Research Review

ROE

ECNU Review of Education
2019, Vol. 2(2) 205–216

DOI: 10.1177/2096531119853084
journals.sagepub.com/home/roe

SAGE

ECNUP

The Learning Sciences in China: Historical Development and Future Trends

Jian Zhao and Xiaozhe Yang
East China Normal University

Abstract

Purpose: This study charts the developmental history of the learning sciences (LS) in China and analyzes the direction of its future development.

Design/Approach/Methods: An extensive literature review is presented to compile notable events in the development of LS in China over different periods. The findings are then systematically sorted and interpreted.

Findings: This study maps the LS developmental process across three main periods: prescientific, psychological paradigm, and initial scientific paradigm. China has achieved certain initial developments in LS and has formed collaborative bodies to conduct sustained and in-depth learning research. However, the field remains at a preliminary developmental stage in China. Overall, there is still no sound mechanism for the production of new knowledge, and contributions bearing distinctive Chinese characteristics remain insufficient.

Originality/Value: This article presents a comprehensive analysis of the development of LS in China. It proposes four main areas for future growth: forming a stable academic community, developing appropriate curriculum and teaching materials, creating an effective mechanism within the discipline for knowledge production, and establishing a local system of discourse for the discipline.

Corresponding authors:
Jian Zhao, Institute of International and Comparative Education, East China Normal University, 3663 N. Zhongshan Rd., Shanghai 200062, China; Xiaozhe Yang, Institute of Curriculum and Instruction, East China Normal University, 3663 N. Zhongshan Rd., Shanghai 200062, China.
Emails: janezj18@icloud.com; worldetyang@gmail.com

Keywords
China, discipline paradigm, learning sciences

Date received: 22 December 2018; accepted: 6 May 2019

Introduction

The learning sciences (LS) has become a popular topic for education research in China. The increasing interest in LS, however, should not be viewed as an unexpected development. As one of the oldest civilizations in existence, China has been accumulating a rich and nuanced understanding of learning over thousands of years. In the mid-1980s, Chinese researchers at the university level and educators in elementary and middle schools recognized the need to improve teaching and proposed concepts such as "learning to learn" and "the science of learning." This was followed by the establishment of the Chinese LS Research Association (the "CLSRA") at the end of the 20th century. The CLSRA was dedicated to promoting the exploration of learning principles and the improvement of pedagogical methods in schools.

The concept of "the science of learning" discussed in academia today came into being as a circumstance of academic liberalization and interdisciplinary communication beginning in the 1990s. Owing to the convergence of theoretical developments in the fields of epistemology, brain and cognitive science, cultural anthropology, and information technology, LS experienced a significant evolution in terms of academic concepts, research methodologies, and terminology. The development of LS in China cannot be detached from the history of traditional learning wisdom. The increased focus on LS is indicative of the ways in which the field of education in China has evolved in recent years, including by adapting to globalization and the information industrial revolution, periodically updating the concept of talent cultivation, actively seeking ways to share knowledge and practices with the international academic community, and striving for improvement and comprehensiveness in its pedagogical practices.

Chinese scholars who focus on LS and its applications are mainly from the academic fields of scientific or comparative education, educational technology, educational psychology, and developmental psychology. Research in cognitive neuroscience, whether conducted under the name of LS or not, has provided new insights into the development of the brain and other physiological foundations, which have helped in the understanding of students' learning in various situations. These new insights and experimental evidence of learning, contributed by multiple disciplines, have led researchers to reexamine, redefine, and redesign traditional learning principles and practices (Sawyer, 2006). Despite these achievements, certain fundamental questions remain regarding the development of the field of LS in China: Can LS (whether from a historical or current multidisciplinary perspective) now be considered a mature and publicly recognized academic discipline in China?

Have the various researchers who discuss LS formed an academic community that has reached a consensus on basic academic assumptions, disciplinary concepts, and methodologies? While striving for cooperation and collaboration with international LS organizations, have Chinese LS researchers proposed any learning problems unique to China's educational and cultural contexts and attempted to provide solutions? In other words, does Chinese LS have its own developmental characteristics?

This study seeks to present a clear path for academic evolution by reviewing the development of learning and understanding from ancient China through the present. It also outlines the growth and achievements of LS in China, current problems, and directions for future development.

Transitioning from the prescientific period to the psychological paradigm period

Although LS is an emerging science, discussions on learning have had a long history in China. There is an abundant understanding of learning contained in the country's long educational history, as well as a rich accumulation of wisdom and advice on learning that can be found in its ancient texts (Qiao, 1996). Almost all modern propositions about learning can be traced to the ancient Chinese classics: regarding learning reinforcement, the need "to learn with constant perseverance and application" was stated in Confucius' *Analects* (Zhang, 2006, p. 2); regarding learning situations, Liu wrote in *The Literary Mind and the Carving of Dragons* that "just as emotions change with the situation, words should be used according to the different sentiments" (Liu, 2017, pp. 30–31); and regarding heuristic teaching, *Xueji* (*Record on the Subject of Education*), a treatise on education, stated "Thus in his teaching, [a wise teacher] leads and does not drag, he strengthens and does not discourage; he opens the way but does not conduct to the end without the learner's own efforts" (Gao, 2016, p. 134). These valuable insights have deeply influenced the modern Chinese in terms of their perspectives on knowledge, learning, and teaching and have shaped their collective understanding of learning values, strategies, methods, and evaluations. These classical texts form the foundation of public knowledge and constitute a tacit learning knowledge system for many teachers, parents, and even researchers in China.

Although these accumulated wisdoms are wide-ranging and profound, they do not directly transfer to the modern context to constitute a contemporary scientific discipline on learning. On one hand, ancient views on learning reflect the way knowledge accumulation operated in a predominately agrarian society and do not reflect the tremendous changes in learning that occurred subsequent to the industrial revolution with the introduction of the modern school system represented by class-based teaching. On the other hand, ancient insights were made without the benefit of evidence derived from modern research on human physiology and psychology, meaning that they do not incorporate a true, scientific understanding of the internal biological mechanisms behind learning as a human activity.

The rich and incisive learning concepts found in the ancient Chinese classics were predominately derived from the generalization of daily experiences. The expressions are primarily literary in nature and are replete with metaphors and symbolism. These insights do not contain any core concepts with respect to sharing or universal ideas nor do they reflect the more recently developed methods used for the expression and development of knowledge. Instead, this ancient wisdom represents what we label as the "pre-scientific period" of LS in China.

Pedagogy and psychology, which originated in Western industrial countries, were introduced to China in the 19th century. These disciplines gradually enriched the theoretical system of learning, which included the essence of learning, conditions for learning, and the evaluation of learning. Educators and psychologists devoted great attention to learning within the context of the school education system. Modern research on learning in the Western context was carried out with psychology as a starting point and led to the introduction of multiple theoretical assumptions. These included the assumption of behaviorism that "learning is behavioral reinforcement," the Gestalt theory that "learning is the sudden understanding and transference of the overall environment," the information processing doctrine that "learning refers to the processing of information," and the belief in cognitivism that "learning involves changing the cognitive structure" (Grant & Berg, 1948). The West contributed most of the impactful and far-reaching theoretical systems on human learning in the 20th century, and Western LS research predominantly followed the psychological paradigm.

In modern China, the understanding of learning enshrined in these psychological theories was introduced from Europe and North America, together with advanced science and technology and views on education. Tao, Chen, Liao, and Panwere Chinese scholars from the early 20th century made major contributions to the development of the disciplines of education and psychology in China. They obtained their degrees from Columbia University, Brown University, and the University of Chicago in the 1910s and 1920s before returning to China to assume the role of educators. Tao emphasized the need to break away from the traditional, old-school educational system and proposed that children should be taught to think, operate, and acquire knowledge independently to engage in problem solving. In other words, "the teacher's responsibility is not to teach, but rather, to teach students how to learn" (Tao, 2017, p. 13). Chen believed that "the lives and development of all preschool children are holistic, and that the impact of the external environment on children is similarly holistic" (Chen, 2008, p. 224). He also argued that a close relationship exists between children's learning processes and the environment. On that basis, he advocated learning through gameplay and collaborative learning in small groups. Liao compiled and published China's first textbook on learning, titled *Educational Psychology*, in 1924. The book helped introduce the Western system of educational psychology to China, promoting awareness of the various learning-related schools of thought in psychology.

The country's colleges and universities underwent restructuring in the early 1950s after the founding of the People's Republic of China. The restructuring resulted in the merger of the psychology and educational disciplines in many colleges. The focus on learning continued to develop under the framework of educational psychology and teaching theories, before gradually reaching a standstill during the Cultural Revolution in the 1960s. After China's reform and opening up, psychology gradually became independent from pedagogy among the disciplines in various academic institutions. The Academic Degrees Committee of the State Council officially listed psychology as a first-tier discipline in the *Directory of Disciplines and Professions for the Award of Doctoral and Master's Degrees by Higher Education and Scientific Research Institutions (Draft for Trial Implementation)* published in 1983, with research on learning being classified as an important topic.

Since the 1980s, efforts by Fu, Li, Du, Gao, Shao, and other prominent Chinese scholars in educational psychology and comparative education led to a gradual but systematic introduction of representative theories on learning into the country. These included the genetic epistemology proposed by Swiss psychologist Jean Piaget and the theoretical system of its related schools of thought (Piaget et al., 1984), the sociocultural–historical perspective of psychology of Soviet scholar Lev Vygotsky (Vygotsky, 1979) and the activity theory developed through Alexei Leontyev and Alexander Luria, and the development of human cognitive structure introduced by American psychologist Jerome Bruner (Wood, Bruner, & Ross, 2010). These theories became the basic theoretical resources for modern research on learning in China. During this period, the main concepts of research on learning—representation of knowledge, transfer, formation and acquisition of concepts, problem solving, and cognitive structure—were all strongly influenced by psychology. Accordingly, we've labeled this as the "psychological paradigm period" of LS in China.

Beginning of LS in contemporary China: Initial LS paradigm

Since the mid-1990s, research on learning in the Western academic world has transitioned (1) from a primarily psychological approach to a more comprehensive approach involving multiple disciplines and perspectives and (2) from being purely laboratory-based to focusing more on the study of learners in real-life situations (including cultural–historical context and physical space) (Zhao, Zheng, Ren, & Pei, 2007). On one hand, the value of Vygotsky's sociocultural–historical perspective, an important academic contribution of Soviet scholars, was rediscovered by Western European and American scholars after the end of the Cold War. With its profound insight into the "fundamental nature of human learning," the sociocultural–historical perspective entered the mainstream discourse of Western scholars in education research and initiated explorations into the origin of human knowledge through sociology and cultural anthropology. Vygotsky's work contributed to the formulation of the learning theory of social constructivism, which had a significant

impact on contemporary education reforms. On the other hand, the "scientific" characteristics of learning became increasingly prominent with the initiation of seven LS centers by the U.S. National Science Foundation (NSF). Research by these centers focused on the neural mechanisms of learning, computer-supported collaborative learning, related linguistic studies, and so on (Zheng, Zhao, Wang, Pei, & Ren, 2014).

During the same period, research on learning based on the psychological paradigm continued to expand in China. Concurrently, various Chinese researchers began conducting international tracking and local exploration of LS, including in the fields of scientific education, learning and instructional design, the brain and cognition, philosophy of science, and educational technology. Their efforts helped spark the process of developing learning into an interdisciplinary and comprehensive field of research.

During the psychological paradigm period, research on implicit learning by local scholars represented by Yang quietly formed a new force through which Chinese scholars could understand learning (Yang & Guo, 2001). Philosophers such as Yu introduced the theory of tacit knowledge, first proposed by British physical chemist and philosopher Michael Polanyi, into China where it was further developed (Yu, 2001). Taken together, the concepts of implicit learning and tacit knowledge, two theories from different fields, severely undermined the theoretical foundation of the long-standing hypothesis that learning is to grant and accept knowledge. This laid a solid foundation for modern research on learning, which pays attention to "silent" practical knowledge in addition to the types of knowledge that can be spoken about.

The early 2000s witnessed the launch of several interdisciplinary LS research centers in China. The first was the Research Center for LS, Southeast University, founded in 2002. A focus on biomedical engineering formed the core of the center, which was dedicated to the development of new methods, techniques, and equipment for LS research. The research findings of the genome and brain sciences were applied to educational science, leading to a multi-level LS research platform consisting of the molecular, physiological, psychological, and behavioral sciences. The center promoted a form of scientific education based on the maxim of "learning while doing," studied the establishment of related standards, and proposed evaluation methods. The work of the center greatly influenced the approach towards scientific education taken by China's elementary and middle schools.

Next, the State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, was founded in 2005. Its core tenet holds that learning is the root cause of an individual's lifelong development and social evolution, as well as the main contributor to both human and artificial intelligence. The basic nature of learning is the process of the brain changing, an indication of its plasticity, while cognitive neuroscience provides the technical means of studying the brain's plasticity. The laboratory conducts scientific research in the areas of advanced cognitive

functioning and learning, emotional and social cognition, cognitive and brain development, basic cognitive functioning and learning, and methodologies for cognitive neuroscience. While also conducting basic research, the laboratory emphasizes the translation of research findings to educational practices, such as psychological and learning evaluations and the development of brain and learning resources.

The Research Center for LS, East China Normal University, founded in 2006, treats LS and technological design as a secondary discipline of education. Its team of researchers conducts in-depth studies on the ideological trends of constructivist education, traces the direction of sociocultural–historical perspective and the application of its activity theory to teaching, and explores the integration of new learning models and classical teaching designs with the support of technology. The center's research covers the traditions of North America and Europe, with in-depth examination of individual disciplines including mathematics, Chinese, English, science, and the social sciences. Researchers at the center have translated and introduced key literature into China and constructed a knowledge base for the country's LS research. In addition, they conducted pairing experiments of international studies, such as the anchored instruction model proposed by the Cognitive and Technological Group (CTG), Vanderbilt University and the Web-based Integrated Science Environment (WISE) project led by Marcia Linn, professor at the University of California, Berkeley, and former President of the International Society for the Learning Sciences. They also introduced nonformal learning as a research branch by undertaking systematic academic accumulation in the field of museum learning, participated in the establishment of a master's degree in scientific education and communication, and have been dedicated to the promotion of LS concepts, techniques, and strategies on learning improvement for basic educational practices.

During the same period, scholars at Nanjing University took the lead in advocating the use of LS concepts and techniques to reform college education and teaching. They sought to cultivate the learning abilities of college students in the information age via LS and technological perspectives (Sang, 2004). Scholars of South China Normal University have worked to apply various theoretical tools such as learning and practice communities, situational and distributed cognition, and cognitive flexibility. They also systematically sorted and built the architecture for computer-supported collaborative learning, thereby interlinking learning, technology, and social collaboration (Zhao & Li, 2003). Scholars from Tsinghua University have focused on the transition from cognitivism to constructivism and made early explorations into the topics of constructivist learning, the construction of a suitable multimedia-based constructivist learning environment, problem solving, and knowledge construction.

The Centre for Information Technology in Education (CITE) at the University of Hong Kong is dedicated to the research and development of learning and teaching models that are supported by

various emerging technologies. The theoretical framework of LS is used to study educational reform, technology-enhanced teaching, and evaluation innovation. CITE offers highly distinctive research and practices in terms of technical support for teachers to learn and innovate.

Within China's academic field, the aforementioned efforts have led to the formation of shared domain discourse and mutually recognized methods for interdisciplinary research in learning. Examples include instructional scaffolding (supported learning), situational learning, technology-based learning, distributed cognition, community of practice, design-based research, and authentic learning. Chinese research on learning has started to exhibit characteristics of the "scientific" paradigm, although this shift has been not universal. As the field of cognitive neuroscience has become increasingly interested in learning, research on learning has attracted the attention of China's National Natural Science Foundation (NSFC). At the NSFC's 186th Shuangqing Forum held in Hangzhou in September 2017, researchers from various fields held discussions on studies conducted by researchers in the fields of natural science, as well as the means by which physiological, psychological, and social-science-based evidence could contribute to the study of learning.

LS research tasks in China

The research system for education and psychology in China has revived since the end of the 1970s, facing the sociocultural interpretations of knowledge theories and learning by the international academic circles, the continuous revelations regarding cerebral mechanisms by cognitive neuroscience, as well as the multidimensional exploration in humans' learning mechanisms via the computer-based learning process. The search for models and problems associated with the development of LS in China continued during the course of restoration, tracking, observation, absorption, and comparative cooperation. The various periods of LS development in China constituted a continuous and iterative process of progress that interweaved history, reality, local issues, and international models. Various new understandings were accumulated, including how human knowledge is formed and the way learning occurs and its related processes. This knowledge greatly reshaped the education sector's understanding of learning over the 40 years since China's reform and opening up and established the theoretical basis for the development and reform of basic education in the country.

The law of discipline development dictates that a field of study must satisfy several conditions before being considered mature. Currently, LS in China is at the stage of enthusiastic discipline development with a strong demand for research findings. Policymakers require empirical evidence to support the formulation of programs and measures to assist Chinese students improve at learning. However, the identity of LS as a discipline in China remains vague, and its cultural characteristics have yet to take shape. Due to the factors listed below, there are still certain barriers to overcome before LS can become a mature field of research in China.

A stable academic community

Although certain Chinese universities have established LS centers and laboratories, the LS academic community has yet to reach maturity at the national level. Reasons for this include a lack of professional societies, academic conferences, and professional academic journals. Presently, there is no LS branch under the Chinese Society of Education nor is there a national academic organization for LS research or a publicly issued academic journal.

Established curriculum and teaching materials

A number of Chinese universities have offered courses such as "Introduction to LS" and "LS and Technological Design." However, a strong curriculum system necessary for the professional development of LS has not yet been developed, and the requisite teaching materials are practically nonexistent. Substantial support and efforts are still needed in key areas, including teaching/training design oriented to the various professions, the use of LS research as supporting knowledge, as well as the requisite human resources, courses, and teaching materials.

An effective knowledge production mechanism

There has been no major original or diachronic research contributed by China's LS discipline over the past two decades. Nor has LS in China given birth to any classic theoretical model or case platform similar to the Jasper Woodbury Problem Solving Series by Vanderbilt's CTG (Shirley, 1998), the Knowledge Forum proposed by Scardamalia et al. (Bereiter, 2010), or WISE by Marcia Linn's Berkeley team (Linn, Clark, & Slotta, 2010). Many issues have yet to be addressed, including ways to promote the sharing, cooperation, and deepening of research by the various disciplines and teams that fall under the umbrella of LS, cessation of dependence on the translation medium, and frequent changes in focus and direction. There is an urgent need to study the NSF's project on LS centers, which provides sustained support for six to seven intercollege/agency LS research projects in the U.S. Research is also required on new disciplines that need to be developed, as well as the laws and paths of development (Besley, 2016). Mechanism-related problems such as funding sources, project evaluation, and methods of talent cultivation for the production of new knowledge must be found as soon as possible. LS is an interdisciplinary field with a lot of scope for theoretical innovation, and it faces strong demands posed by real problems; therefore, it is urgently needed for the development of educational policies.

A local system of discourse for the discipline

As mentioned earlier, certain common LS concepts and tools entered China's academic context from the West starting in the late 1990s. These include knowledge construction, social constructivism, legitimate peripheral participation, community of practice, cognitive apprenticeship, situated

cognition and learning, knowledge building, cognitive tools, instructional scaffolding (supported learning), adaptive expertise, authentic learning, and so on. These concepts have since been integrated into China's educational research system and have become tools for interpreting and understanding learning behaviors in humans. They have also laid a solid foundation for broadening the theoretical depth and breadth of Chinese LS research and have enabled Chinese scholars to utilize North American and European academic discourses in the study of LS.

At this point, the development of educational practices in China and the West has led to the accumulation of numerous insights. Certain of these insights highlight a common and consistent basis for human development in the era of globalization. Currently, Chinese researchers can continue to learn about this basis to establish the rationality of the LS discipline in China (Pei, 2018). However, more often than not, researchers in China are beginning to focus on learning and developmental issues specific to students in the Chinese cultural context. Families, cultural traditions, and the educational culture in China have developed and accumulated over time, becoming deeply ingrained. China's process of social evolution has engendered unique challenges.

Scholars are turning their attention to contemporary issues with learning facing Chinese students. In response, LS with Chinese characteristics must be established. Basic and experimental research on learning must be conducted within the situational context of Chinese traditional culture and contemporary developments, as well as in the multiple loci of Chinese society (including families and within and outside of schools). The aim of Chinese-focused LS should be to explain macroscopic issues such as "How do Chinese students learn?" "How should Chinese students learn?" and "How can the nation, municipalities, schools, families, and other education-related stakeholders support students in their learning endeavors?" The answers to these questions will provide the international LS community with conceptual tools, cases, and models unique to China, thereby enabling the country to contribute toward revealing the profound mysteries of human learning.

Conclusion

Human learning is an age-old issue, but LS is a brand-new field. LS in China is a young and emerging discipline, albeit one that is rooted in an ancient heritage. The continued development of LS in China should not entail revisiting and interpreting the learning wisdoms passed down by our predecessors nor should it involve the wholesale import of the constantly evolving understanding of human learning made by Western scholars in the 20th and early 21st centuries. The task of establishing the LS discipline in China involves (1) consolidating the initial research paradigm to produce new academic knowledge more effectively and (2) forming a cultural identity within the discipline on the international academic platform. China has the potential to contribute its own way of thinking, cases, and practices toward the fundamental issue that LS seeks to solve: the profound

mystery of human learning. To complete these tasks, there is an urgent need for Chinese researchers to explore the spirit and methodology of the learning mechanism based on contemporary LS with a focus on real-life situations. Researchers must also conduct in-depth and scientific research on the learning problems faced by Chinese students in their unique cultural context. The learning environments and mechanisms of Chinese students should be interpreted based on their immediate situational contexts. Enhancing their ability to learn effectively represents a fundamental goal of basic education reform. Preparations must be made for the next generation to survive and thrive in the era of globalization and informatization. These are the contemporary missions of China's learning scientists.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the National Office for Educational Sciences Planning through the Key Project of Ministry of Education of China "School Improvement on District Level: A Comparative Study between China and the United States."

References

Bereiter, C. (2010). Can children really create knowledge? *Canadian Journal of Learning & Technology*, *36*, 15.

Besley, J. C. (2016). The National Science Foundation's science and technology survey and support for science funding, 2006-2014. *Public Understanding of Science*, *27*, 94–109.

Chen, H. (2008). *Complete works of Chen Heqin* (Vol. *2*). Nanjing, China: Jiangsu Education Press [in Chinese].

Gao, S. (2016). *Xueji*. Beijing, China: People's Education Press [in Chinese].

Grant, D. A., & Berg, E. A. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Weigl-type card-sorting problem. *Journal of Experimental Psychology*, *38*, 404.

Linn, M. C., Clark, D., & Slotta, J. D. (2010). WISE design for knowledge integration. *Science Education*, *87*, 517–538.

Liu, X. (2017). *The literary mind and the carving of dragons*. Beijing, China: The Writers Publishing House [in Chinese].

Pei, X. (2018). Co-evolution of learning science and scientific education: Dialogue with Professor Marcia C. Linn, former President of the International Society of the Learning Sciences. *Open Education Research*, *4*, 4–12 [in Chinese].

Piaget, J. (1984). *Principles of genetic epistemology*. New York, NY: Routledge Kegan & Paul.

Qiao, B. (1996). *History of learning and thinking in ancient China*. Beijing, China: People's Education Press [in Chinese].

Sang, X. (2004). *Learning science and technology: Cultivating college students' learning abilities in the information age*. Beijing, China: Higher Education Press [in Chinese].

Sawyer, R. K. (2006). *The Cambridge handbook of the learning sciences*. New York, NY: Cambridge University Press.

Shirley, L. (1998). The Jasper Project: Lessons in curriculum, instruction, assessment, and professional development. Cognition and technology group at Vanderbilt University. *Mathematics Teaching in the Middle School*, *404*, 316.

Tao, X. (2017). *Anthology of Tao Xingzhi*. Nanjing, China: Jiangsu Education Publishing House [in Chinese].

Vygotsky, L. S. (1979). Consciousness as a problem in the psychology of behavior. *Journal of Russian & East European Psychology*, *17*, 3–35.

Wood, D., Bruner, J. S., & Ross, G. (2010). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, *17*, 89–100.

Yang, Z., & Guo, L. (2001). Progress in research of cognitive styles. *Journal of Psychological Science*, *24*, 326–329 [in Chinese].

Yu, Z. (2001). Polanyi's theory of tacit understanding. *Studies in Dialectics of Nature*, *17*, 5–10 [in Chinese].

Zhao, J., & Li, K. (2003). Principles and basic structure of CSCL (I). *e-Education Research*, *5*, 3–7 [in Chinese].

Zhao, J., Zheng, T., Ren, Y., & Pei, X. (2007). Overview of the development in research on learning science. *Open Education Research*, *13*, 15–20 [in Chinese].

Zhang, Y. (2006). *Analects*. Beijing, China: Zhonghua Book Company [in Chinese].

Zheng, T., Zhao, J., Wang, M., Pei, X., & Ren, Y. (2014). Learning science and educational reform: Review and prospects of the 2014 International Conference of the Learning Sciences. *Educational Research*, *9*, 150–159 [in Chinese].