Development of Artificial Intelligence Literacy Model for Secondary School Teachers in Shenzhen

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Abstract

The purposes of this research were: 1) To study the current level of knowledge of secondary school teachers' artificial intelligence literacy 2) To develop a teachers' artificial intelligence literacy improvement model for secondary schools 3) To evaluate the teacher's artificial intelligence literacy improvement model.

The study invited 21 experts to conduct three rounds of consulting using the Delphi method to identify core competencies and refine the model components. This was done to determine the variable issues of effective teacher artificial intelligence literacy, resulting in the developing of a model for improving secondary school teachers' primary index factors includes: Cognition, Ethics, Artificial Intelligence Applications, Artificial Intelligence Pedagogy, Development, and Evaluation. For the accuracy of the data, the interviewees were experts with professorial titles from artificial intelligence professionals, the online education field, and normal universities. The expert qualifies to have the rank of professor or above and has at least 20 years of experience working in a related field.

The results show that the Teacher Artificial Intelligence Literacy Model consists of 6 primary index factors and 36 secondary index factors. The specific content of the 6: Cognition, Ethics, Artificial Intelligence Applications, Artificial Intelligence Pedagogy, Development, and Evaluation.

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Introduction

AI as a key part of modern society. Artificial Intelligence (AI) has moved from science fiction to an essential part of everyday life, influencing sectors like healthcare, transportation, and finance. AI-powered tools, such as virtual assistants and recommendation systems, enhance efficiency and user experience. Its growing presence marks a major shift in how people work and interact, making AI a central force in the fourth industrial revolution.

The importance of AI literacy is crucial for digital inclusion, equitable knowledge access, and social progress. UNESCO highlights four key pillars for an inclusive knowledge society: freedom of expression, universal access to information, quality education, and cultural diversity. AI supports these goals by expanding learning opportunities and fostering innovation. As AI continues to shape education and workforce demands, equipping educators with AI literacy is essential.

The need to train secondary school teachers. Despite AI's growing role in education, many secondary school teachers lack training in AI concepts, limiting their ability to prepare students for future careers. Studies show that teachers often feel unprepared due to inadequate training, resources, and institutional support. Addressing this requires a structured AI literacy framework tailored for educators.

Enhancing AI literacy through teacher training. Bridging this gap requires comprehensive AI training programs in teacher education and professional development. Universities and training institutions should integrate AI courses into curricula, while workshops, seminars, and peer-learning programs can further support educators. Exposure to AI experts and best practices will help teachers effectively integrate AI into their teaching.

Research Objectives

1) To study the current level of knowledge of secondary school teachers' artificial intelligence literacy

2) To develop a teachers' artificial intelligence literacy improvement model for secondary schools

3) To evaluate the teacher's artificial intelligence literacy improvement model

Literature Review

Teaching AI concepts can help students become informed citizens and prepare for AI-related careers (Kong & Abelson, 2022; Touretzky et al., 2019). Consequently, current

research focuses on designing optimal curricula for young students (Chiu et al.,2022; Eguchi et al., 2021; Lin & Van Brummelen, 2021; Vartiainen et al.,2020; Zhou et al., 2020), highlighting the need to prepare teachers with the necessary competencies to teach AI concepts (Ayanwale et al., 2022; Kong & Abelson, 2022; Wilson, 2011).

Artificial intelligence (AI) was first defined as “the science and engineering of making intelligent machines” in 1956 (McCarthy, 2007, p. 2). Throughout several decades of the 20th century, AI has evolved progressively into intelligent machines and algorithms that can reason and adapt based on sets of rules and environments that mimic human intelligence (McCarthy, 2007). Wang (2019) broadened the definition of AI which can perform cognitive tasks, particularly learning and problem-solving with the exciting technological innovations such as machine learning, natural language processing and neural networks (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

According to a literature search, there is a dramatic increase in AI literacy publications from 2014 to 2024. As AI becomes more and more important in work settings and everyday life, researchers began to define AI literacy based on the term 'literacy' which has been applied to define skill sets in varied disciplines (Long & Magerko, 2020). However, few studies have provided comprehensive explanations of how to conceptualize AI literacy. To achieve a better understanding of the concept of AI literacy, researchers categorize how researchers define the term in multiple aspects, inspired by the cognitive domains in Bloom's taxonomy (Ng, 2021).

The reason that we adopt the TPACK model is that it is widely used across studies to identify how teachers can incorporate technologies into their pedagogical methods and content knowledge and conceptualizes their capacity and knowledge that is needed to integrate relevant technologies in AI literacy education (e.g., Graham, 2011; Koehler et al., 2013). It provides a map for understanding how to integrate AI literacy into classrooms effectively. For example, Kim et al. (2021, pp. 1-13) based on AI learning resources to conceptualize TPACK to improve teaching for K-12 AI education, which offers core foundations of AI taught to young learners.

Research Conceptual Framework

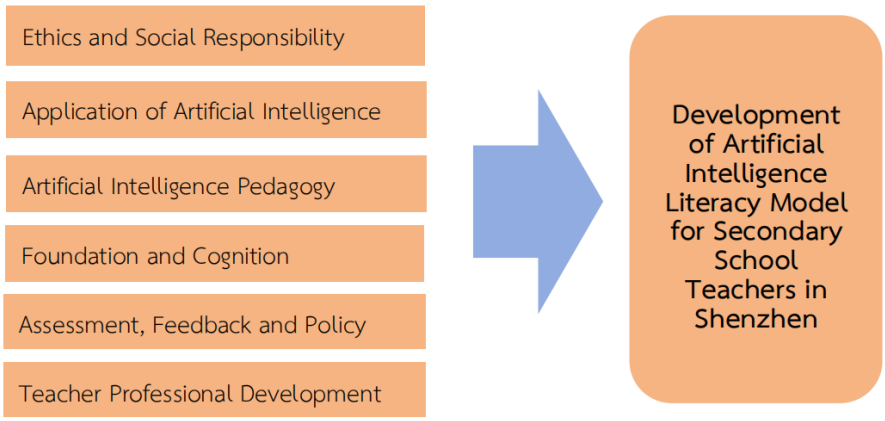

Figure 1 Research Framework

Research Procedure and Processes

Research objectives 1 and 2 are addressed by discerning the feasibility of factors influencing digital technology support in the context of the Secondary School Teacher Artificial Intelligence Literacy Improvement Model.

The Delphi method, a structured communication technique, is utilized to engage experts and reach a consensus on relevant factors. Insights from the literature review are combined and reconciled with expert opinions to iteratively refine and develop the model. Five experts were invited to conduct an IOC (Index of Item - Objective Congruence) test on the discussion outline. The five experts reached a consensus on the composition of 8 elements related to the current training problems of secondary school teachers. To study the effective elements of current secondary school teacher training, 21 experts were interviewed, and conclusions were drawn. Questionnaire data analysis was used to analyze the questionnaire on the artificial intelligence literacy cultivation model in Shenzhen secondary schools, which was classified according to the median, mode, and interquartile range. To evaluate the effectiveness of the model, this study combined the established training model for teachers' artificial intelligence technology teaching methods and developed pre - test and post - test questionnaires to assess the changes in teacher training satisfaction and evaluate the training model for artificial intelligence technology teaching methods. After the initial formation of the questionnaire, it was submitted to 5 experts for feedback to examine its language applicability, integrity, and comprehensiveness, and was improved according to the experts' suggestions. After modification, the Innovation and Entrepreneurship Ability Test Questionnaire was verified by 5 experts using the IOC method. The experts believed that the questionnaire had good consistency and could be used for the course satisfaction test. Finally, a training model for secondary school teachers' artificial intelligence technology teaching

methods was designed. Through three rounds of expert interviews, an artificial intelligence literacy model for secondary school teachers in the Shenzhen area was established.

Research Results

Part I: To study current problems and solutions of AI literacy assessment of teachers in Shenzhen.

What problems exist in the current training of secondary school teachers regarding the Teacher Artificial Intelligence Literacy Improvement Model? The investigation of current situation problems includes eight aspects: basic knowledge of artificial intelligence and needs, integration of artificial intelligence in teaching, computational thinking and problem - solving, ethical and responsible use of artificial intelligence, professional development and lifelong learning, management of artificial intelligence tools and resources, student empowerment supported by artificial intelligence, and systemic challenges and institutional support. Each aspect is evaluated at high, medium, low and uncertain levels.

The survey results indicate that all respondents (100.0%) assessed the Foundational AI Knowledge and Needs of secondary school teachers as being at a high level. Similarly, 90.5% rated the Integration of AI in teaching as high, while 9.5% rated it as medium. For Computational Thinking and Problem-Solving, 85.7% provided a high rating and 14.3% rated it as medium. In terms of Ethics and Responsible AI Use, 57.2% of respondents rated it as high, 28.6% as medium, and 14.2% as low-indicating a more varied perception compared to other factors. Regarding Professional Development and Lifelong Learning, 90.5% assessed it as high and 9.5% as medium. All respondents (100.0%) evaluated AI Tools and Resource Management as high. For AI-Supported Student Empowerment, 47.6% of respondents rated it as high, 33.4% as medium, and 19.0% as low, reflecting a relatively lower consensus on this dimension. Finally, for Systemic Challenges and Institutional Support, 85.7% provided a high rating and 14.3% a medium rating. These findings highlight strong consensus on foundational knowledge, resource management, and professional development, while indicating the need for targeted improvement in ethical practice and student empowerment in AI-enhanced learning environments as shown in Table 1.

Through data analysis and literature review, a discussion outline on the current status of AI literacy training for middle school teachers in Shenzhen was formed, and 5 experts were invited to conduct IOC tests on the discussion outline. The 5 experts reached a consensus on the 8 elements of the current status of AI literacy training for teachers.

The survey results reflect the current status analysis of the problems of AI literacy training for teachers in the comprehensive information technology teaching methods. The current status includes 8 elements: Foundational AI knowledge and needs, Pedagogical

Integration of AI, Computational Thinking and Problem-Solving, Ethics and Responsible AI Use, Professional Development and Lifelong Learning, AI Tools and Resource Management, AI-Supported Student Empowerment, Systemic Challenges and Institutional Support.

Table 1 Current Situation Analysis of problems in secondary schools teacher Artificial Intelligence Literacy training

Item	High (%)	Middle(%)	Low(%)	Unspecified(%)
1. Foundational AI knowledge and needs	21 /100%	0 /0.00%	0 /0.00%	0 /0.00%
2. Pedagogical Integration of AI	19 /90.5%	2 /9.5%	0 /0.00%	0 /0.00%
3. Computational Thinking and Problem-Solving	18/ 85.7%	3 /14.3%	0 /0.00%	0 /0.00%
4. Ethics and Responsible AI Use	12 /57.2%	6 /28.6%	3 /14.2%	0 /0.00%
5. Professional Development and Lifelong Learning	19 /90.5%	2 /9.5%	0 /0.00%	0 /0.00%
6. AI Tools and Resource Management	21 /100%	0 /0.00%	0 /0.00%	0 /0.00%
7. AI-Supported Student Empowerment	10 /47.6%	7 /33.4%	4 /19.0%	0 /0.00%
8. Systemic Challenges and Institutional Support	18 /85.7%	3 /14.3%	0 /0.00%	0 /0.00%

Part 2: To develop a teacher's artificial intelligence literacy improvement model for secondary schools.

According to Table 2, in the second round of research, 21 experts reached a consensus on 8 effective strategies for the elements of the training model of teachers' artificial intelligence literacy for Secondary school teachers in Shenzhen City. The ranking from high to low is as follows:

Foundational AI knowledge and needs (Md=5.0, Mo=5.0, IQR=0.0), AI Tools and Resource Management (Md=5.0, Mo=5.0, IQR=0.0), Computational Thinking and Problem-Solving (Md=5.0, Mo=5.0, IQR=0.5), Professional Development and Lifelong Learning (Md=5.0, Mo=5.0, IQR=0.5), Systemic Challenges and Institutional Support (Md=5.0, Mo=5.0, IQR=0.5), Pedagogical Integration of AI (Md=4.0, Mo=4.0, IQR=0.0), Ethics and Responsible AI Use

(Md=3.0, Mo=4.0, IQR=1.0), AI-Supported Student Empowerment (Md=3.0, Mo=4.0, IQR=1.0). Among these factors, Ethics and Responsible AI Use and AI-Supported Student Empowerment had a consensus level of less than 70%.

Table 2 Second Round Survey Results: Elements of the teachers' artificial intelligence literacy improvement model

Item	Elements of the teachers' artificial intelligence literacy improvement model	Md	Mo	IOR	Consensus
1.	Foundational AI knowledge and needs	5.0	5.0	0.0	95.24%
2.	Pedagogical Integration of AI	4.0	4.0	0.0	85.71%
3.	Computational Thinking and Problem-Solving	5.0	5.0	0.5	90.48%
4.	Ethics and Responsible AI Use	3.0	4.0	1.0	42.86%
5.	Professional Development and Lifelong Learning	5.0	5.0	0.5	90.48%
6.	AI Tools and Resource Management	5.0	5.0	0.0	95.24%
7.	AI-Supported-Student -Empowerment	3.0	4.0	1.0	42.86%
8.	Systemic Challenges and Institutional Support	5.0	5.0	0.5	90.48%

For objective 2, the Delphi method was used to refine the AI literacy training model for middle school teachers in Shenzhen through three rounds of expert surveys. Data from the questionnaires were analyzed using median, mode, and interquartile range. After two rounds of expert interviews, six key dimensions were identified: Cognition, Ethics, AI Applications, AI Pedagogy, Development, and Evaluation. In the final round, experts validated the model, leading to a revision of the original indicators. The number of primary factors was reduced from 8 to 6, and secondary indicators from 80 to 36, improving clarity and relevance. The final AI literacy model consists of six key components: Cognition, Ethics, AI-Apps, AI-Pedagogy, Development, and Evaluation as shown in Table 3.

Table 3 Results of the third round: training model elements of teachers' artificial intelligence literacy for Secondary Schools Teachers

Item	Training model elements of teachers' artificial intelligence literacy for Secondary Schools Teachers	Md	Mo	IOR	Consensus
1.	Cognition	5.0	5.0	0.0	95.24%
2.	Ethics	5.0	5.0	0.5	90.48%

Item	Training model elements of teachers' artificial intelligence literacy for Secondary Schools Teachers	Md	Mo	IOR	Consensus
3.	AI-Apps	5.0	5.0	0.0	95.24%
4.	AI-Pedagogy	5.0	5.0	0.5	90.48%
5.	Development	5.0	5.0	0.0	95.24%
6.	Evaluation	5.0	5.0	0.5	90.48%

According to Table 3, in the third round of research, 21 experts reached a consensus on the 6 effective strategies for the elements of the artificial intelligence technology teaching model for Secondary school teachers in Shenzhen Secondary Schools.

Based on the relevant opinions and suggestions put forward by experts on the selection of indicators, the influencing factors of the AI literacy model for middle school teachers in Shenzhen were modified, merged, and supplemented. The AI literacy model for teachers was finally determined. Compared with the originally selected indicators, 8 indicator factors were modified to 6 indicator factors, ranked in order of importance: foundation and cognition, ethics and social responsibility, AI applications, AI-pedagogy, Development, and Evaluation. The secondary indicators were reduced from 80 to 36, and 44 were deleted. The final study shows that the teachers' artificial intelligence literacy model consists of 6 main indicator factors and 36 secondary indicator factors.

In summary, the Artificial Intelligence Literacy Model for Secondary Schools Teachers (Figure 2) consists of 6 main indicator factors and 36 secondary indicator factors.

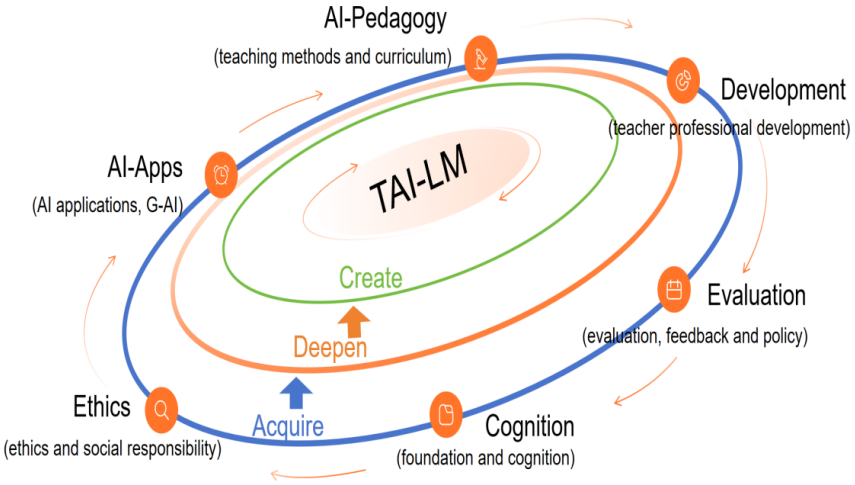

Figure 2 Teachers' Artificial Intelligence Literacy Model (TAILM)

Following focus group discussions with nine experts, the model was unanimously recognized as effective. This validated framework now serves as the Teachers' Artificial Intelligence Literacy Model (TAILM) for training educators.

Combined with the established training model for teachers' artificial intelligence technology teaching methods, pre-test and post-test questionnaires were developed to assess the changes in teacher training satisfaction and evaluate the training model for artificial intelligence technology teaching methods.

After discussing the above 36 items, this project was unanimously approved by 9 experts. According to the feedback from the experts, the guiding principles of the model were modified. Compared with the influencing indicators in the second round, 6 key indicators remained unchanged. They are Cognition, Ethics, Artificial Intelligence Applications, Artificial Intelligence Pedagogy, Development, and Evaluation.

Through this study, the Secondary School Teacher artificial intelligence technology teaching method training model was further confirmed. The evaluation results of the project indicate that the model has a significant effect. The model was also validated by expert interviews using the focus group interview method. Subsequently, the model was designed and explained. The final revised version generated the Secondary School Teacher artificial intelligence technology teaching method training model (Figure 3).

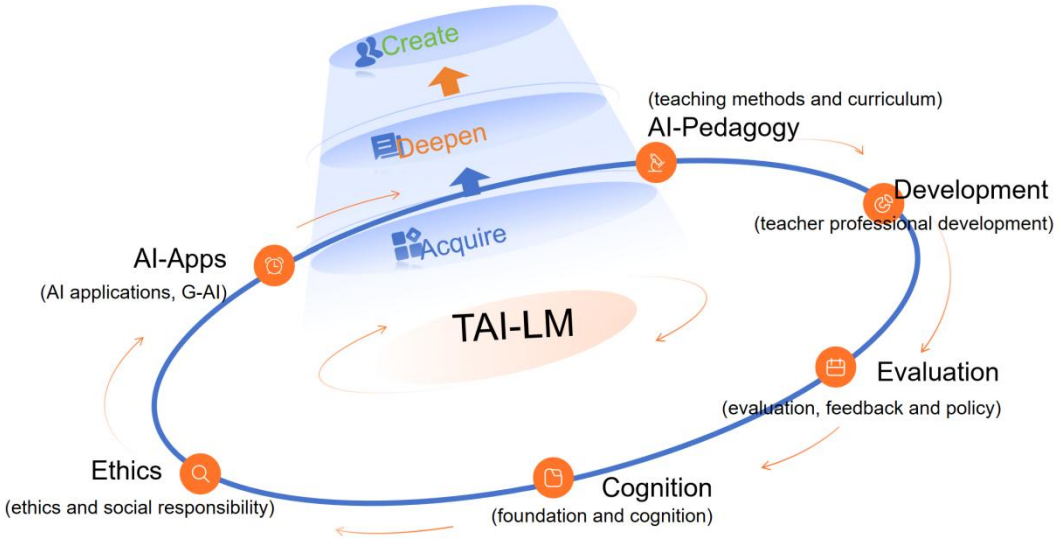

Figure 3 Teachers' Artificial Intelligence Literacy Model (TAILM modified version)

Conclusion

Research Objective 1 aimed to identify the key problems in the current training model for secondary school teachers' Artificial Intelligence (AI) literacy. The findings indicate

several persistent issues: insufficient practical and relevant training content, limited training resources, outdated pedagogical concepts and methods, lack of personalized learning pathways, and the absence of systematic tracking and evaluation mechanisms.

Drawing on concepts of AI literacy training, information technology pedagogy, and learning theory, the study employed literature review, expert interviews, and survey research to systematically identify these challenges. Eight primary factors were recognized: Foundational AI Knowledge and Needs, Pedagogical Integration of AI, Computational Thinking and Problem-Solving, Ethics and Responsible AI Use, Professional Development and Lifelong Learning, AI Tools and Resource Management, AI-Supported Student Empowerment, and Systemic Challenges and Institutional Support.

Expert consensus analysis revealed that the highest-priority factors were Foundational AI Knowledge and Needs, AI Tools and Resource Management, and Computational Thinking and Problem-Solving, followed closely by Professional Development and Lifelong Learning, and Systemic Challenges and Institutional Support. Pedagogical Integration of AI received moderate priority, while Ethics and Responsible AI Use and AI-Supported Student Empowerment showed relatively lower consensus (below 70%), indicating areas where further research and capacity-building are required.

Based on these priority rankings, the study developed the Artificial Intelligence Literacy Model for Secondary School Teachers in Shenzhen City, providing a structured framework to address both high-consensus competencies and underdeveloped areas in future teacher training programs.

Research Objectives 2 to design an Artificial Intelligence Literacy Model for Secondary school teachers.

Based on the elements determined in Research Objective 1, combined with concepts of teacher training, learning theories, etc., based on identifying the main factors of current teacher training problems, a comprehensive training model questionnaire for teachers' artificial intelligence technology teaching methods was designed. Through two rounds of expert interviews, the data results were analyzed and modified according to expert opinions, resulting in a new questionnaire for the training model of teachers' teaching methods for artificial intelligence technology. The model was verified through expert focus group interviews. Finally, the model was revised to form a training model for secondary school teachers' artificial intelligence technology teaching methods.

The six effective strategies for the Cognition (Basic Artificial Intelligence Knowledge and Needs) element are: basic artificial intelligence concepts, key applications of artificial intelligence in education, limitations and challenges of artificial intelligence, understanding artificial intelligence data structures and sources, the impact of artificial intelligence on society and the economy, and privacy and security issues in the use of artificial intelligence.

The five effective strategies for the Ethics (Morality and Social Responsibility) element are: the foundation of artificial intelligence ethics, understanding regulatory frameworks and guidelines, promoting digital citizenship in the use of artificial intelligence, protecting student data using artificial intelligence tools, and balancing technology use and ethical considerations.

The six effective strategies for the Artificial Intelligence Application (Artificial Intelligence Application, especially Generative Artificial Intelligence) element are: using artificial intelligence for personalized learning, using artificial intelligence tools to promote active learning, artificial intelligence - based adaptive learning technologies, selecting artificial intelligence tools suitable for classroom use, developing teaching resources with the assistance of artificial intelligence, and customizing artificial intelligence tools to meet different learning needs.

The six effective strategies for the Artificial Intelligence Pedagogy (Teaching Methods and Curriculum) element are: designing artificial intelligence-supported lesson plans, implementing artificial intelligence-driven formative assessments, algorithmic thinking and problem decomposition, designing basic artificial intelligence models for the classroom, exploring data-driven decision - making processes, and applying pattern recognition of datasets.

The six effective strategies for the Development (Teacher Professional Development) element are: participating in artificial intelligence-focused professional training, exploring global artificial intelligence education practices, leveraging online artificial intelligence learning platforms, creating artificial intelligence professional learning communities, attending artificial intelligence education conferences, and advocating for artificial intelligence policy reforms in the education field.

The seven effective strategies for the Evaluation (Assessment, Feedback, and Policy) element are: assessing the effectiveness of artificial intelligence tools in teaching, addressing common challenges of artificial intelligence tools, encouraging students to design artificial intelligence projects, teaching students about artificial intelligence career paths, addressing barriers to the adoption of artificial intelligence in schools, formulating artificial intelligence literacy assessment standards, and integrating artificial intelligence practices with school goals.

Discussion

This study examined the integration of mastery learning principles with artificial intelligence (AI) technologies, utilizing the digital learning platform and its extensive resources. By employing big data analytics for diagnostic assessment, the instructional design enabled adaptive teaching and the provision of tailored resources until students achieved the intended

learning outcomes-specifically, enhancing writing proficiency through reading-based strategies. This process facilitated the deep integration of AI technologies with subject instruction, fostering a mutually reinforcing relationship between reading and writing, generating innovative instructional strategies, and shaping a new form of teacher-student interaction.

With the increasing use of AI in writing instruction, integrating automated writing evaluation into a scientifically grounded framework is vital for assessing teachers' AI literacy. Such a framework should define the scope and principles of AI-assisted assessment, link evaluation methods to core teacher competencies, and guide targeted professional development. This approach enhances the validity of assessment practices while supporting teachers in effectively applying AI tools in their pedagogy.

The AI literacy framework proposed in this research aims to provide educational leaders from diverse contexts with evidence-based guidance for designing learning opportunities that foster AI literacy. Based on a participatory model in which comprehension, evaluation, and application of AI mutually reinforce one another, the study proposes strategies for policymakers, educators, learners, and families to advance AI literacy across all segments of society. This approach positions AI literacy as a means to enhance personal agency, critical awareness, and the capacity to make informed decisions for both individual and societal well-being.

Looking forward, it is essential to develop additional resources and guidance tailored to educators, learners, and families, enabling them to make well-considered decisions about when and how to integrate AI tools in diverse contexts. This includes providing appropriate scaffolding to support responsible and effective use. Ultimately, AI literacy must be understood as a multidimensional construct that encompasses not only technical knowledge but also ethical considerations, application competencies, and critical reflection on AI's societal impacts. The findings of this research underscore the need for systematic integration of AI literacy into curriculum design, teacher professional development, and policy frameworks to prepare individuals to engage with and shape AI-driven futures.

Recommendations

1. Establish the National AI Literacy Training System. Construct a tiered curriculum framework integrating UNESCO guidelines, encompassing technical principles, pedagogical applications, ethics, and innovation. Implement hybrid certification combining online micro-credentials and offline workshops to standardize teacher competencies nationwide.

2. Strengthen AI Ethics and Data Governance. Develop ethical frameworks aligned with UNESCO recommendations, emphasizing data privacy, algorithmic fairness, and human oversight. Establish school-level ethics committees and standardized training on data security

protocols (e.g., ISO/IEC 29134, TLS encryption), ensuring compliance in sensitive AI applications.

3. Formulate Classroom AI Implementation Standards. Define four operational boundaries: age thresholds (≥13 years), functional constraints (excluding value judgments), usage limits (≤25% class time), and human oversight mechanisms. Develop discipline-specific guidelines using Delphi consensus methods, supported by case repositories and risk assessment databases.

4. Build AI Education Practice Communities. Foster tripartite collaboration (academia-industry-schools) through professional learning networks. Create case-sharing platforms and interdisciplinary toolkits, prioritizing humanities integration and dual evaluation metrics (technical efficacy vs. humanistic impact) to balance innovation with pedagogical values.

5. Ensure Equitable AI Resource Allocation. Standardize infrastructure (computing power, connectivity, device coverage) per UNESCO benchmarks. Implement federated learning for data sharing and Gini coefficient monitoring (≤0.3) to optimize resource distribution. Establish compensation mechanisms for underserved populations, embedding equity metrics in AI adoption evaluations.

This research framework systematically constructs a national-level teachers' artificial intelligence literacy training system from five aspects: teacher training, ethical governance, application norms, practice community construction, and resource equity. In the future, with the continuous development of artificial intelligence technology, we should continue to develop and optimize the AI intervention model in educational scenarios, strengthen interdisciplinary collaboration, and ensure that AI technology can effectively promote educational equity and teaching innovation.

References

Ayanwale, M. A., Sanusi, I. T., Adelana, O. P. Kehinde D. Aruleba, K. D., & Oyelere, S. S. (2022). Teachers' readiness and intention to teach artificial intelligence in schools. *Computers and Education: Artificial Intelligence*. 3, 1-11. https://doi.org/10.1016/j.caeai.2022.100099

Chiu, T. K. F., et al. (2024). Developing and validating measures for AI literacy tests: From self reported to objective measures. *Computers and Education: Artificial* Intelligence. 7, 100282. https://doi.org/10.1016/j.caeai.2024.100282

European Parliament. (2006). *Key Competences for Lifelong Learning.* Author.

Kong, S.-C., & Abelson, H. (Eds.). (2022). *Computational Thinking Education in K–12: Artificial*. The MIT Press.

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)?. *Journal of Education*. *193*(3), 13–19.

Kim, S., Jang, Y., Choi, S., Kim, W., Jung, H., Kim, S., & Kim, H. (2021). Analyzing teacher competency with TPACK for K-12 AI education. *KI–Künstliche Intelligenz*. *35*(2), 139 151. https://doi.org/10.1007/s13218-021-00721-2

Lin, P., & Van Brummelen, J. (2021). Engaging teachers to co-design integrated AI curriculum for K–12 classrooms. In *Proceedings of the 2021 CHI conference on human factors in computing systems* (pp. 1–16). https://doi.org/10.1145/3411764.3445737

Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. In *Proceedings of the 2020 CHI conference on human factors in computing systems* (pp. 1–16). https://doi.org/10.1145/3313831.3376727

Lin, B., & Zhang, B. (2024). Construction of civil servants' digital literacy based on the competency model in the artificial intelligence era. *Information Technology and Management Application*. *(04),* 159–168. https://doi.org/10.20186/ j.cnki.hustitama2022.2024.04.14

McCarthy, J. (2007). From here to human-level AI. *Artificial Intelligence*. *171*(18), 1174–1182.

Ma, M., Ng, D. T. K., Liu, Z., & Wong, G. K. W. (2025). Fostering responsible AI literacy: A systematic review of K-12 AI ethics education. *Computers and Education: Artificial Intelligence*, 8, Article 100422. https://doi.org/10.1016/j.caeai.2025.100422

Ministry of Education, China. (2023). *Digital Education 2.0 Action Plan.* Appendices. Author.

Ng, D. T. K., Leung, J. K. L., Su, J., Ng, R. C. W., & Chu, S. K. W. (2023). Teachers' AI digital competencies and twenty-first-century skills in the post-pandemic world. *Educational Technology Research and Development*. *71,* 137–161. https://doi.org/10.1007/s11423-023-10249-0

Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., et al. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*. *2,* 100041. https://doi.org/10.1016/j.caeai.2021.100041

Touretzky, D., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). Envisioning AI for K-12: What Should Every Child Know about AI?. *Proceedings of the AAAI Conference on Artificial Intelligence*. 33(01), 9795-9799. https://doi.org/10.1609/ aaai.v33i01.33019795

Touretzky, D., Gardner-McCune, C., Breazeal, C., Martin, F. & Seehorn, D. (2019), A Year in K 12 AI education. *AI Magazine*. 40, 88-90. https://doi.org/10.1609/aimag.v40i4.5289

UNESCO. (2024). *AI Competency Framework for Teachers.* https://www.unesco.org/en/ articles/ai-competency-framework-teachers

UNESCO. (2019). *Artificial Intelligence in Education: Challenges and Opportunities.* Author.

Yang, Z., Yin, Y., Yang, G., Xu, J., Zeng, Q., & Chen, J. (2022). Construction of the artificial intelligence literacy model and its implementation path. *Modern Educational Technology*. *(03),* 42–50.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators?. *International Journal of Educational Technology in Higher Education*. *16*(1), 1–27. https://doi.org/10.1186/s41239-019-0171-0

Zhao, F., Dai, Y., & Xu, J. (2023). Construction of evaluation indexes for middle school students' artificial intelligence literacy. *Journal of Bingtuan Education Institute*. *(06),* 68–74.

Zhang, H., & Guo, W. (2022). Research on the artificial intelligence literacy framework in the STEM context. *E-Education Research*. *(04),* 26–32. https://doi.org/10.13811/j.cnki.eer.2022.04.004