A Study on the Framework for Measuring Artificial Intelligence Literacy in Junior High School Students

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Abstract. Artificial Intelligence (AI) literacy is the inevitable requirement to comply with the development of the intelligent era, is the specific embodiment of the talent in the AI era, and is crucial to the learning and future development of junior high school students. Constructing an AI literacy assessment framework for junior high school students is conducive to improving the evaluation standard of AI literacy for junior high school students. In this study, on the basis of systematically sorting out the connotation and constituent elements of AI literacy, we initially constructed a framework for the assessment of AI literacy, and compiled and distributed a questionnaire; then we conducted a reliability test and a validation factor analysis of the questionnaire, and finally determined a framework for the assessment of junior high school students' AI literacy that included four core dimensions: AI affective attitudes, AI knowledge, AI skills, and AI values and ethics, after correction; and finally we analyzed and gave the assessment standard of junior high school students' AI literacy in terms of the data from the questionnaire. Finally, the questionnaire data were analyzed and suggestions for the cultivation of AI literacy in junior high school students were given.

Keywords: AI Literacy; Junior High School Students; Assessment Framework; Literacy Development

1 Introduction

AI has now jumped to become a key competitiveness for social development, not only leading the innovation trend in the field of science and technology, but also exerting far-reaching impacts on various levels of the economy, culture, and education, and becoming an important symbol of national competitiveness and a new focus of global competition.

In February 2022, the United Nations Educational, Scientific and Cultural Organization (UNESCO) released the report "K-12 Artificial Intelligence Curriculum Mapping: government-endorsed AI curricula", which emphasized that all citizens need to have a certain level of AI literacy to adapt to a world increasingly driven by AI technology. In October of the same year, the Ministry of Education of the People's Republic of China developed and promulgated the "Compulsory Education Information

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Technology Curriculum Standards (2022 Edition)" (hereinafter referred to as the "New Curriculum Standards"), and the "New Curriculum Standards" provide a detailed description of the AI knowledge that students need to master in the content of the curriculum for the fourth academic period (grades 7 to 9).AI education has been slowly gaining popularity, and educators are developing related curricula to improve students' s AI literacy, but there is no consensus among scholars on the structure of AI literacy for junior high school students, and few scholars have developed tools to measure junior high school students' AI literacy.

This study intends to explore the following two questions under the perspective of focusing on the "New Curriculum Standards": (1) What is the definition of AI literacy for junior high school students, and what are the elements of the AI literacy structure? (2) How to construct a framework for measuring AI literacy of junior high school students in China?

2 Review

2.1 AI literacy Connotation

The following widely recognized views on the definition of AI literacy exist. Long and Magerko argue that AI literacy encapsulates a set of competencies that enable individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace [1]. Gary et al. define the scope of AI literacy as AI Concepts, AI Applications, and AI Ethics and Safety, where AI Concepts refers to understanding basic AI concepts and their origins.AI applications mean to appreciate the practical applications of AI concepts.AI ethics means to be able to describe the ethical challenges and safety issues faced when applying AI technologies in the real world [2]. Wong et al. specifically defined AI literacy in K-12 education. AI literacy is the ability to solve problems effectively and ethically in a variety of socio-cultural contexts with the use of AI tools, systems, and frameworks to and thus the ability to readily interact with AI [3].

The "New Curriculum Standards" aimed that through the learning of this module, students can recognize and feel the charm of AI, know the ethical and moral norms that must be followed in the development of AI, and recognize the new opportunities and challenges under the new social form of the smart society [4].

This paper argues that AI literacy is to help students master the necessary character and key abilities to adapt to the intelligent society, and junior high school students do not need to have a very in-depth grasp of the underlying technical principles of AI. It is a comprehensive and up-to-date cognitive system and skills, and a comprehensive literacy integrating effectivity, knowledge, skills, and ethics.

2.2 Elements of AI Literacy Measurement

In the previous period, using the literature reading method, we searched, sorted and analyzed numerous related literatures at home and abroad, and refined and summarized the following high-quality and highly persuasive framework for AI literacy.

Long et al. summarized the definition of AI literacy and a set of competencies that students need to master, based on which they proposed a framework for AI literacy [1]. Wong et al. established a clear scope of AI literacy for K-12, and divided the elements of AI literacy into three dimensions [2]. Hyein defined the core elements contained in students' AI literacy in the K-12 stage, and based on this, he proposed a framework of AI literacy elements [5]. Wang Yijun et al. analyzed the connotation interpretation of AI literacy and constructed a five-dimensional AI literacy education content system [6]. Yang Hongwu constructed a framework of AI literacy in the context of STEM and clarified the core elements of each dimension [7]. Zhang Yinrong et al. constructed a three-dimensional AI literacy model based on the theoretical foundation of the "Five Concepts of Artificial Intelligence"[8]. Zhong Bachang et al. constructed an AI literacy framework based on the three-dimensional goal model and tracing back the technology ontology [9]. Cai Yingchun introduced the KSAVE model and constructed an AI literacy framework covering five key areas [10].

Existing studies are mostly reviews and analyses at the theoretical level, with insufficient empirical studies and a lack of quantitative studies. There is an urgent need to construct operationalized scales based on theoretical frameworks. Based on Long, Hyein et al.'s framework, this study integrates the requirements of the AI module in the "New Curriculum Standards", and finally selects four dimensions: the AI affectivity, the AI knowledge, the AI skills, and the AI value ethics. Using a research method that combines quantitative and qualitative means, this study takes junior high school students as the research subjects, based on in-depth interviews, questionnaires, and data analysis, to validate the proposed AI literacy framework and to test whether the scale is reliable and valid.

3 Research Design

3.1 Preparation of the Measurement Scale

Since the domestic research related to the assessment of AI literacy in junior high schools is still in its infancy, this study refers to a few of domestic and international literatures, extracts and integrates the keywords of the dimensions of AI literacy, and merges and categorizes them according to the connotations of the dimensions. Finally, the localized revisions and pre-tests were integrated with the requirements set forth in the "New Curriculum Standards" for students in the field of AI. The study culminated in an initial questionnaire consisting of 24 Likert 5 scale items. In addition to the AI literacy related items, the questionnaire also included basic information such as whether the family had purchased smart products and the parents' education.

To improve the quality of the questionnaire, 10 junior high school students were invited to conduct in-depth interviews before the questionnaire was officially distributed. They were first asked to fill out the questionnaire, and then asked about their understanding of the questions, the logic of their answers, and suggestions for revision. Finally, the questionnaire was adjusted to ensure that the formal subjects could fill in the appropriate answers according to the questions and their own real situations.

3.2 Data collection and Statistical Methods

This study took junior high school students in the city center of a certain city as the target of the survey. 392 questionnaires were collected, and after strictly eliminating cases with too many outliers and missing values, 359 valid questionnaires were finally obtained, with a valid recovery rate of 91.6 %.

The distribution of the samples was relatively balanced in terms of gender, grade, and other key indicators. There were 161 male students, accounting for %44.85 and 198 female students, accounting for 55.15%; 40.39% in the first grade, 30.07% in the second grade, and 29.54 in the third grade. 40.39% of the students had learned programming, and 84.4% had purchased smart products at home. The distribution of parents' education shows a relatively balanced feature.

Exploratory factor analysis of the questionnaire was conducted using SPSSAU software to ensure the consistency, stability, and reliability of the questionnaire. Validated factor analysis (CFA) was carried out using AMOS26.0 to test the validity and reasonableness of the AI literacy assessment scale.

4 Research

4.1 Exploratory Factor Analysis

The KMO value of the scale was 0.946, and the Bartlett's test of sphericity reached the significance level (p=0.000), making the data suitable for factor analysis. The initial exploratory factor analysis, without limiting the number of factors, used the maximum likelihood method with the Promax skewed transcendental method to extract five common factors with eigenvalues greater than 1, with a cumulative variance explained of 58.6%. Based on the inter-item correlation and factor loading coefficients were checked, the framework structure was re-adjusted, and finally 22 items with four dimensions were retained. The cumulative variance explained after rotation was 66.952% >50% (Chisquare=5195.114, df=231, p<0.001), indicating good validity of the final scale. The Cronbach's coefficient alpha coefficients for the four dimensions ranged from 0.798 to 0.913, with ideal internal reliability.

4.2 Validation Factor Analysis

A validation factor analysis was conducted to test the convergent and discriminant validity of the scales to validate the fit of the model structure to the actual data. To verify the structural validity of the model, the researcher conducted the calculation of convergent validity and discriminant validity. After deleting some question items based on the indicators, the data of Composite Reliability (CR), Average Variance Extraction (AVE) and Heterogeneous-monomers ratio (HTMT) are shown in Table 1. The CR of the four factors is greater than 0.7, and the AVE is greater than 0.5, which has good convergent validity. The discriminant validity analysis is conducted for the HTMT values, and all of them are less than 0.85, which implies that there is a good differentiation between

the factors. Therefore, the model has good lean convergent validity and discriminant validity.

Table 1. Convergent and differential validity of factors

Dimension	Items	CR	AVE	HTMT			
				Affectivity	Knowledge	Skills	Value ethics
Affectivity	4	0.808	0.515	-	-	-	-
Knowledge	7	0.905	0.576	0.730	-	-	-
Skills	4	0.809	0.514	0.686	0.834	-	-
Value Ethics	7	0.905	0.578	0.755	0.801	0.721	-

The overall fit of the model was good after the model was adjusted according to the correction indicators. Finally, the AI literacy measurement framework scale was formed as shown in Table 2.

Table 2. Dimensions and indicators of the AI literacy assessment framework for junior high school students

Primary dimension	Sencondary dimension	Subject matter	Factor load
AI affectivity	AI aspirations	I am willing to learn AI.	0.609
		I am willing to experience and use the AI.	0.774
	AI awareness	I think about AI technology to help me solve a problem when I run into it.	0.702
		I think people and machines working together can improve the efficiency and quality of problem solving.	0.775
AI knowledge	AI concepts	I know that AI is a technology that uses machines to simulate, extend and expand human intelligence.	0.715
		I know data, algorithms and arithmetic are the three main technological foundations of AI.	0.762
		I know general process of machine learning.	0.802
		I know that machine learning includes supervised and unsupervised learning.	0.751
	AI development	I know what stages of development AI has.	0.800
		I can apply learned AI to come up with ideas to solve problems.	0.710
		I know that moving from perceptual to cognitive intelligence is the future trends in AI.	0.767
AI skills	AI application skills	I can apply AI to achieve specific functions.	0.735
		I can use AI to create my own work.	0.704
	AI basic skills	I can write a program that calculates the sum of numbers from 1 to 100.	0.688
		I can use some software for data processing.	0.740
AI value ethics	AI ethics knowledge	AI and human intelligence each have their own strengths and reinforce each other.	0.703
		AI can mimic the human ability to perceive, think, learn, and behave.	0.601

		AI can be used in areas such as autonomous driving, education, healthcare, and security.	0.773
	AI ethic	The application of AI may compromise the privacy of individuals.	0.767
		The development of AI is guided by the principle of protecting privacy and security.	0.855
		AI must be developed in a safe and controlled manner to achieve sustainable development.	0.874
		AI development must be human-centered.	0.715

4.3 Data Analysis

The survey data showed that junior high school students vary widely in the four AI literacies (as shown in Table 4). Among them, value ethics (M=4.25) and affective attitudes (M=4.06) are higher, which may be due to the fact that junior high school students are more curious about emerging things, and at the same time the ethical value concepts of AI, compared with the other dimensions, are more likely to be effectively guided and infiltrated in the three key domains of school, society, and family, which in turn influences the individual value judgments and ethical choices in a subtle way. The lower mean value of the knowledge and kills dimensions may be attributed to the lack of curriculum resources, insufficient teachers, low recognition of offering AI courses in schools, and the lack of practice opportunities in a single mode of learning.

Table 3. Indicator dimension statistics

Dimension	AI affectivity	AI knowledge	AI skills	AI value ethics
Average Value	4.06	3.86	3.79	4.25

5 Conclusions

On the basis of sorting out the meaning of AI and the elements of the framework, combining the relevant research results of previous researchers and the relevant contents of the "New Curriculum Standards", this study prepared and distributed a questionnaire, and constructed a framework for assessing junior high school students' AI literacy in the four core dimensions of affective attitudes, knowledge, skills, and values and ethics, after scientifically and rigorously exploratory and validation factor analyses. This framework provides a more systematic and comprehensive assessment standard for assessing students' AI literacy, which helps schools and educators to understand students' mastery more accurately in the field of AI, provides scientific guidance for cultivating students' AI literacy, lays a solid foundation for future scientific and technological talent cultivation, and is of great significance in promoting the modernization of education and the development of intelligence.

But the assessment framework may be difficult to adapt to the actual situation in different regions. There may be differences in the educational level, cultural background, and student characteristics in different regions, and one assessment framework cannot fully adapt to the actual situation in all regions. In practical application, it needs

to be adjusted and optimized appropriately according to local characteristics. Therefore, subsequent researchers or users of this scale need to take these factors into full consideration during the design and implementation process, and make appropriate adjustments and optimizations to the assessment framework.

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