

# *Research on Ai Education for Primary and Secondary Schools in China*

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**Abstract:** Based on the existing problems in AI education for primary and secondary schools in China, as well as the demand for innovative talents in science and technology, this paper takes the core literacy of AI education as the target, and absorbs the concept of STEM education, to form a special model of AI education for primary and secondary schools. Focusing on the study of the curriculum system, teaching resources, teacher training, curriculum evaluation and other aspects of AI education for primary and secondary schools, the framework of teaching programmes is proposed.

## **1. Introduction**

### **1.1 Motivation**

The rapid development of artificial intelligence(AI) is beyond our imagination, and AI has brought many changes in different fields, such as intelligent campus, intelligent transportation, intelligent agriculture, intelligent community, intelligent factory and so on. Therefore, many countries around the world have taken AI education as a national strategy to international competition. So it is an educational responsibility to deploy a new generation of the talent training to seize the opportunities of AI talents and technologies as soon as possible. In the field of basic education in China, AI education has received certain attention. In July 2017, the State Council officially issued the “New Generation of AI Development Plan”, which clearly pointed out that ‘AI courses will be set up for primary and secondary schools, and programming education will be promoted gradually’[1]. In early 2018, the Ministry of Education issued the “Curriculum Standard of IT courses for high school”, which pointed out ‘AI education focus on cultivating students’ logical thinking, and includes three parts: the basis of AI, the development of simple intelligent system, and the application of AI technology’[2]. In 2019, the “Modernization of Chinese Education in 2035” also put forward clear requirements for AI education and information literacy training for primary and secondary schools[3].

In the process of experiencing, learning and applying AI knowledge and technology, students can improve their interest in AI, broaden their vision, and cultivate their innovative ability and logical thinking. So, it is of great significance to offer AI education for primary and secondary schools. However, there are still many problems in AI education for primary and secondary schools in China, and the situation is very worrying. Firstly, the AI education has not yet formed a discipline system,

mainly relying on information courses, and lacks common curriculum standards. Secondly, the primary and secondary schools are extremely short of professional AI teachers, moreover the teachers' AI literacy is really defective. Thirdly, the AI laboratories cannot meet demand, as well as the software platform, programming platform, hardware equipment. Fourth, the penetration rate of AI courses for primary and secondary schools in China is far lower than that in European and American countries. Moreover, most of the AI courses are dominated by interest courses or competitions, so that very few students have access to them.

## 1.2 Related Work

Therefore, the construction of AI education for primary and secondary schools is an urgent subject. However, different from other disciplines, AI needs abundant mathematical knowledge and skilled computer programming ability, as well as inter-disciplinary knowledge. Due to the limitation of school hours and students' insufficient math knowledge, we need scientific and rational course plan for the AI education. In recent years, STEM education has become a hot topic at home and abroad. As a new talent training method, with inter-disciplinary integration, STEM education plays a pivotal role in improving students' scientific literacy, problem-solving ability and innovative thinking etc.[4] [5]. Core literacy, as a global development strategy and educational concept, reflects the common demand for talent training of all countries in the 21st century. And, core literacy in China contains the cultural customs, educational conditions and talent training vision [6][7].

By integrating STEM education with core literacy, we form the teaching mode of AI education for primary and secondary school. The first is to aim at the core literacy of AI education, the second is to absorb the concept of STEM education, and the third is based on the actual situation and talent demand in the country. In this paper, we commits to the research on teaching mode, course system, teaching resources, teacher training, course evaluation and so on, and propose the framework of teaching programme.

## 2. Core Literacy of Ai Education for Primary and Secondary Schools

### 2.1 Core Literacy

In 2016, the overall framework of the “The Development of Chinese Students’ Core Literacy” was officially released, which stated ‘The core literacy of student is a necessary character and key competency, for lifelong development and social development. Chinese students’ core literacy has the following characteristics: Take scientization, modernization, nationalization as the basic principles; Focus on cultivating well-rounded people; Contain three aspects of cultural foundation, independent development and social participation; Include six qualities of humanistic background, scientific spirit, learning ability, healthy life; Involves eighteen basic points, such as cultural precipitation, social responsibility and national identity’ [8].

Nevertheless, core literacy is the macro guidance of talent cultivation, which needs effective carrier to achieve, for example, core literacy of specific subject is a good way. The official documents “Curriculum Plan of Ordinary High School”, issued by the Ministry of Education, mentions that ‘The core literacy of each subject is the correct value concept, essential character and key ability that students should achieve after learning this subject course’ [9], and as a complement, the “List of core Literacy of all subjects in Ordinary Senior high schools” describes in detail about the core literacy of each subject in senior high school.

### 2.2 Core Literacy of Ai Education Subject

For traditional subjects, such as Chinese, mathematics, physics, etc., with mature course standards, we determine core literacy of the subject according to course objectives and course content, and finally carry out course design on the basis of the core literacy. But for AI education in primary and secondary schools, there is no unified course standard, so as to course objectives and course content. Moreover, AI is a very complex subject, for example, the combination of theory and practice, technical difficulty, extensive knowledge points, and inter-disciplinary nature, etc.. So the research on the core literacy of AI education for primary and secondary schools is the top priority, and we conduct the design from the following aspects: First, we draw lessons from the “Core literacy model of Chinese students” and “the core literacy of various disciplines”, taking the core literacy model of Chinese students as the research guidance and basis; Second, we summarize the important knowledge and technical points of the AI subject; Third, learn from the “core literacy of information technology subjects” in the “List of Core Literacy of Various Subjects in General High Schools”.

In the process of designing the core literacy of AI for primary and secondary schools, we mainly refer to the three-layer framework of subject core literacy proposed by Li Yi et al[10], which mentions: ‘The first layer is the “double foundation”, taking basic knowledge and skills as the core. The second layer is “problem solving”, focusing on the methods obtained in the process of solving problems. The third layer is “disciplinary thinking”, focusing on the worldview and methodology of understanding and transforming the world in the systematic subject learning’[10]. The choice of knowledge and skill in the “double foundation layer” should think about not only the knowledge reserve of primary and secondary school students, but also the consistency and systematicness of knowledge in different learning stages. In the “problem solving layer”, it is mainly to apply AI knowledge and skills to solve problems in life and prove life quality. The study case of AI education can choose from multiple fields, such as intelligent education, intelligent transportation, intelligent agriculture, intelligent finance, intelligent medical care, etc.. The “Subject thinking layer” focuses on computational thinking, logical thinking, scientific thinking, information literacy and innovative thinking, from the characteristics of AI subject and social talent needs.

*Table 1 Core Literacy Of Ai Education for Primary and Secondary Schools*

Core literacy		Target of ability	Course content
Dimensions of core literacy	Content of core literacy		
Humanistic connotations	Humanistic feelings		Concern with issues related to human development and human well-being in society. Explore and analyze the existing problems in agriculture, transportation, education, environment and other aspects, as well as the improvement of the above fields by AI technology. And pay attention to AI to promote human development and human happiness.
Scientific spirit	Rational thinking	Computational thinking	Master computer programming, and achieve the application of AI function models, so as to cultivate the ability of applying computer science to solve problems. Primary school: graphic programming, call of AI function modules; Junior high school: simple Python programming, application of AI function modules; High school: Python programming, database, core algorithm of AI, realization of AI function
		Engineering thinking	Complete engineering projects and experience the engineering process, so as to cultivate the engineering thinking. Project-based teaching: realize functions such as voice recognition and face recognition by calling APIs, and complete AI systems such as smart classroom and smart monitoring.

		Scientific literacy	Understand scientific knowledge, scientific research methods, and the impact of science on society, so as to cultivate the scientific literacy.	Primary school: Recognize, perceive and experience AI; Junior high school: study the research process, research methods and knowledge system of AI; Senior High School: acquaint the frontier development and application of AI.
Healthy life	Self-management and healthy personality		Time management, self-control, teamwork, communication, frustration resistance, competitive ability.	On the one hand, through group learning and project teaching, cultivate teamwork and communication ability. On the other hand, set up scientific assessment methods, such as work display, group competition, etc., to cultivate competitiveness, frustration resistance, and self-management capabilities.
Practice and innovation	Innovation ability and problem-solving ability		Find problems, define problems, explore solutions to problems, and apply knowledge and technologies, so as to cultivate the innovation ability and problem-solving ability.	Guide students to discover problems in life, define problems, put forward solutions through the application of AI, and explore the application of technology.

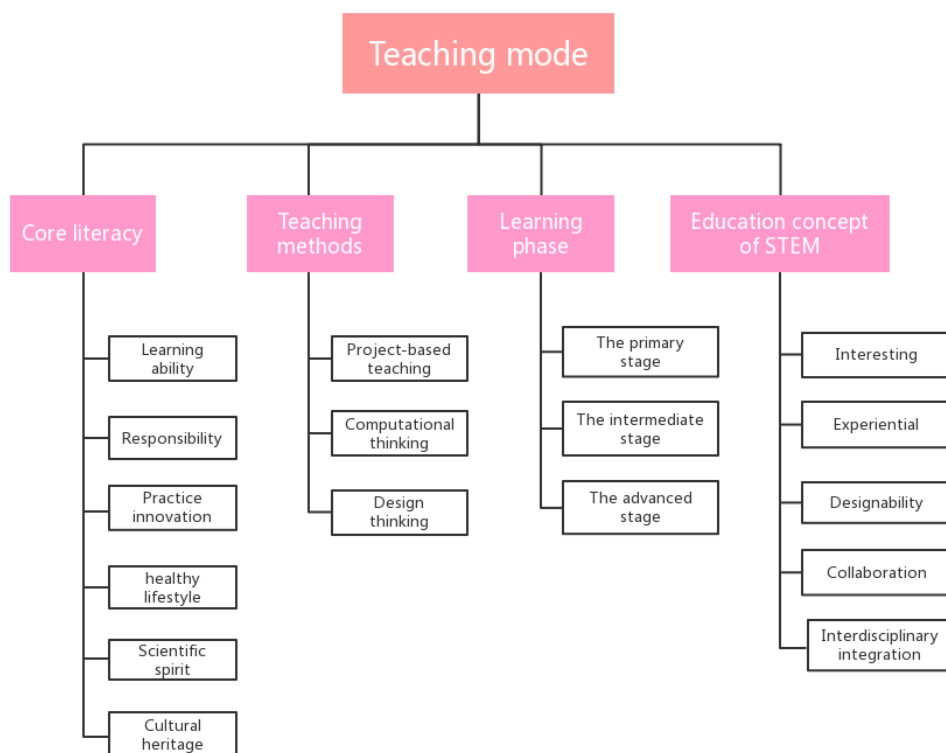
### 3. Framework of Ai Education for Primary and Secondary Schools

#### 3.1 Teaching Model

From the agrarian age to the industrial age to the information age, productivity are driven by technology. In the future, only those with the core literacy of the 21st century can take the initiative in the fierce competition. To face the challenges of the 21st century, students must have excellent comprehensive qualities and a solid foundation in science, technology, engineering and mathematics, that means having a good STEM literacy. The teaching model of AI education in this article is based on the principles of creativity, openness and systematicness. In addition, the teaching model aims at the core literacy of AI and is guided by the concept of STEM education. Therefore, we have constructed the teaching model of AI education for primary and secondary schools , with the structure of “posing questions-investigation and analysis-learning related knowledge-designing schemes-development and production-display and evaluation”. The main idea of the teaching model is to start form the real life, rely on project-based teaching[11], carry out exploratory learning, and realize knowledge acquisition and development of core literacy in the process of project learning. Among them, the research, analysis and decomposition of the project can focus on the method of computational thinking[12], and the design and manufacture procedure can focus on the method of design thinking[13].

In summary, the teaching model of AI education for primary and secondary schools contains the following: Firstly, learn form the concept of STEM education, especially fully absorb its characteristics of inter-disciplinary integration, interest, experience, context, collaboration, design, artistry and empirical, so as to design a content-rich, implementable and evaluable course system for AI education. Secondly, aim to cultivate students’ core literacy of AI. First of all, the course focuses on cultivating students' scientific literacy, information literacy and computational thinking, by means of various AI learning modules, such as programming, robotic operation, speech recognition, computer vision, ect.. Then, the core literacy of AI education is integrated into the whole teaching process, by project-based teaching method, with particular emphasis on innovation ability and problem solving ability. Finally, during project learning, the principles of student-led,

teacher’s guidance, and group cooperation are followed to cultivate students' teamwork skills, communication skills, and critical thinking, etc. Thirdly, we divide AI education for primary and secondary schools into three stages: elementary, intermediate and advanced. In terms of teaching methods, teaching contents, teaching resources, and so on, we must pay attention to systematization, migration and connection.



*Fig.1 Block Diagram of Teaching Model*

### 3.2 Course System

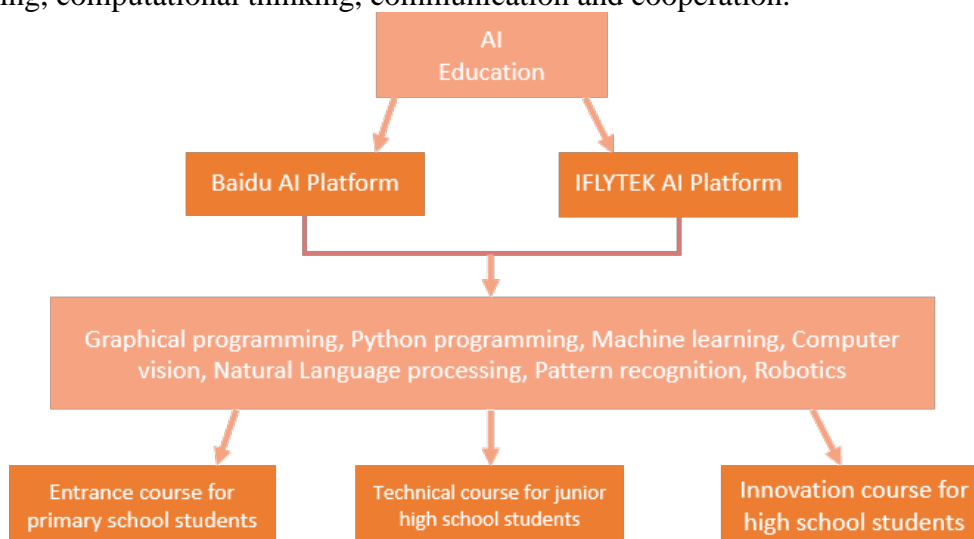
The AI courses should not only focus on subject knowledge and hands-on operation, but also pay attention to students' rational thinking. The AI courses rely on the iFLYTEK’s AI platform and the Baidu’s AI platform. The content of AI course includes graphical programming, python programming, machine learning, deep learning, computer vision, natural language processing, speech recognition, pattern recognition, robotics and other course modules. Each course module is carried out by project-based teaching, by applying knowledge and technology to solve problems in real life. Piaget’s cognitive development theory states that, “students in primary school can internalize their perceptions, and can conduct simple abstract logical thinking with the support of specific learning content. Form the beginning of the junior high school, students can get rid of specific learning content for abstract logic, and can make assumptions, deductions, and inferences”. According to the cognitive ability, interests, and knowledge reserves of students at different stages, the AI courses are divided into three stages: entrance course, technology course, and innovation course, as well as divided into three forms of implementation: compulsory courses, elective courses and vocational courses. For each learning stage, we develop three learning projects with

corresponding difficulty levels for each course module. Schools can freely choose and combine learning projects.

The entrance course is designed for primary school students. The goal is to cultivate students' problem-solving ability, scientific literacy and learning interest. The entrance courses are mainly based on cognitive and experiential courses at entry-level, such as graphical programming and experience of face recognition, voice recognition, so that students can understand the impact of AI on life and society, and stimulate the enthusiasm of science. In this learning stage, teachers and students learn together, discover problems together, and solve problems together.

The technology course is designed for junior high school students. The goal is to develop students' ability to find problems, communicate, cooperate and solve problems creatively. It focuses on simple technical application courses such as python programming, robot operation, application of AI module, etc. Through a series of activities such as understanding, experience, and simple creation, students can understand the basic principles of science, and how science and technology “do”.

The innovation course is designed for high school students. It focuses on practical courses such as high-level python programming, AI algorithms, intelligent robots, etc. It emphasizes the understand of basic concepts and principles of AI. And, in the process of project teaching, students need to define problems, and apply knowledge and technology to solve complex and open problems in the real world. Through actual projects, students will be able to develop their ability to understand the world and positive values, as well as the ability to innovation, logical thinking, critical thinking, computational thinking, communication and cooperation.



*Fig.2 Block Diagram of Course System*

#### 4. Teaching Team

The AI education has the characteristics of new ideas, multiple contents, great difficulty and rapid development, so various problems and difficulties will be encountered in the implementation process. And, constraints on the number and professional competence of teachers are the biggest bottleneck. Therefore, the cultivation of AI teachers for primary and secondary schools is a top priority. There are mainly two ways to train high-quality teachers. One is undergraduate or master's degree education in normal colleges or universities, and the other is to carry out their own teacher training for primary and secondary schools.

For degree education program, there are also mainly two ways. The first is to set up a bachelor's degree in normal colleges or universities. We can offer AI education majors, or add AI education

courses to computer majors. The second is to set up two kinds of master's degree in AI education, the one is for university students, and the other is for in-service teachers in primary and secondary schools or other persons in AI education. AI training program in primary and secondary schools, is also an important way to improve the quality of AI teachers. The school can train their own AI education teachers through various forms such as pre-service teacher training, on-the-job training, and school teaching reform. In addition, it can promote the training of AI teachers through government-enterprise schools cooperation or school-enterprise cooperation. For example, establish teacher training centers at the provincial and municipal levels. Furthermore, through school-enterprise cooperation, primary and secondary schools can also set up their own labor and AI teacher training base, etc.

## 5. Course Evaluation

To design a practical and floorable evaluation system for AI education , we must not only learn from high-quality evaluation theories, but also adopt constructional method of scientific evaluation system. On the one hand, we take the theory of multiple intelligences [14] and the thought of expressive evaluation [14] as the theoretical basis. The theory of multiple intelligences contains, “paying attention to the intelligent development of students, diversified evaluation content, diversified subjects of evaluation, contextual evaluation methods, intelligent display, etc.”. The expressive evaluation is worthy of our reference, which mentions “requires to stimulate students’ high-level thinking ability, and requires students to demonstrate, create, and produce during evaluation”. On the other hand, the constructional methods of the evaluation system we adopted include the following: First, the content of evaluation should be clearly defined, and the three-dimensional goals of “knowledge and skills”, “process and method”, “Emotion and value” should be organically unified. Second, the evaluation should be integrated into the whole teaching process, as an important part of students’ learning. Third, specific evaluation methods should be selected according to specific learning contents. Moreover new evaluation methods, such as growth record, learning contract, evaluation scale and concept map, can be tried. Fourth, the evaluation system is diversified, which is composed of teacher groups, student groups, parent groups, and social evaluation agencies. And multiple comprehensive methods can be used, such as self-evaluation, mutual evaluation, and teacher evaluation [15].

AI education for primary and secondary schools emphasizes hands-on operation and design, so it adheres to the principle of combining display and share with multiple evaluation. At the same time, by giving students objective evaluations in all aspects, it can promote the improvement and perfection of students' works, and can cultivate students' reflective ability and problem-solving ability. In terms of curriculum evaluation, the development value of evaluation to students should be highlighted, and the diversity of student activities and problem-solving strategies should be fully affirmed, and self-evaluation and the communication about experience sharing between peers should be encouraged. In addition, teachers should adopt qualitative evaluation method more than quantitative method, in order to avoid simplifying the evaluation to scores or grades.

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