A Review of Deep Learning Research in the Past Two Decades at home and Abroad

Tiantian He*, Xingyu Hu

Xi'an Eurasia University, Xi'an, Shaanxi, 710065, China
* Correspondence author: Tiantian He

Abstract: With the rapid development of science, technology and education informatization, learners' learning styles have changed drastically, and deep learning is an inevitable requirement for education teaching and talent training in the new era. This study analyzed the research status of deep learning in the past two decades at home and abroad through literature analysis method, and further explored the future research and development direction of deep learning in education based on the existing research. The study aims to provide new thinking for the future research of deep learning in blended learning environment.

Keywords: deep learning; literature analysis method; review study

1. Introduction

With the advent of the fourth industrial revolution and the smart era, people's lifestyles and cognitive patterns have gradually changed. The 2017 Higher Education Edition of the New Media Consortium's Horizon Report pointed out that higher education should focus on deep learning for college students and emphasize the development of students' critical thinking, practical problem solving, independent learning, writing and expression skills [1]. As an important base for the cultivation of contemporary innovative professionals, colleges should constantly understand the market demand for talents and carry out reform and innovation of teaching models so that students can acquire multiple skills and comprehensive literacy by means of deep learning. Deep learning is a new requirement for the cultivation of learners and innovative talents in the new era of education and teaching, and it is an important symbol of the change and development of education concept and learning mode in the era of " Internet Plus".

The superficial learning of mere mechanical memorization and recitation of knowledge by college students can no longer meet the requirements of talent cultivation in the new era. They should master more deep learning abilities such as comprehension, analysis, application, and evaluation in the classroom in order to gain a foothold in the intelligent and innovative social environment of the future. In the complex and changing teaching environment, how to use deep learning technologies and strategies to develop high-quality teaching resources and teaching models is a growing concern for educators, which could meet students' learning needs and improve the quality of student learning. To this end, understanding the current state of domestic and international research on deep learning plays an important role in facilitating students' deep learning in a blended learning environment.

2. The Status of Foreign Deep Learning Research

In the first half of the 20th century, deep learning has appeared in foreign research in the fields of computer science, engineering, communication, automatic control systems, biomedicine, mathematics, artificial intelligence and so on. Bloom first proposed the concept that "cognition has dimensional levels" in the field of education in 1956. In 1976, American scholar Marton proposed the concept of deep learning for high-level cognition of shallow learning [2]. In 1979, researcher Biggs suggested that deep learning should include high-level or active cognitive processing, compared with shallow learning such as simple memory or mechanical memory[3]. Beattie, Collins and Mcinnes similarly believed that the difference between deep and surface learning is related to students' learning intentions, learning styles, learning methods and learning outcomes [4].

To further understand the research status of deep learning in foreign countries, this study used "deep learning*" as the subject search term in the Web of science core database, and the search period was from 2003 to 2022, and the subject category was selected as " EDUCATION EDUCATIONAL RESEARCH". The literature not related to this study was manually deleted. At last, a total of 546 records were retrieved (Figure 1). In the past two decades, the research results of deep learning in the field of education and teaching have been developing. The studies were published the most in 2020, followed by slow growth, in which the specific directions of research included educational science research, engineering, computer science, health science services, life sciences, mathematics and so on. The countries with more research achievements are the United States, Australia, Spain, The United Kingdom, China, the Netherlands and so on, among which the national Science Foundation of the United States has the most funding organizations. The top research keywords are deep learning, education, learning methods, assessment, classification, neural network learning strategies, etc.

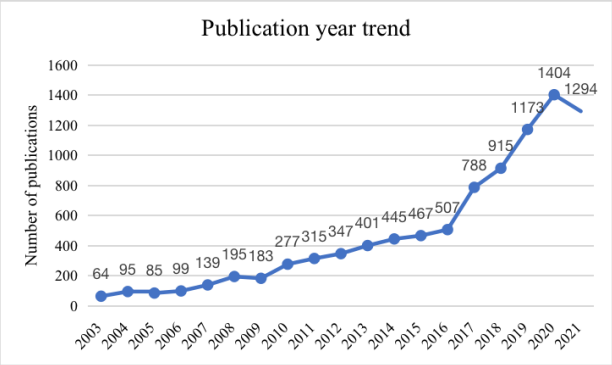

Figure 1. The number of foreign deep learning research publications in the past two decades

From foreign studies on deep learning, it can be found that the United States is the birthplace of deep learning. And it ranked first in terms of research breadth and depth, theory and practice, and a large number of institutions and organizations have initiated and implemented projects on deep learning. One of the most influential projects is the Study of Deeper Learning: Opportunities and Outcomes (SDL) project conducted by the American Institutes for Research. This project established the concept and connotation of deep learning, and carried out deep learning teaching models in different regions of the United States, forming a linked network of deep learning and conducting quasi-experimental research [5].

According to existing studies, the main research fields of deep learning abroad is in the field of computer, which mainly refers to the use of different deep learning algorithms to simulate the human brain mechanism to process or analyze data. Deep learning research in the E-learning environment mainly focuses on how to use information technology to achieve higher-order learning through platforms such as online classrooms, online learning communities or educational games [6]. In the learning science perspective, research on the pedagogical application of deep learning aims to promote students' deep learning through novel project or problem-based teaching methods [7]. In recent years, researchers have focused on the development of higher-order thinking skills through empirical studies or blended studies to investigate deep learning in the context of learning science, but less research has been conducted on metacognitive skills and problem solving [8]. In addition, researches on the process and results of deep learning pay more attention to exploring the influencing factors of deep learning for college students, the main factors include the characteristics of teachers and students, academic activities, teachers' teaching, students' learning, and classroom environment and atmosphere [9].

Overall, foreign research topics on deep learning have focused on strategies, approaches and evaluation, and deep learning has been widely used in various disciplines, and the research subjects are mostly college students at the higher education level [10]. With the rapid changes in information technology and artificial intelligence, classroom teaching is also undergoing reversal changes. Moreover, it is important to focus on the current situation, influencing factors and teaching practice research of students' deep learning in blended learning environment.

3. Status of Domestic Deep Learning Research

The research on deep learning in China was carried out later than that in foreign countries. In2005, professor Lai Jiahou first proposed that "deep learning refers to the fact that on the basis of understanding, students can critically learn and accept new knowledge and new ideas and integrate them effectively with their original cognitive structure; redefine existing knowledge through a new cognitive system; make new Learning to make decisions and solve practical problems through new cognitive systems" [11], Since then, domestic studies have been widely carried out. In order to further understand the current situation of domestic research on deep learning, we searched a total of 3529 papers through China Knowledge Network database with "deep learning" as the subject keyword and "educational theory and management" as the subject category from 2005 to 2022, including 1808 Chinese Academic Articles, 567 master's theses and 51 doctoral theses.

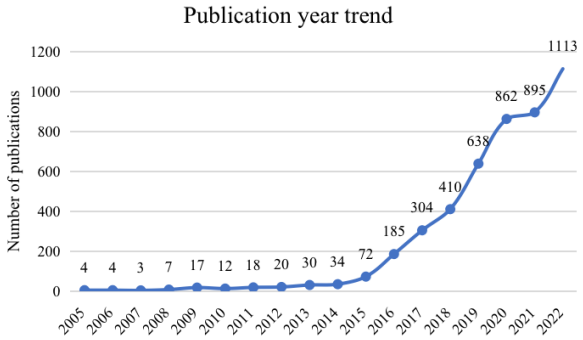

Figure 2. The number of deep learning research articles published in China in the past two decades

The trend of publications in the past two decades is shown in Figure 2. Through screening and reading analysis, it is found that most of the dissertation studies are the application studies of deep learning algorithms in various disciplines. In 2010, the National Medium and Long-term Education Reform and Development Plan (2010-2020) was promulgated which proposed that education and teaching should pay attention to cultivating students' subjective initiative and interest in learning, and improving students' core literacy [12]. In 2012, the number of publications started to increase gradually, and subsequently deep learning began to be gradually focused on by researchers. From the distribution of major themes as shown in Figure 3. Domestic researches on deep learning pay more attention to flipped classroom, blended teaching, teaching models, artificial intelligence, and Smart Classroom [13].

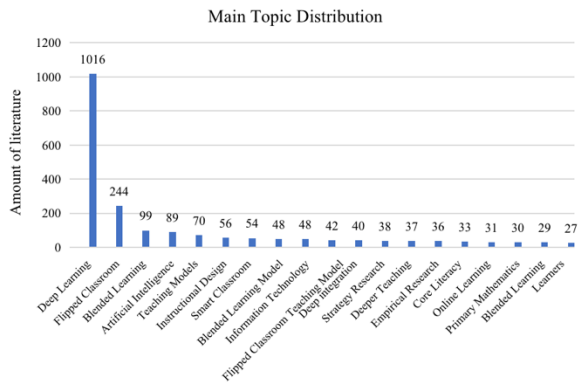

Figure 3. Distribution of deep learning research topics in China in the past two decades

Through the existing research, it is found that the main research areas about deep learning in China are divided into basic theoretical research, methodological and technical research, application and resource construction research, and evaluation research.

(1) The basic concepts and theoretical research of deep learning mainly focus on connotation and cognition. From the perspective of different stages and modes of deep learning, deep learning can be defined from the aspects of learning mode, learning process and learning outcome, which can be seen as a method, strategy, or expected effect. Taken together, deep learning is comprehension-based learning that focuses on critical interrogation and emphasizes the promotion of knowledge construction and problem solving through the integration of information [14].

(2) Research on methods related to deep learning mainly focuses on teaching strategies, models research and environment design research. The research on strategies and models mainly focuses on promoting deep learning through different strategies or methods, such as teaching strategies to promote deep learning in information technology environment, learning-based assessment strategies, etc. [15]. Researches on deep learning environment mainly involve MOOC environment and network environment. Deep learning can be promoted by improving learning environment or establishing deep learning model based on certain environment.

(3) Research on deep learning applications and resource construction, which mainly involves the fields of education teaching and networking. The application of deep learning in teaching and network mainly refers to advocating deep learning in various disciplines, which mostly focuses on the level of strategy and method, viewing and solving practical problems through critical thinking, and multi-perspective learning. Research on deep learning resource construction mainly refers to providing rich learning resources and personalized learning services for deep learning in blended online learning environments by building deep learning content, platform interfaces, and system modules for online courses [16].

(4) Zhang Hao et al. constructed a multidimensional evaluation system of deep learning that integrates cognition, thinking, motor skills, and emotion based on different goal classification methods. This research suggested that the evaluation of deep learning should be goal-oriented, and value judgment should be made on the process and results of deep learning by means of survey, test and statistical analysis, so as to promote the development of higher-order thinking such as learners' independent learning, problem solving and critical innovation [17].

In conclusion, from the overall research on deep learning in China, there are more studies on promoting learners' deep learning through flipped classroom and blended teaching, focusing on strategies and methods. However, theoretical studies on deep learning are not profound enough, and evaluation and environmental studies are less, which need further attention.

4. Research Prospects of Deep Learning in Education

Throughout the relevant research on deep learning at home and abroad, the focus of deep learning has gradually overstepped from machine learning algorithms in the computer field to deep learning under the threshold of learning science. How to further optimize teaching strategies, improve the quality of classroom teaching services and promote learners' deep learning with the advantages of information technology in the new era of education informatization deserves more attention. Based on the above, the following suggestions are put forward for deep learning research in the field of education.

4.1 Explore the Main Factors that Influence Learners' Deep Learning

Nowadays, the blended learning environment integrates the advantages of online and offline learning, which provides a whole process and all-round support for the occurrence of deep learning among college students. Sorting out the influencing factors of deep learning in the blended learning environment can help researchers to deeply understand the occurrence mechanism of deep learning among learners, which is conducive to the development of more targeted teaching strategies. It can further help front-line teachers to clarify the learning pattern in the classroom, master the learning rules, optimize the teaching design and improve the quality of classroom teaching, so as to develop a series of scientific, systematic and effective teaching strategies.

4.2 Provide the Necessary Learning Resources and Technical Support

There are still many characteristics of deep learning technologies that need to be recognized, explored and utilized. At present, how to use rich learning resources to carry out blended teaching activities is a key issue to be addressed [18]. Teachers and researchers can provide learning resources through online learning platforms such as China University MOOC, Coursera, Udacity, and edX, and use deep learning algorithms and technical tools to create a meaningful deep learning atmosphere and blended learning environment.

4.3 Improve Deep Learning Theory, Strategy and Evaluation Research

Understanding the architecture of deep learning in a blended learning environment and exploring strategies and methods for measuring or evaluating deep learning are important for promoting learners' deep learning. Future deep learning research should attach importance to ontology theory research, analyze the connotation and essence of deep learning, pay attention to the implementation role of deep learning in the formation process of cultivating students' core literacy, and develop a multiple evaluation system combining quality and quantification.

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References

[1] Jin Hui, Ying Ying Hu, Song Lei. Technology for educational innovation--Interpretation of the New Media Consortium's Horizon Report (2017 Higher Education Edition). Journal of Distance Education, 2017, 35(02): 3-8.

[2] Chen Dexin, Jim Yuan Yuan, Yang Bing. Analysis of deep learning techniques in the field of educational big data mining. Electrochemical Education Research, 2019, 40(02): 68-76.

[3] Biggs J. Individual Differences in Study Processes and the Quality of Learning Outcomes. Higher Education, 1979, 8: 381-394.

[4] Beattie V, Collins W, McInnes W. Deep and surface learning: A simple or simplistic dichotomy? Accounting Education, 2010, 6.

[5] Bu Cai-Li, Feng Xiao-Xiao, Zhang Bao-Hui. The concept, strategy, effect of deep learning and its insights--interpretation and analysis of the US Deep Learning Project (SDL). Journal of Distance Education, 2016, 34(05): 75-82.

[6] Zhang S-Q, Zhang W-L, Li B. Research status and development trend of foreign deep learning in the past ten years--knowledge mapping analysis based on citation analysis and co-word matrix. Journal of Distance Education, 2016, 35(02): 64-72.

[7] Yang, N. C., Zeng, Y. P., Chen, Z. Y., et al. Analysis of the mainstream development of learning science and its insights--a study based on the content analysis of the American Journal of Learning Science (1991-2009). Journal of Distance Education, 2012, 30(02): 15-27.

[8] Duan Jinju, Yu Shengquan. Research on deep learning of e-Learning in the context of learning science. Journal of Distance Education, 2013, 31(04): 43-51.

[9] Sadeghi A, Sadeghi A. The Factors Affecting University Student Deep Learning (USDL) in the University of Guilan, IRAN (comparative study among Humanities, Agricultural and Physical Education Faculties). Procedia - Social and Behavioral Sciences, 2012, 31: 810-815.

[10] Shen Xajuan, Zhang Baohui, Zeng Ning. A review of foreign empirical studies on deep learning in the past decade - themes, contexts, methods and results. Electrochemical Education Research, 2019, 40(05): 111-119.

[11] He L, Lai JH. Promoting students' deep learning. Modern Teaching, 2005(05): 29-30.

[12] Gu Mingyuan. Study and interpretation of the Outline of National Medium and Long-term Education Reform and Development Plan (2010-2020). Higher Education Research, 2010, 31(07): 1-6.

[13] Fan Yaqin, Wang Binghao, Wang Wei, et al. A review of domestic research on deep learning. China Distance Education, 2015(06): 27-33+79.

[14] Ye Xiaoyun, Qin Jian. On shallow learning and deep learning. Software Guide, 2006(02): 19-21.

[15] Du Juan, Li Zhaogun, Guo Liwen. Study on the strategies of information-based instructional design to promote deep learning. Research in Electrochemical Education, 2013, 34(10): 14-20.

[16] Chen Lin, Li Fan, Wang Chu, et al. Research on the construction of e-learning resources to promote deep learning. Research on e-learning, 2011(12): 69-75.

[17] Zhang H, Wu Xiujuan, Wang Jing. Construction of objectives and evaluation system of deep learning. China's e-learning, 2014(07): 51-55.

[18] Ma Yun. Research on MOOC-based blended teaching for higher-order learning of college students. Changchun: Northeast Normal University, 2019.