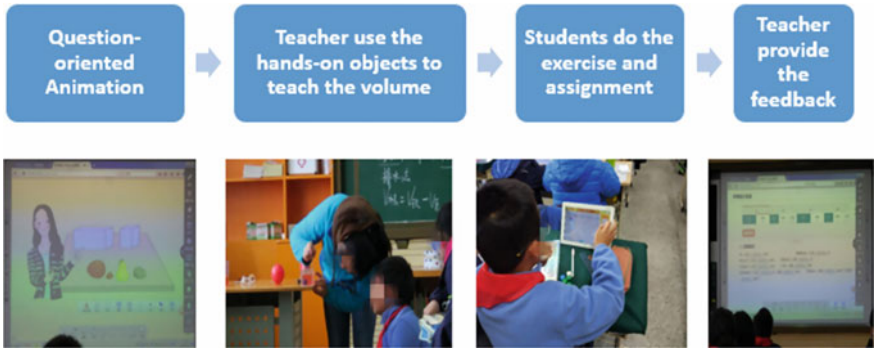


Fig. 2.12 The smart Education in Wuhan Economic & Technological Development Zone Experimental Primary School

results of their experiment. Eventually, they drew mind maps which the teacher then shared with the whole class using the function of a smart classroom, named screen broadcasting to share the mind map.

In addition, a fifth grade math class was asked "To find the volume of irregular objects" in Wuhan Economic and Technological Development Zone Experimental Primary School as an example, where the brand Youxuepai Electronic schoolbag for information technology teaching is used (Fig. 2.12).

At the beginning of the course, the teacher sent daily practice questions to the students' pad through Youxuepai teacher side. Students answered and submitted solutions in their Youxuepai, and the teacher explains the answer according to the feedback from the system. Then, in the lead-in, the Electronic whiteboard shows the flash from the resource library, which demonstrates "how to measure irregular objects, such as potatoes, rubber mud and other deformable objects", stimulating student interest and discussions. The focus of this lesson was how to measure the volume of undeformable objects, such as a glass crystal ball. According to the answers proposed by the students, the teacher made an experiment to demonstrate the use

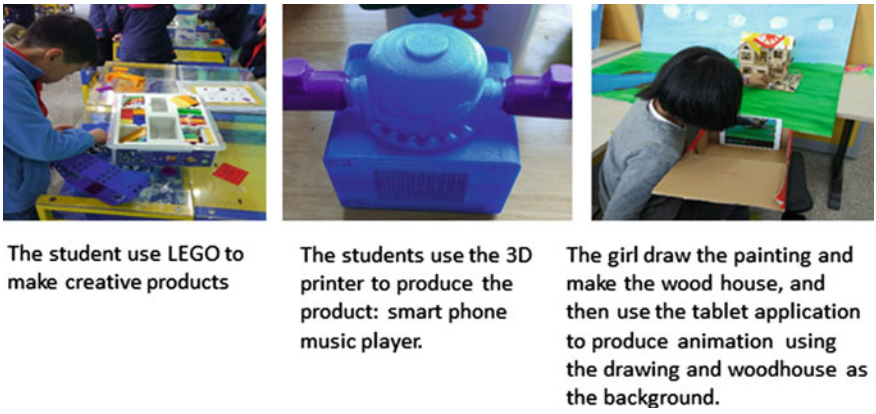


Fig. 2.13 The smart Education in Wuhan Economic & Technological Development Zone Experimental Primary School

of drainage method to measure the volume of the crystal ball. After the summary, the teacher used the exercises function of Youxuepai again, in order to test whether students master the knowledge and learned how to use it or not.

The above summary outlines the case of the use of the APT model in the smart classroom in Wuhan Economic and Technological Development Zone Experimental Primary School. The creative ability of the students was fully developed while the robot education vigorously introduced. STEAM education involving 3D printing courses was also used for students to develop a wide range of capacities, enriching the meaning of the smart classroom (Fig. 2.13).

2.9 Conclusion

We have introduced some of the concepts of the smart classroom, which include perspectives from China and abroad. We traced the origins of the smart classroom, described the basic equipment and resources in the smart classroom, and summarized three main functions of the smart classroom.

We then considered in more detail of one teaching model of the smart classroom. The informative teaching model, APT, developed by Prof. Yi Zhang, focuses on the integration of assessment, pedagogy, and technology. The model is emphasized from varying degrees that a scientific and diversified evaluation system is important. In the section, we also conclude the theoretical basis which the teaching activities are relying on. Then we specifically introduce the teaching activities based on the APT model.

Some researchers focus on the Framework in the Smart Learning Environment (Serral & Snoeck, 2016). Because challenging, personalized and automated feed-

back is essential to improve students' learning, Serral and Snoeck plan to study which combinations of feedback content and presentation are recommended in the literature for each specific learning context to increase the use and the impact of feedback. Through the second part of the model and case summary and the above researchers of the future planning, the model of smart classroom will continues to attach importance to the evaluation and feedback of the study and proposes a generic framework combined with the theory of constructivism and other theories to include cooperative learning, problem-based learning with the aim to provide hands-on experience and practice online (Staubitz et al., 2016).

From another perspective, Belskaya et al. (2016) believe that the application of smart technologies in university guidance counseling allows creating a flexible system of student-centered learning. Kaewkamnerdpong (2016) points that Portable EEG devices may become another crucial technology for smart education; portable EEG devices with classification model can not only serve as a tool for indicating the performance of learning/teaching methods but also can be used to develop smart educational materials for better educational outcomes. Elias described mobile-assisted learning result in principles toward building flexibility of instructional design of learning content and operating system (Simonova, 2016). There is also some research that focuses on one fragment of the economic issue, on mapping the costs on the purchase of SMART. Svobodova and Cerna anticipate that the trend will be that there will be an enormous increase in the creation of new teaching materials and that even more new companies dealing with digital media products will enter the business so that, consequently, this kind of products might become less costly technology equipment per one class (Svobodova & Cerna, 2016).

To sum up, new developments in information technology are enabling students to learn at any time in a smart classroom while actively sharing data and engaging in long-distance learning. However, more research is needed on the benefits of tangibles for learning in smart classrooms.

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