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The Components and Functions of Smart Learning Environments for Easy, Engaged and Effective Learning

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The construction of learning environment is the foundation for the reform of the ways of teaching and learning. Based on the demands of new generation of students for the reform of learning environment and the analyzing of challenges for both the online learning environments and classroom former environments, we proposes the concept of "smart" learning environment which is the high level of digital learning environment with the aim at facilitating "easy, engaged and effective" learning for learners. We analyze the differences of smart learning environment and digital learning environment from learning resources, learning tools, learning communities, teaching communities, ways of learning and ways of teaching and then we put forwards a system model and TRACE3 functional model of "smart" learning environment.

Keywords: progress, challenge, E-learning, China

The Demands on Rebuilding Learning Environments in Information Society

We live in an information society where the creation, distribution, use, integration and manipulation of information is a significant economic, political, and cultural activity. Every sector of the society has been influenced by information technology so deeply that a digital world has expanded quickly. The digital world is a combination of the real world and virtual world, thus, people's life style and ways of working have changed as well as the ways of learning.

The new way of learning not only focuses on the physical world, but also on the virtual world and the blended ways by fusing the two together. Informal learning through observation and participation in the family and community settings is a complex educational practice seen in many indigenous communities (Pewewardy, 2002). Not only can students learn in a physical learning environment, but also they can learn in a virtual learning environment.

The terms like net generation, digital natives, millennials, and generation Y refer to the students who have grown up with digital technology surrounding them. Authors such as Howe and Strauss (2000) , Palfrey and Gasser (2008) , Tapscott (2009) , Prensky (2010) and others have argued that today's generation of young people behave differently than previous generations mainly because they have been immersed in a world infused with networked and digital technologies. Group activity, goal and achievement orientation, multitasking, trial and error, a heavy reliance on network access, pragmatic and inductive, ethnically diverse, visual, and interactive are the 10 characters of the new generation students defined by Brown (2005). The new generation of students put new demands on the learning environments. They want have access to the mobile internet so as to acquire all kinds of information and personalized learning resources. They would like to learn anytime, anyplace as they need to learn by using handheld devices. They hope that the learning environment is comfortable enough for them to enjoy learning just like when they watch movies in the cinema and listen to music as they travel about. They enjoy sharing their opinions, and having communications and discussions via social network. They hope to keep track of issues that concern their personal interests via a variety of flexible and convenient ways.

The "21st century skills" are the requirements for the new generation of students in the information society. The framework for 21st century skills consists of living and vocational skills, learning and innovation skills, information media and technology skills. And the establishment of supporting systems for the development of 21st century skills requires standard and evaluation systems, curriculum and instructional systems, individual professional development and learning environment (Trilling and Fadel, 2009). Now, the learning with deliver-receive model in a traditional classroom or even in a technology-rich one focuses on the lower order of cognitive skills. While the higher order of cognitive skills in the "21st century skills", are generally not supported in the current environment of both physical and virtual separately. So how do we make the learning environment more suitable for solving these challenges is an emergency task.

Predicaments of current learning environments in formal educational settings

The international communities have engaged in the development of learning environment by integrating ICT in education for many years. The United States has implemented the "National Educational Technology Plan" four times, from which we can clearly see the development path of ICT in education in the United States (1) Plan 1996 focuses on construction of infrastructure, (2) Plan 2000 focuses construction of learning resources, (3) Plan 2005 focuses capability construction of the application of information technology, (4) Plan 2010 focuses promotion of educational reform. The educational informatization in China can be also be divided into four stages, which are the instruction of computer science started in the late 1970s and early 1980s, the computer-aided instruction and management started in the middle and late 1980s, the infrastructure-centered construction of educational informatization started in the late 1990s and the construction of educational informatization with the focus on application capability started in 2005(Huang, 2011). In fact if we look the educational informatization all over the world, lots of developing and developed countries have the four stages. However, though much efforts have been put into educational informatization, the learning environments are not geared to the new

generation of students. Learning environment is a broad concept, and different researchers focus on different areas of learning environment. Generally, the online learning environment, the physical learning environment and the blended learning environment which integrated the above two together are the three areas of learning environment research.

For online learning environment, Learning Management Systems (LMSs) and Virtual Learning Environments (VLEs) are the key concepts. LMSs have the following functions: user registration and management, courseware directory management, learners' information data recording and reporting to the administrator. Virtual Learning Environment (VLE) refers to a software system used to support learning and teaching in the field of education covering a variety of categories such as teaching support platforms, learning content management systems and discussion forums, etc(Huang, Chen, Yang, & Loewen, 2013). The former president of Open University in UK, Prof. John Daniel (2001) performed an analysis on the effects of e-learning and the online learning environments. Firstly, in the past few years, the Internet has changed the definition of distance education. Before 1997, distance education generally referred to using broadband to implement synchronous teaching for distant learners in different places, with an emphasis on recreating the classroom environment (for example simulating face-to face-inter- action). However, the situation has changed today; distance education refers to asynchronous teaching on the Internet. Secondly, the mode of asynchronous teaching on the Internet borrows from some traditional distance education concepts. In the simplest form, students study the contents of the course presented as html on the network and then take online tests after each session. Third, this simple and ineffective mode of e-learning has been rejected by students. Currently, the development trend is to combine online instruction with a large number of other activities using a web based course to facilitate learning. However, this is not the only means of learning. Fourth, the experience of using a network in teaching at Open University shows that the best application of network technology in teaching is to facilitate interaction among people rather than delivering all contents of the course to the students' computer. Fifth, the value of the interactivity of the Internet and the facilitation of learning by 8,000 tutors is very valuable. Though this five problematic issues on e-learning have been proposed by John Daniel more than ten years ago, we must realize and rethink these typical problems existed worldwide in todays' e-learning situation. Therefore, the simplest learning mode of e-learning described earlier is invalid due to the misunderstanding of functions of online learning environments, and the best application of network technology is to achieve interaction among people.

Physical learning environments mainly refer to the learning environment in a school or college, such as classroom, learning commons, multimedia sandbox, residential study areas, huddle rooms, and the classroom is the most important formal learning environment. Part of the problem that now exists in education may be the classroom environment in which students are taught: certain kinds of spaces make it too easy to teach by "delivery" , broadcasting knowledge from the instructor's mouth toward the student's brain, which makes it awkward to teach in ways that, research suggests, can produce deeper, more lasting learning(Long & Ehrmann, 2005). In the late 1990s, the construction of infrastructure of utilizing ICT in education took place in China, and after 20 years of construction, a lot of classrooms have been equipped with computers. However, ICTs do not fully integrate into teaching and learning in the classrooms and the current instructional model had not changed and effective learning had not taken place

(Huang, 2011). The digital learning environment only supports the low-order cognitive objectives, such as knowledge, comprehension and application, while not supporting higher-order cognitive objectives, such as analysis, synthesis, and evaluation. The main challenges of effective learning in the current multimedia classrooms are as follows.

First, in a multimedia classroom, instructors present their teaching content with serialized presentations, which hinders students' understanding of the learning content. Current multimedia presentation tools (such as Microsoft's PPT or Apple's Keynote) present material sequentially page by page, potentially leading to incoherent thinking for students. Teachers always use PowerPoint or Keynote to show the learning content to students. But in the PowerPoint the linkage between each page and the main topic may be overlooked by the students, which is the reason why the students may become lost in many instances. In many classrooms, projector screens have replaced blackboards as a medium for displaying educational content. In teaching activities supported by projectors, the content projected on the screen is the same as the content projected on blackboards, so the advantages of multimedia technology are not being fully realized.

Second, multimedia consoles are always fixed in the front of the classroom, which limits the flexibility of teaching. In the multimedia teaching process, teachers often sit at the console to operate the courseware and rarely move or interact with students (Yang, 2009). Teachers use too much energy in operating computers in class because of their unskilled information literacy, thereby reduce communication between teachers and students, which hinders the interaction between teachers and students.

Third, a unified and fixed seating layout is not conducive for teachers to carry out diverse teaching activities. Classrooms often use a traditional seating layout, which is appropriate for the lectures but is not suitable for student-centered learning activities (Wu, 1998). In order to better support student-centered learning, different seating layouts, such as rectangles, circles and horseshoes shape, could provide the flexibility to meet the needs of different student-centered learning activities (JISC, 2006).

Fourth, computer-networked classroom’s equipment does not meet the needs of the students' inquiry learning. At present, the functional advantage of a computer-networked classroom in practice are not being fully utilized (Li, 2006). Computer-networked classrooms have numerous computer security problems, including viruses, information loss problems, and etc. Failure to defend against viruses and unsecured networks hinders the multimedia teaching process (Lin, 2010).

Fifth, a gap exists between teaching with electronic whiteboard applications and expectations of deeply interactive teaching. Many classrooms are equipped with interactive whiteboards, but the interactive features are often not utilized, and many classrooms use them only as projection screens. Some teachers lack the skills to conduct team-based collaborative learning activities in an interactive whiteboard classroom, partly because they do not know how to fully utilize the interactive whiteboard, thereby team-based reading and discussion does not have a positive effect on students’ comprehension to problems. (Liu, 2010)
To some extent, the plight of the multimedia classroom closely relates to the design and

technical equipment of the classroom environment. The reconstruction and creation of a new learning environment for learning and teaching is an inevitable trend. “The 10 year plan of ICT in education in China (2010-2020)” has been issued in 2010 to advocate the infusing of ICT in education, in which Smart Learning Environments (SLE) is an effective way to realize the infusion of ICT in education.

Making Learning Environments Smart to Optimize Digital Learning Environments

Different scholars put forward their understandings of SLE from different perspectives. Smart environments could be naturally considered to be a new degree of technology enhanced learning environment, with a considerable number of new facilities (Mikulecký, 2012). Zhong Guoxiang et al. (2006) propose SLE is a learner-centered intelligent, open, integrated digital virtual reality learning space based on constructivist learning theory, blended learning theory and modern teaching theory, consisting of corresponding equipment, tools, technology, media, textbooks, teachers, and students, etc. which not only supports the self-construction of learners’ learning, but also provides timely guidance to learning. Malaysian scholar Ms. Kang Wai Chin (1997) points out in her presentation that "SLE is a learner-centered environment based on the application of information and communication technology, with the following characteristics: (1) Adapt to different learning styles and learning abilities of learners; (2) Provide support to lifelong learning; (3) Provide support to the development of learners."

Learning space is a newly emerging area which seeks not only the construction of formal learning environment and informal learning environment in a school or college, but also the virtual learning environments in a school or college. While infusion of these two kinds of environments in a school or college is mandatory in the information society for the new generation of students. Based on the above points of view and the analysis of the development trend of "Technology Enhanced Learning", SLE should have the following characteristics:
1) SLE should realize the integration of physical environment and virtual environment. In the smart environment, the perceptive, monitoring and regulating functions of physical environment are further enhanced. The application of the technology of augmented reality makes the seamless integration of virtual environment and physical environment realized.
2) SLE should provide better learning support and services according to the individual characteristics of the learners. SLE emphasizes the teaching and learning process recording, personalized assessment, evaluation of learning outcomes, and content delivery of learners’ learning. According to the learner model, SLE plays the role of planning, monitoring and evaluating the development of their independent learning capabilities.
3) SLE supports both campus learning and off-campus learning, and both formal learning and informal learning. The learners in this situation refer to not only the campus learners but also adult learners that need to update their knowledge or skills when needed for employment or a better life.

Therefore, **we propose SLE as the learning place or an activity space that can sense learning scenarios, identify the characteristics of learners, provide appropriate learning resources and convenient interactive tools, automatically record the learning process and**

evaluate learning outcomes in order to promote the effective learning. SLE is the high level of common digital learning environment, which is the inevitable result of the development of educational technology. There are significant differences in learning resources, learning tools, learning communities, teaching community, learning methods and teaching methods between SLE and common digitalized learning environment, as shown in Table 1.

Table 1. *The Comparison of Common Digital Learning Environment and Smart Learning Environment*

	Common Digital Learning Environment	Smart Learning Environment
Learning Resources	1) Digital resources based on rich media; 2) Online access becomes the mainstream; 3) Users select resources.	1) Digital resources independent of the devices; 2) Seamless connection or automatic synchronization becomes fashionable; 3) Deliver on-demand resources.
Learning Tools	1) All-function in one tools, systematized tools; 2) Learners judge the technology environment; 3) Learners judge the learning scenarios.	1) Specialized tools and miniaturized tools; 2) Automatically sensing technology environment; 3) Learning scenarios are automatically recognized.
Learning Community	1) Virtual community focusing on online communication; 2) Self-selected community; 3) Restricted to information skills.	1) Combine with the mobile interconnected real community to communicate anytime and anywhere; 2) Automatically matched communities; 3) Depend on media literacy.
Teaching Community	1) Difficult to form a community, which is highly dependent on experience; 2) Make the regional community possible.	1) Automatically form community, which highly concerns about the users' experience; 2) Make the cross-regional community fashionable.
Learning Methods	1) Focus on individual knowledge construction; 2) Focus on low-level cognitive objectives; 3) Unify evaluation requirements; 4) Interest becomes the key to the diversity of learning methods.	1) Highlight the knowledge construction of community collaboration; 2) Focus on high-level cognitive objectives; 3) Multiple evaluation requirements; 4) Thinking becomes the key to the diversity of learning methods.
Teaching Methods	1) Emphasize resource design and explanation; 2) Summative evaluation of the learning outcomes based on the learners' behaviors; 3) Observation of learning behaviors.	1) Emphasize activity design and guidance; 2) Adaptive evaluation of learning outcomes based on the cognitive characteristics of learners; 3) Intervention in learning activities.

The TRACE^3 Functional Model of Smart Learning Environment

Hannafin, Land, and Oliver (1999) pointed out that open-ended learning environments (OLEs) typically include four components: enabling contexts, resources, tools, and scaffolds. Jonassesn (1999) described that the essential components in the constructivist learning environments include: problem, question or project as the focus of the environment, related cases, information resources, cognitive tools, conversation and collaboration tools, and social/contextual support. Zhixian Zhong (2005) pointed out that learning activity, learning context, learning resources, learning tools, learning community, scaffolds, evaluation, teachers, and learners are the key elements of learning environments. Ronghuai Huang (2010) argues that in order to make sure the occurrence of technology enhanced learning (TEL) we should consider the following five aspects: digital learning resources, virtual learning communities, learning management system, designer's psychology and learner's psychology. So we believe SLE should include six components which are resources, tools, learning communities, teaching community, learning ways and teaching ways, as shown in Figure 1. Learners and teachers (designers) interact with SLE by the learning ways and teaching ways.

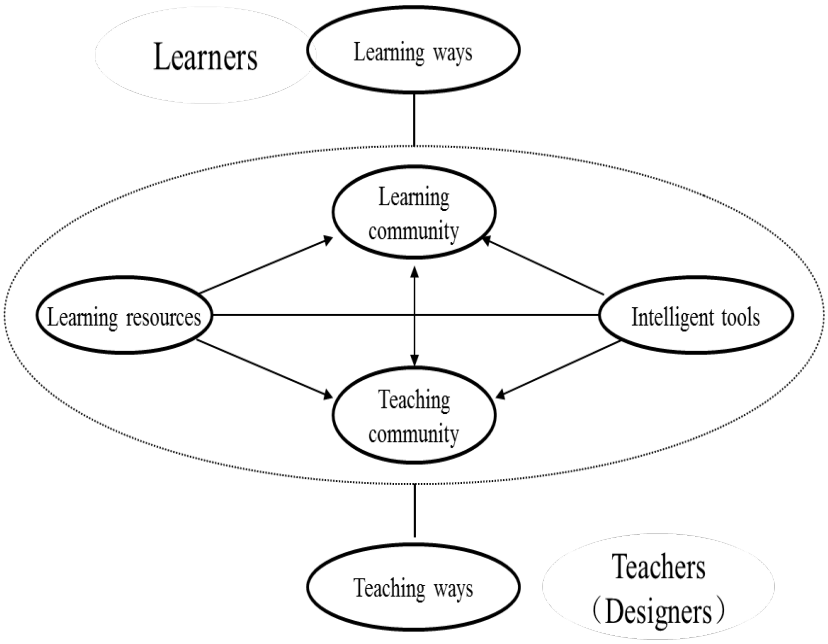

Figure 1. *The Components of Smart Learning Environment*

1) Learning resources, intelligent tools, learning community, teaching community, learning ways and teaching ways are the six elements of SLE.
2) Learners and teachers interact with the four elements of learning resources, intelligent tools, learning community, and teaching community, which interact with the other two elements of learning ways and teaching ways at the same time. Apart from the learning ways and teaching ways, SLE cannot be a learning environment.
3) The occurrence of effective learning is the mutual result of individual construction and group construction. Learning community emphasizes the interaction, collaboration and exchange of

learners, while teaching community is a continuum by where teachers learn together, work collaboratively to pursue continuing professional development.
4) Learning resources and intelligent tools provide support to both the learning community and teaching community. The development of the learning community and teaching community is inseparable from the resources and tools. All kinds of intelligent tools provide comprehensive support to the "intelligence" of the learning environment. At the same time, learning community and teaching community advance the evolution of digital resources and tools.

The technical features of smart learning environment are mainly reflected in the four aspects of tracking, recognizing, connecting and awareness, which aim to promote easy, engaged and effective learning of learners.
1) Tracking learning process. SLE can track the status of learners in the aspects of knowledge acquisition, classroom interaction, group collaboration, etc. By using motion capturing, emotion computing and eye movement tracking, we can track the learning process, analyze learning outcomes and establish the learner model, which will give an important basis for providing a more comprehensive and accurate assessment of the learning effects.
2) Recognizing learning scenario. SLE can provide personalized resources and tools for learners according to the learner model and learning scenarios to facilitate the occurrence of effective learning. It can recognize learning scenarios, including learning time, learning place, learning peers and learning activities. The recognition of learning scenarios provides support to teaching activities.
3) Awareness of the physical environment. SLE can monitor air, temperature, light, sound, smell and other physical environmental factors with sensor technology to provide learners with a comfortable physical environment.
4) Connecting learning community. SLE can set up a learning community for specific learning scenario and provide support to the learners for effective connecting and using learning community for interacting and exchanging information.
5) Easy, engaged & effective learning. The objective of SLE is to promote easy learning, engaged learning and effective learning by creating a tracking process, recognizing scenarios, awareness of the physical environment and connecting community.

The technical features of a SLE, which are tracking, recognizing, awareness, connecting and the easy learning, engaged learning and effective learning, are also a functional requirements of SLE. It is referred to "TRACE3" functional model of SLE, as shown in Figure 2.

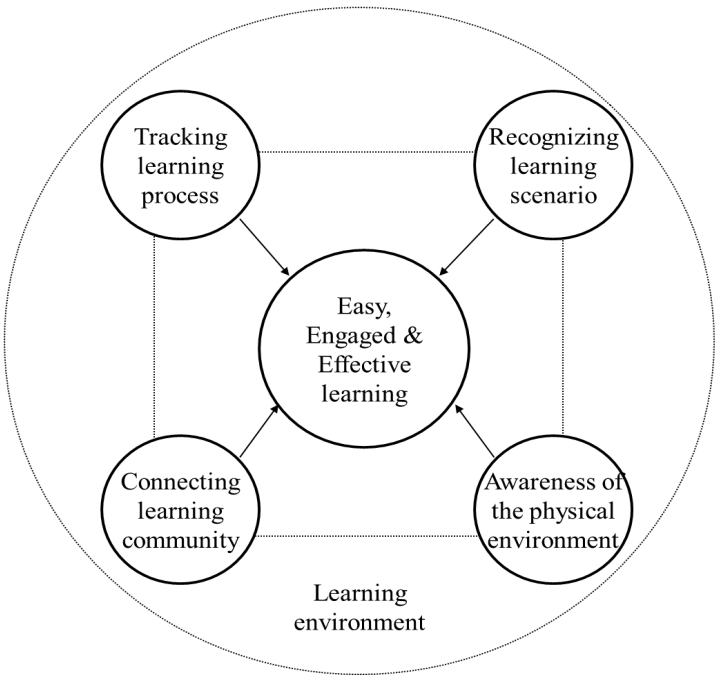

Figure 2. *TRACE[3] Functional Model of Smart Learning Environments*

Conclusion and Future Perspective

The SLEs not only consists of intelligent tools, learning resources, learning community and teaching community, but also the learning ways and teaching ways, which make the learning environments "smart" according to the different needs of learning. The TRACE3 model proposed in the paper is just a tentative effort to describe the functions of SLEs, while more research should be done on the issues related to the reform of the ways of teaching and learning through advancing current learning environments towards SLEs. Research such as the limitations of existing learning environments, need for reform, innovative uses of emerging pedagogical approaches and technologies, and sharing and promotion of best practices, leading to the evolution, design and implementation of SLEs is research issues in SLEs. We call for actions in the following areas for promoting SLEs research and practice.

(1) SLE is a comprehensive research area, which calls for efforts from different areas such as education, computer science, psychology and engineering. The communication and collaboration in these areas are the basis for the development of SLEs.

(2) The objectives of developing SLE are to support learning and teaching, to serve the new generation students' easy and engaged learning. New emerging technologies, such as intelligent system, the Internet of things, cloud computing, should be integrated into the SLEs.

(3) Personalized learning is the basic rule for design SLE, and high user experience is the first principle in developing SLEs. The research on how to improve the user experience in SLE is highly focused.

(4) The role of teachers in SLE must change from that of an instructor to that of a facilitator, and the community of teachers is leading elements of SLEs, which should support the

faculty development. Technological Pedagogical Content Knowledge (TPACK) has emerged as a useful frame for describing and understanding the goals for technology use in faculty development(Schmidt et al., 2009).

(5) International collaborations in different principles and among different researchers will help to share case studies and best practice in SLE, which will promote the innovation for each research party.

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