Education Challenges and Coping Mechanisms for Artificial Intelligence in Primary and Secondary Schools

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The application of artificial intelligence (AI) education at the primary and secondary levels has far-reaching implications for the universalization of AI education, the cultivation of AI talent for national growth, and the improvement of student intellectual competency. This article focuses on the history of AI education in China and the challenges it faces in terms of course standards, teaching materials, personnel availability, and instructional strategies. Suggestions for coping tactics include adjusting course standards; creating a scientific textbook structure; expanding the availability of high-quality AI instructors; and promoting fundamental AI education through multi-agency collaboration. It is hoped that this study will help improve how AI is taught in elementary and secondary schools.

Keywords: Information Technology Education; AI Education; Course Standards; Primary and Secondary Schools

ARTIFICIAL intelligence (AI) research is a cutting-edge interdisciplinary branch of study that focuses on the replication and expansion of human intelligence using computer applications (1). AI has proved its broad applicability and influence in a variety of professions, including education and medicine, and has become a new driving force for the advancement and reform of these fields. As a result of the continuous incorporation of artificial intelligence into a variety of vertical fields, it is vital to equip average citizens with fundamental AI knowledge and application abilities. In this setting, interest in AI education has been growing steadily. In July 2017, the State Council of China announced the *Development Plan for a New Generation of Artificial Intelligence*, which said that AI education must be given in primary and secondary schools for the national intelligence education project to be implemented (2). In April 2018, China's Ministry of Education announced the Action Plan for Artificial Intelligence Innovation in Colleges and Universities, recommending the construction of a multi-level AI education system and the universalization of AI education in elementary and secondary schools (3). The proclamation of these policies has fostered the growth of AI education in China and prompted considerable and in-depth research into AI course design and implementation methodologies. AI is increasingly integrated into elementary and intermediate school curric-

ula.

The Status Quo of AI Education
AI Education in the World

The majority of nations in the world currently view AI technology research and application as a key factor in boosting their level of national competitiveness and starting AI talent development in primary education. For example, in 2019, US President Donald Trump issued the Executive Order on Maintaining America's Leadership in AI, which promotes the development of AI technology bases, the expansion of STEM education with a focus on computer science, and the integration of AI technology into classroom instruction. The same year, MIT launched a website with resources for K–12 students on artificial intelligence education. It offers intelligent online tutoring for primary school students and gives secondary school students the chance to learn about and participate in the design and development of AI applications. In 2021, the Biden administration set up the National Task Force on Artificial Intelligence Research Resources. Its goal was to make it easier for people to get to important resources and teaching tools related to AI technology (4).

Many nations have incorporated programming into their national curricula as part of the recent wave of reforms to primary and secondary curricular standards. Finland, for instance, is the first EU member state to incorporate AI technology development into national-level goals. The National Core Curriculum Outline, which highlights the need for educational innovation to satisfy the country's demand for AI talent, was launched countrywide in August 2016. (5). The updated Learning Guidelines, which emphasized the value of programming instruction and made it a required course in elementary and secondary schools, went into effect in Japan in 2020. Its objective is to develop students' "programming thinking" and proficiency with computer language. In response to the growing interest in AI education around the world, the UNESCO Institute for Information Technologies in Education published Artificial Intelligence in Education, a study that looked at how AI technology affects students, teachers, parents, educational administrators, etc., and what problems it might cause for society as a whole.

AI Education in China

"Basics of AI" was included as an optional module in the General Senior Secondary Course Standards for Information Technology in China as early as 2003, among other modules such as "Algorithm and Program Design," "Network Technology Application," and "Data Management Technology" (7). Due to the developmental stage of AI technology at the time, early AI teaching content was limited to classical ideas such as "expert systems" and "distributed computation," as well as programming practices such as recursive programming. According to the 2017 General Senior Secondary Course Standards for Information Technology, "Basics of AI" is an elective module taught under three themes: introductory knowledge of AI, fundamental AI application development, and the history of AI technology development and application (8). This module aims to teach students about the evolution and key concepts of AI, as well as how to understand the actualization process of typical AI algorithms and how to create simple AI applications. It also aims to

raise students' awareness of the importance of using intelligent technology to advance social development. AI-related content is also included in other elective modules. Analyses of typical AI application cases, for example, are undertaken in the module "Data and Computation" to help students comprehend the increasingly crucial role of AI in constructing an information-based environment. In recent years, cities including Guangzhou, Shenzhen, Tianjin, and Nanjing have conducted extensive research into developing independent AI courses for basic education (including primary and secondary schooling). Guangzhou intends to universalize AI instruction in all city schools by 2022 in order to cultivate innovative AI talent for the city's future development (9). Shenzhen has chosen 61 schools to be the first pilot schools for the Primary and Secondary AI Education Project, which aims to put AI courses in the city's primary and secondary schools (10).

Primary and Secondary AI Education's Challenges

To ensure the effectiveness of AI instruction at the basic education level, several concerns concerning course standards, teaching materials, personnel supply, teaching methods, and course regulations must be addressed.

Problems in the National Course Standards

Chinese primary and secondary schools are currently implementing the Basic Education Course Standards for Information Technology 2012 and the General Senior Secondary Course Standards for Information Technology 2017, both of which have been significantly modified from the original versions (11). The course purpose, teaching content, and evaluation methodology were updated based on the key competencies to be cultivated through the learning of these courses and the major concepts of this discipline (12). On the other hand, the key competencies that are emphasized have more to do with IT and digital education, but they can't meet the needs of the AI era. Big ideas like "information awareness" and "the responsibilities of information societies" are part of IT.

The General Senior Secondary Course Standards for Information Technology were changed further in 2020, but "top-level design" flaws remained. The objective of the course was to "increase the IT literacy of senior secondary students" and "allow them to become qualified citizens in the digital era" (13), although AI literacy and the requirements of the AI era were not addressed in the text. Moreover, despite the fact that AI education is included in the IT curriculum, it is worthwhile to explore whether more emphasis should be placed on AI education due to its transdisciplinary character. More needs to be talked about how to make AI education more connected to the real world and how to integrate it with other fields.

Inconsistency among AI Textbooks

Since 2018, there has been an increase in the number of AI textbooks created for various levels of fundamental education. However, due to the disparities in viewpoints and compilation techniques across them, these textbooks lack a coherent structure. For instance, the Experimental Textbook for Artificial Intelligence is overly tough and doesn't have a defined criterion

for course evaluation (14). The Junior Secondary Edition of Artificial Intelligence (JSE) focuses on the fundamentals of AI technology, the development of solutions based on AI, AI in communication and cooperation, and other topics. However, it is overly theoretical, ignoring exercises that can be put into practice, and its network supporting resources need to be improved. The algorithmic concepts of AI, such as deep learning, are emphasized in Fundamentals of Artificial Intelligence (Senior Secondary Edition), but once again, the book places too much emphasis on theoretical knowledge's depth and not enough on its breadth. Overall, these textbooks for various educational phases lack coordination in terms of difficulty and transition (15). Teaching materials frequently repeat their information.

A Severe Shortage of AI Teacher Supply

The following three factors are the key causes of the severe teacher shortage that China's primary and secondary AI education is currently experiencing. First, it's challenging for schools to find graduates with AI backgrounds. Only a small number of teachers universities offer AI majors or courses closely connected to AI. The Ministry of Education authorized the establishment of additional AI majors at 35 and 180 general colleges and universities in 2019 and 2020, respectively, but the increase in AI graduates still cannot keep up with the need for AI expertise nationwide (16). Being a primary or secondary AI teacher is not appealing to professional AI practitioners, who prefer to work in developed regions. Second, there is a wide range in the abilities of the current AI teaching staff. Because of the complexity and cross-disciplinary nature of AI, professors in this field must possess a high level of intellect and comparative expertise. The results of AI education as a whole are unexpected since there are significant gaps in professional knowledge, technology application expertise, and teaching experience among present AI teachers. Third, there is not enough in-service instruction for teachers of AI. In China's primary and secondary schools, AI instructors come from a variety of academic backgrounds, with the majority having taught IT and the remainder having taught math, science, robotics, and maker technologies. There is currently not a mechanism in place for expert training of AI instructors.

Immature AI Teaching Methods

Due to the practicality and comprehensiveness of primary and secondary AI education, scientific teaching techniques are incredibly important for the effective implementation of AI courses. There are currently primarily two methods for classroom instruction. One of these is the knowledge-focused model, which was adapted from college AI teaching and ignores the age-related traits and learning preferences of elementary and secondary students. Students usually become fatigued during the course because the course's AI knowledge requirements are too high for them to understand. The learning-through-play strategy, on the other hand, only allows students to have a cursory understanding of this discipline. The learning environment and learning process are engaging under this model, but students do not master the fundamentals of AI knowledge and literacy. As a result, using non-scientific teaching techniques will always produce poor learning results. The choice of teaching strategies affects how easily basic AI concepts can be understood by primary and secondary students who have restricted cognitive capacities, intelligence levels, and knowledge bases. Teachers have to keep coming up with new, better ways to teach and improve the ones they already use.

Strategies for Improving Primary and Secondary AI Education
Enhancing IT Course Standards

The direction of the instructional materials is greatly influenced by the course standards. The purpose of the ongoing IT courses in primary and secondary schools should change from educating "digital natives" to educating "AI citizens" (17). To maximize the effects and potential outcomes of the IT course, greater focus needs to be placed on building students' AI competences (such as AI literacy, skills, attitudes, and ethics) and thinking ability (including computer, data-based, inventive, and interdisciplinary thinking). Additionally, the current IT course can be improved by basing it on the key ideas of the field. Perception, representation, reasoning, learning, interaction, and social influence are the five elements that are highlighted in the K–12 Artificial Intelligence Education Guidelines in the United States. There are explanations, keywords, subheadings, examples, resources, a resource expectation list, and directions on what students should understand and be able to accomplish surrounding each idea (18). Although some key ideas, such as data, algorithms, information systems, and social information, are determined by the IT course standards in China, they are not given any concrete or practical elements. It is essential to define the key AI education concepts and build a conceptual framework to establish standards for student learning, teacher course design, and textbook creation. Additionally, the entire basic education curriculum should include AI education in addition to the IT course. In AI education, trans-disciplinary learning is a crucial component. It is important to promote the "penetration" of AI instruction into fields like physics and mathematics. Education in AI must extend beyond IT courses.

Constructing Systematic Teaching Materials

A number of modifications can be made to address the problems with the current basic AI training materials. First, there should be improved coordination between the connections and transitions between the various learning phases in AI education. The depth of AI knowledge must be gradually addressed, and the amount of content difficulty must be proportional to student cognitive capabilities. An integrated AI teaching material system should be built in accordance with the spiral process of perception, understanding, application, and creation throughout the basic education stage. Teaching materials should be developed on the basis of the major concepts of AI with a scientific control of the difficulty of contents. Second, a future compilation of AI textbooks should demonstrate a solid balance between theoretical knowledge and practical application. Due to the complexity of AI knowledge, basic AI education must carefully select the teaching resources that will be used. The multidisciplinary character of artificial intelligence also specifies the broad range of knowledge required, and there should be a natural relationship between AI and the pertinent disciplines to broaden stu-

dents' academic vision. Third, to better prepare students for a future in which humans and AI coexist, AI security and ethical hazards should be covered in primary and secondary AI education textbooks. From a human-centered point of view, it is important to encourage students to think about humanistic ideals in the AI age.

Ensuring an Adequate Supply of Qualified AI Teachers via Multiple Avenues

Addressing the AI personnel shortages and improving the professionalism of in-service teachers are both critical at the moment. In order to develop programs for recruiting and training AI talent, elementary and secondary schools must first establish significant partnerships with teacher's universities, scientific research organizations, and AI firms. For instance, by acting as a base for placement and internships for AI majors, schools can work with teacher's universities to train AI talent. They can also use retired researchers to support their AI instruction. Second, professional development for AI teachers can be effectively delivered in schools. The school may bring together IT, math, science, and maker teachers to construct a "learning community" that will develop school-based AI course frameworks, AI teaching and learning tools, and an online AI education platform because it is a place where several academic fields intersect. In order to improve the professional competencies of AI teachers, they could also offer scheduled online and offline topic training. Third, peer support is a further tool that can be used to improve teacher preparation. To share their knowledge of AI education, anchor AI teachers in the area can be chosen to host frequent theme-based talks and sponsor teaching research projects. This will help teachers grow as a whole and, in the long run, make AI education in the area better.

Encouraging Multi-agency Collaboration to Promote Basic AI Education

It takes coordinated efforts from the government, schools, scientific research institutions, and high-tech firms, as well as the integration of numerous resources from pertinent parties, for primary and secondary AI education to develop robustly and healthily. Government policy support is crucial in the first place for advancing AI education. When creating the elementary and secondary curriculum programs, educational authorities should give AI education more consideration. Second, to innovate course standards, instruction methods, and course administration, elementary and secondary schools should involve academic institutions of higher learning, high-tech businesses, and colleges and universities in the formulation of the AI course plan. In line with scholarly and commercial growth in this sector, AI education must constantly be updated and modified. Third, it's important to promote long-term enterprise-school cooperation on AI education initiatives. Corporate involvement can help schools set up a system for preventing and controlling the risks and dangers associated with AI data security. High-tech businesses should use their technological advantages in data collection to help basic education administrators get the information they need to make decisions. They can do this through learning analytics and educational data mining.

Conclusion

Primary and secondary students benefit greatly from a good AI education. It can not only improve students' cognitive abilities and comprehensive competency but also suit their personal development needs and prepare them for future AI advancement. In terms of course planning, teaching methodologies, and facilities, there is now a significant difference between China's fundamental AI education and that of Western countries. China's basic AI education needs to be a strong backbone for the country's major AI strategies. To do this, the government, schools, and other social forces must work together to maximize AI instruction and build a stable team of top-notch teachers.■

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