Smart Learning Institute of Beijing Normal University

中国教育国际交流协会
CHINA EDUCATION ASSOCIATION FOR INTERNATIONAL EXCHANGE

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How Can Teachers Upgrade in the Intelligent Era?

Digital Literacy Frameworks, Assessment and Development from an International Perspective

Empowered Teachers | Better Learning | Stronger Education Systems

Jointly Released by

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Table of Content

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Smart Learning Institute of Beijing Normal University

The Smart Learning Institute of Beijing Normal University (SLIBNU) was established in 2015 as an interdisciplinary platform for scientific research, technological development, and educational experimentation under Beijing Normal University. It was established by Beijing Normal University and is jointly supported by the University and NetDragon Websoft's Elernity. Building on Beijing Normal University's strengths in education, psychology, educational technology, and related disciplines, SLIBNU focuses on understanding how learning takes place in information-rich, digital, and intelligent environments. Its research and practice span areas including smart learning theories, smart learning environments, artificial intelligence in education, educational big data, and future schools. The Institute is committed to developing smart learning environments and platforms that support lifelong learning and respond to learners' diverse, personalized, and differentiated learning needs. Through the development of experimental zones and pilot schools, international collaboration, and university-industry-research partnerships, SLIBNU promotes theoretical innovation, technological development, and the practical application of smart education. It has become an important research and innovation platform in the fields of smart education and educational digital transformation in China.

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Executive Summary

The rapid development of AI is profoundly reshaping the operational logic of education systems, the professional roles of teachers, and the ways in which students learn. Technology is reconfiguring knowledge production, instructional organization, learning support, and assessment practices. International research shows that digital and intelligent transformation is continuously reshaping the skills structure of the labour market, while generative AI may affect a wide range of knowledge-work tasks. In teachers' professional work, lesson preparation, assignment grading, administrative tasks, and learning feedback are also being significantly influenced by AI. Against this backdrop, teachers' and students' digital literacy is no longer an additional technical-operational competence, but a foundational capability that supports the improvement of educational quality, the transformation of talent cultivation, and the development of future learning.

Focusing on the core question of how teachers should upgrade in the intelligent era, this report provides a systematic analysis of the practical needs, conceptual frameworks, assessment tools, development pathways, and training system construction related to teachers' digital literacy. Drawing on reports from international organizations, international frameworks for teachers' digital literacy, global assessment tools, expert seminar materials from the Global Smart Education Cooperation Network, and interview data from teachers and students in Chinese universities, the report aims to reveal the key trends, practical challenges, and action directions for the development of teachers' digital literacy in the age of AI from both international and local perspectives.

The report first points out that AI is driving education to move toward learning design, competency development, and human-AI collaboration. The role of teachers is shifting from content deliverers to learning designers, technology judges, process evaluators, and supporters of student development. AI can help teachers improve the efficiency of resource generation, instructional feedback, and personalized support, but it also brings new challenges, such as the weakening of professional judgment, threats to assessment authenticity, and the increasing complexity of academic integrity governance. Therefore, the focus of teachers' digital literacy is shifting to whether teachers can use technology responsibly, critically, and creatively in alignment with educational goals.

Second, the report argues that students' use of AI has become an important part of everyday learning. Students use AI for writing, translation, information retrieval, literature reading, coding assistance, and learning support. Their learning behaviors show a coexistence of strategic use and dependent use. On the one hand, AI can provide immediate feedback, language support, and low-pressure learning assistance; on the other hand, it may weaken deep reading, independent reasoning, original expression, and sustained cognitive engagement. Accordingly, the core of students' digital literacy has shifted to being able to develop problem awareness, judge the reliability of information, maintain learner agency, and use AI responsibly.

In the section on international consensus, the report reviews the evolution of related concepts such as digital literacy, digital competence, teachers' digital literacy, and AI literacy. It analyzes representative frameworks for teachers' digital literacy developed by UNESCO, the European Union, the International Society for Technology in Education, the United Kingdom, Norway, Australia, China, and other countries and organizations. Overall, international frameworks show a common trend: teachers' digital literacy is no longer limited to information technology operations, but has gradually expanded to include digital resource integration, instructional design, learning assessment, student empowerment, professional development, data ethics, understanding of AI, and human-AI collaboration. Teachers' digital literacy is becoming an extension and reconstruction of teachers' professional competence in the intelligent era.

In terms of assessment approaches, the report compares international digital literacy assessment tools directly targeting educators, as well as international indicator systems that indirectly reflect the digital competence environment of teachers. These tools include both self-assessment-based competence diagnosis and system-level indicator monitoring and policy evaluation. The report notes three emerging trends in international assessments of teachers' digital literacy: first, a shift from assessing single technical skills to assessing comprehensive professional competence; second, a shift from static competence judgment to developmental diagnosis and improvement support; and third, a gradual extension from general digital competence assessment to the assessment of AI literacy, data ethics, and intelligent teaching competence.

In terms of development pathways, the report summarizes major international policy and practice approaches for enhancing teachers' digital literacy. These include embedding digital literacy into pre-service teacher education and teacher qualification processes; establishing stratified and progressive systems for in-service training and continuing professional learning; providing school-based support centred on authentic teaching application scenarios; and supporting teacher competence development through coordinated policies, platforms, and resources. International experience shows that the development of teachers' digital literacy cannot remain at the level of short-term tool training. Instead, it needs to be deeply integrated with curriculum reform, instructional innovation, school governance, and systems for teachers' professional development.

Based on the above analysis, the report proposes that a future-oriented training system for teachers' digital literacy should be advanced in five areas. First, a localized yet internationally comparable framework for teachers' digital literacy should be established. Second, a closed-loop mechanism integrating framework, assessment, development, and certification should be constructed. Third, training should move from tool operation toward the cultivation of instructional transformation competence. Fourth, the enhancement of teachers' digital literacy should be embedded into systemic school change. Fifth, digital leadership should be strengthened to support teachers' continuous development. For education enterprises, this means that products and services need to move beyond single content provision or tool delivery toward integrated competence development solutions that cover competence diagnosis, learning pathways, practice tasks, process feedback, and certification support.

Overall, this report argues that the key to building teachers' digital literacy in the age of AI does not lie in enabling teachers to master more technological tools more quickly. Rather, it lies in helping teachers maintain professional agency amid rapid technological change and enabling them to responsibly select, design, evaluate, and govern the educational applications of AI with learner development at the centre. Future training for teachers' digital literacy needs to respond simultaneously to teachers' practical anxieties, schools' organizational needs, changes in student development, and the education system's goal of quality improvement. Only by integrating technological competence, pedagogical competence, ethical judgment, and systemic support can AI truly become a powerful force for advancing teachers' professional upgrading and improving the quality of learning.

01

PART ONE

Practical Demands

Reconstructing Teacher and Student Competencies amid Digital and Intelligent Transformation

Part I

1. AI is Reshaping the Logic of Educational Development and the Demands of Talent Cultivation

1.1 Intelligent Society is Reshaping Talent Competencies

At present, the global economy is rapidly moving toward a form of digital economy driven primarily by data and AI. This transformation is manifested not only in the upgrading of industrial structures, but also in the systematic restructuring of the competency structure required of the labour force. The World Economic Forum, in The Future of Jobs Report 2025, notes that by 2027, approximately 44% of workers' core skills are expected to change, while around 23% of jobs will undergo structural transformation (World Economic Forum, 2025). Viewed over a longer period, changes in workers' core skills have become a sustained trend. A comparison of survey results from 2016 to 2025 by the World Economic Forum, as shown in Figure 1.1, indicates that respondents consistently expected a high proportion of workers' core skills to change within the following five years: 35% in 2016, rising to 42% in 2018, reaching 57% in 2020, standing at 44% in 2023, and remaining at 39% in 2025. This suggests that skills renewal is not a short-term phenomenon triggered by a single wave of technological change, but rather a normalized trend in workforce development against the backdrop of digitalization, intelligent transformation, and industrial restructuring.

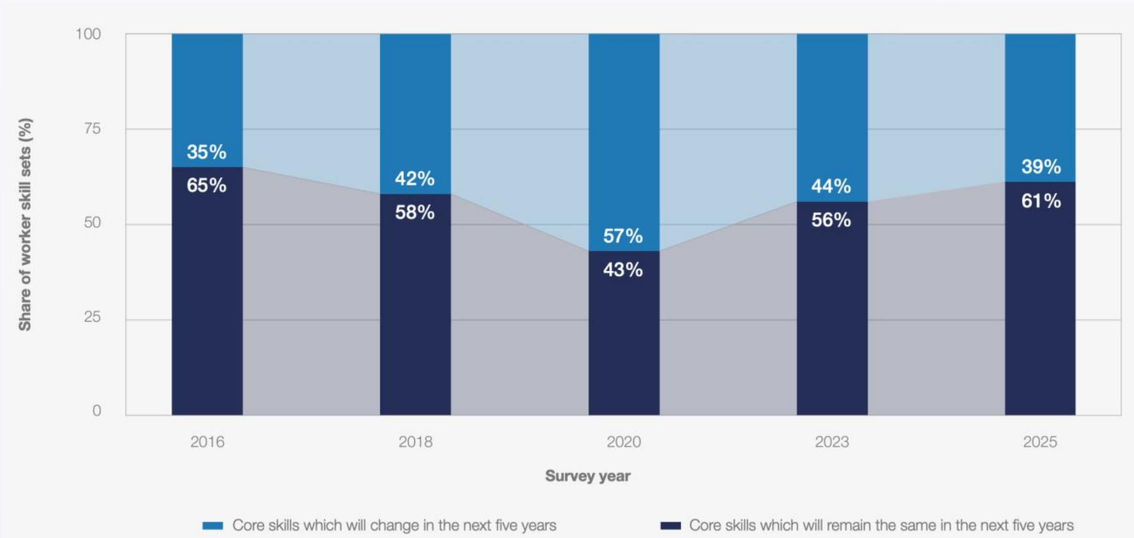


Figure 1.1 Changes in Workers' Existing Core Skill Sets from 2016 to 2025 (World Economic Forum, 2025)

Meanwhile, research by McKinsey & Company shows that generative AI may affect approximately 60% to 70% of work tasks, particularly in knowledge-intensive fields (McKinsey & Company, 2023). Research on the impact of AI on K-12 teachers further indicates that existing technologies are already capable of automating 20% to 40% of teachers' current working time, equivalent to approximately 13 hours per week, covering multiple areas such as lesson preparation, assignment grading, administrative work, and learning feedback (McKinsey & Company, 2020). These data indicate that AI is not simply replacing labour; rather, it is systematically changing competency demands by restructuring the composition of work tasks.

Technological progress does not simply replace jobs; rather, it redefines the content of work and the competencies required by restructuring the task structure (McKinsey & Company, 2023). Against this backdrop, the nature of digital literacy has undergone a fundamental transformation. It has evolved from an early-stage capacity for information access and tool operation into a foundational capability that supports individuals' participation in digital society and complex work contexts. The World Economic Forum further notes that analytical thinking, technological literacy, and complex problem-solving have remained among the most essential competencies for several consecutive years, and are closely coupled with creative thinking and systems thinking (World Economic Forum, 2025). More importantly, with the rapid diffusion of generative AI, the structure of competencies is undergoing a second-order transition. Research by McKinsey & Company indicates that generative AI has the potential to affect approximately 60% to 70% of work tasks, with knowledge work being particularly affected (McKinsey & Company, 2023). This means that competency demands are shifting from whether one can use technology to whether one can understand, evaluate, and effectively collaborate with technology.

This change indicates that digital literacy is no longer an additional skill, but has become a foundational capability structure that supports individual learning, work, and social participation. The widespread application of AI is driving a shift in competency demands from using technology to understanding and evaluating technology. Learners need not only to master the operational use of digital tools, but also to develop the ability to judge algorithmic outputs, select appropriate technological pathways in complex contexts, and collaborate with intelligent systems to complete tasks. Accordingly, digital literacy is gradually expanding into a composite competency system encompassing data literacy, information literacy, technological understanding, and AI literacy. From an educational perspective, this transformation places new demands on talent cultivation models: education should no longer focus solely on knowledge acquisition and skills training, but should place greater emphasis on learners' adaptability in uncertain contexts, capacity for continuous learning, and ability to transfer learning across contexts. This, in turn, fundamentally drives the transformation of educational goals from a knowledge-oriented paradigm toward a competency-oriented paradigm.

1.2 AI is Accelerating the Reconstruction of Educational Scenarios

A new wave of technological transformation, represented by generative AI, is fundamentally changing the operational logic of education systems. Its impact is not limited to the tool level, but extends deeply into the basic structures of knowledge production, instructional organization, and learning process mechanisms. According to a research report jointly released by Microsoft and LinkedIn, AI is shifting from a tool that merely improves efficiency to a cognitive collaborative agent capable of participating in information generation, problem analysis, and decision support, thereby playing an increasingly important role in these areas (Microsoft & LinkedIn, 2024).

In education, this change is directly reflected in the transformation of teaching and learning. Research by OECD indicates that the impact of digital technology on learning outcomes does not depend on technology itself, but on how it is used in teaching and learning (OECD, 2021). This means that there is no simple linear relationship between technology investment and learning outcomes; rather, the relationship is highly dependent on teachers' instructional design and learners' behaviors. More specifically, as knowledge acquisition and basic information processing are increasingly supported, and in some cases substituted, by AI, the focus of education is no longer knowledge itself, but the processes of understanding, evaluating, reconstructing, and applying knowledge. This shift directly gives rise to a systematic reconstruction of the roles and competency structures of both teachers and students.

At the teacher level, teaching activities are moving from content delivery toward learning design and learning support. Teachers' use of digital technology has been mainly concentrated on resource acquisition and classroom presentation, while significant gaps remain in using technology to support personalized learning and learning analytics (OECD, 2019). Teachers in the intelligent era need not only to integrate digital resources, but also to use learning data and intelligent tools to make instructional decisions, thereby supporting personalized learning and differentiated development. At the same time, with the widespread application of AI in education, teachers also need to develop the capacity to make ethical judgments and conduct risk assessments regarding technology use. This transformation indicates that teachers' digital literacy is being upgraded to human–AI collaborative teaching competence and professional judgment.

At the student level, learning approaches are undergoing a fundamental transformation. In a context where AI can undertake some information-processing and content-generation tasks, the focus of learning is no longer simple information acquisition, but the understanding, evaluation, and reconstruction of information. Research shows that effective learning in digital environments increasingly depends on learners' critical thinking, self-directed learning capacity, and ability to judge technology-generated outputs (OECD, 2021). The core of digital literacy has therefore shifted to whether learners can use technology in a high-quality manner. In addition, the widespread use of AI has raised a series of new issues, including data security, academic integrity, and algorithmic bias. These issues further expand the meaning of teachers' and students' digital literacy, making it not only a matter of competence, but also a matter of ethics and responsibility (UNESCO, 2023).

1.3 Changes in Learner Needs Reconfigure Educational Products

Generative AI has evolved from an auxiliary tool into a normalized support system within the learning process. It is now widely used in scenarios such as academic writing, information retrieval, problem solving, and personalized tutoring, thereby reshaping learning, research, and even modes of thinking. As learners become increasingly dependent on AI, issues of learner agency, critical thinking, and academic integrity have become more prominent. AI may serve as a cognitive scaffold that promotes understanding and creativity, but when used inappropriately, it may also weaken deep reading and independent thinking. Therefore, its educational value depends to a large extent on whether learners possess the ability to use technology appropriately, including the ability to develop problem awareness, judge the reliability of information, and reflect on the influence of technology on their own cognitive processes.

Student development needs are undergoing a substantive transformation to that they can become digital learners with agency, criticality, and a sense of responsibility. This requires learners not only to master basic skills such as prompt design and information retrieval, but also to develop comprehensive competencies, including critical thinking, creativity, independent problem-solving ability, source evaluation, ethical awareness, and metacognitive capacity. Pearson's global learner survey shows that most learners perceive significantly increasing uncertainty in future career pathways and attach greater importance to the development of transferable skills and lifelong learning capabilities (Pearson, 2023). HolonIQ notes that global education technology is shifting from a stage dominated by tool provision toward a stage oriented toward learning outcomes and competency development, with solutions centred on digital literacy and AI literacy becoming one of the fastest-growing areas

(HolonIQ, 2024).

Figure 1.2 New Learner Demands for Educational Products in the Intelligent Era

Based on existing research findings, learners' demands for educational products are mainly reflected in four areas. First, learners need learning products that provide accurate knowledge instruction and reliable content sources. In a generative AI environment, the richness of learning content has increased significantly, but risks such as misinformation, fabricated content, and algorithmic bias have also grown. Therefore, educational products need to strengthen content quality control, source verification, and knowledge explanation mechanisms to help learners build a reliable knowledge foundation (Miao & Holmes, 2023).

Second, learners need learning pathways that can effectively promote the development of digital competence and AI competence. Competency development in the digital era should not remain at the level of tool use, but should cover comprehensive capabilities such as information evaluation, digital content creation, problem solving, understanding of AI, and responsible use of technology (OECD, 2021a; Vuorikari et al., 2022).

Third, learners need support mechanisms that are adapted to their learning status and emotional needs. Although digital learning and AI-assisted learning have improved learning convenience, they may also lead to problems such as learning isolation, cognitive dependence, and fluctuations in motivation. Therefore, educational products should not only provide tasks, resources, and feedback, but also attend to learners' engagement, self-regulation, learning confidence, and sustained motivation. In the intelligent era, students need to develop critical understanding, information judgment, and self-directed learning capabilities in complex information environments (OECD, 2021b).

Fourth, learners need personalized learning support systems integrated with AI.

Generative AI offers new possibilities for personalized explanation, immediate feedback, learning pathway recommendation, and learning process analysis. However, its educational application should remain centred on human development and should empower both learners and teachers through appropriate governance and capacity building (UNESCO, 2024).

2. New Challenges and Demands for Teachers' and Students' Digital Literacy Based on International Consensus

To further understand the practical demands placed on teachers' and students' digital literacy after AI enters educational practice, this report draws on two complementary sources of evidence: international expert seminars and interviews with teachers and students in Chinese universities. The first source of evidence comes from international seminars on digital literacy organized by the Global Smart Education Network. These seminars focused on issues such as teacher practice, teacher professional development, learner development, and the construction of educational support systems in the age of AI. Expert representatives from international organizations, regional education institutions, higher education institutions, educational research organizations, and professional educational technology associations were invited to participate in the exchanges. Participating institutions included the UNESCO Institute for Information Technologies in Education, the UNESCO Mahatma Gandhi Institute of Education for Peace and Sustainable Development, the International Society for Technology in Education, the Southeast Asian Ministers of Education Organization, the SEAMEO Regional Centre for Education in Science and Mathematics, as well as universities and educational institutions from several countries. The discussions provided important references for this report to understand, from an international perspective, issues such as teachers' and students' capacity readiness and development, human-AI collaborative teaching, and educational support in AI-enabled educational applications.

The second source of evidence comes from interview data collected from teachers and students in Chinese universities. Teacher interviews mainly focused on university teachers' understanding of generative AI, their experience of using it, and adjustments in teaching models. Student interviews mainly examined students' use of AI in digital learning environments and their needs for personalized learning. These interview materials provide practical evidence for understanding the concrete experiences, real-world barriers, and localized demands associated with AI applications in Chinese higher education contexts. Based on the above evidence, this report further summarizes and analyzes the core viewpoints emerging from the expert seminars and teacher-student interviews.

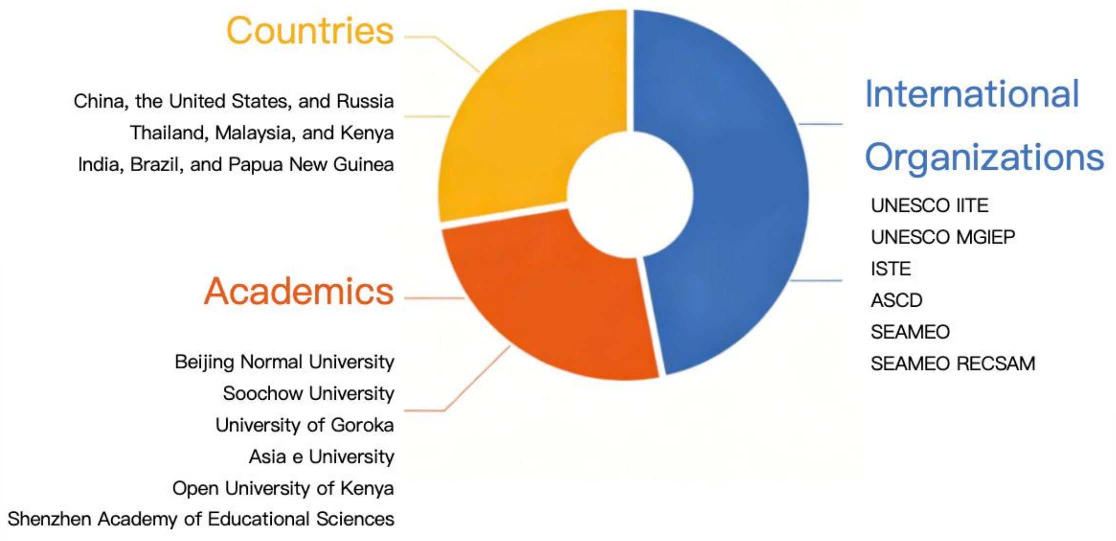


Figure 1.3 Distribution of Survey Participants by Institution and Country

2.1 Teachers' Preparedness is Lagging Behind AI Development

Teachers have already been widely exposed to and begun using AI tools, yet their professional preparedness, institutional support, and ethical guidance have not kept pace. Citing OECD data, Romeo Ramirez from ISTE noted that in some regions, a large number of teachers have already used AI tools, while systematic training and professional support remain clearly insufficient. This mismatch between high use and low support is becoming an important risk in the educational application of AI.

Table 1.1 Core Competencies of Teachers' Digital Literacy in the Age of AI

Competency Dimension	Core Meaning	Significance for Teacher Practice
Critical AI literacy	Understanding the operational logic, data limitations, and potential biases of AI tools	Enabling teachers to judge whether AI-generated outputs are reliable, appropriate, and fair
Pedagogical discernment	Judging in which contexts AI can add value and when human professional judgment remains indispensable	Avoiding the use of technology for technology's sake
Ethical responsibility and agency	Clarifying teachers' leading responsibility in instructional decision-making, student assessment, and ethical oversight	Preventing teachers' professional judgment from being replaced by AI algorithms

Competency Dimension	Core Meaning	Significance for Teacher Practice
Adaptive professional competence	Continuously updating teachers' understanding of AI, pedagogy, and assessment through ongoing learning	Supporting teachers in responding to a rapidly changing technological environment

The core of this issue is not merely whether teachers are able to use a particular type of tool, but whether they can maintain professional judgment, instructional design capacity, and educational value judgment in a context where AI is deeply embedded in the teaching process. Teachers need to be able to identify the limitations of AI-generated outputs, judge whether such outputs genuinely serve learning objectives, and model the critical, ethical, and creative use of AI in the classroom. Therefore, teachers' digital literacy in the age of AI has shifted from technical operational competence in a general sense toward an integrated form of professional practice competence.

2.2 Teacher Professional Development Shift to Capacity Building

Expert from SEAMEO emphasized that although many countries have already articulated policy visions for AI in education, genuine educational transformation must respond to the realities of teachers' frontline work, including the digital divide, inadequate infrastructure, unequal access to tools, and insufficient teacher training. Particularly in regions such as Southeast Asia, the challenges teachers face are not merely matters of technological learning, but also issues of educational equity, resource conditions, and institutional support. This perspective suggests that teacher professional development should no longer be understood as simply teaching teachers how to use a particular AI tool. Teachers need to learn how to design prompts, use AI to generate resources, or improve work efficiency, understand how to embed AI into learning objectives, classroom tasks, learning support, and assessment design. AI should not be regarded as a technical patch for traditional instructional processes, but as an opportunity to promote the reconstruction of pedagogical models.

Asha Kanwar further cautioned against an overly optimistic efficiency narrative surrounding AI. Although some teachers subjectively perceive AI as capable of significantly saving work time, relevant experiments show that the actual time saved may be far lower than expected. At the same time, over reliance on generative AI may also lead to risks such as cognitive dependence and the weakening of professional judgment. Teacher professional development should therefore not only help teachers use AI more effectively, but also enable them to judge when AI should not be relied upon. Ronald from the Open University of Kenya further pointed out from the perspective of developing countries that the digital divide, the cost of devices and connectivity, insufficient integration with teaching, data privacy concerns, and employment risks continue to constrain teachers' effective use of AI. This indicates that the development of teachers' AI capabilities cannot be separated from specific institutional contexts and resource conditions.

2.3 Pedagogical Innovation Positions AI as a Learning Scaffold

The international seminar showed that AI is driving pedagogical models to shift from content delivery toward learning support, personalized guidance, and the cultivation of higher-order thinking. Natalia Amelina from UNESCO IITE noted that the responsible design and use of AI has the potential to support personalized learning, inclusive education, and the participation of disadvantaged groups, particularly in supporting learners with disabilities, adapting learning pathways, and reducing teachers' administrative workload. Practice cases from China further show that AI has begun to be embedded in concrete classroom contexts. Taking primary school English teaching as an example, Lu from the Shenzhen Academy of Educational Sciences demonstrated how teachers use the National Smart Education Platform, DeepSeek, and intelligent pronunciation tools to support lesson preparation, resource generation, home-based learning support, and speech feedback. The significance of this case lies not in showcasing the use of a particular tool, but in demonstrating that AI applications have already extended across multiple levels, including classroom instruction, school-based teaching research, regional expert support, and the national policy environment.

Table 1.2 Educational Ecosystem Levels of AI Applications in Teaching

Ecosystem Level	Specific Scenarios	Key Focus of AI Applications
Classroom level	Teacher instruction and learning activities	Multi modal resources, immediate feedback, and learning support
School level	Teaching research groups and teacher collaboration	Collaborative lesson preparation, optimization of teaching resources, and experience sharing
Regional level	District- or city-level expert teams	Professional guidance, case dissemination, and quality support
Policy level	National education digitalization strategy	Platform support, resource provision, and institutional guidance

Sivaranjini Sinniah from SEAMEO RECSAM emphasized that the real challenge posed by AI to pedagogical models lies in the reconstruction of classroom tasks. Teachers should not remain at the level of asking students to recall answers or complete standardized tasks;

instead, they should design learning activities that require reasoning, reflection, judgment, and the demonstration of higher-order thinking. In a generative AI environment, simple answers and standardized texts can increasingly be generated automatically. Therefore, the focus of education must shift toward whether students truly understand, can explain, can transfer knowledge, and can make responsible judgments. Accordingly, the international seminars repeatedly emphasized the principle of teacher-in-the-loop. AI can serve as a learning scaffold, a resource-generation tool, and a feedback support system, but the setting of instructional goals, the design of learning activities, judgments about student development, and the oversight of ethical boundaries must remain teacher-led. AI is not a predetermined destiny for educational development; rather, it is a tool that needs to be actively shaped by educators on the basis of pedagogy, equity, and trust.

2.4 International Teacher Professional Development is Moving to the Reconstruction of Teaching Practice

Different from the macro-level perspectives provided by the international seminars, interviews with Chinese university teachers reveal more concrete experiences from teaching practice. The interviews show significant differences in teachers' familiarity with and attitudes toward generative AI. Some teachers have already been using AI frequently for lesson preparation, grading, and material generation; some mainly use it for translation, summarization, or occasional assistance; while others remain cautious, or rarely use such tools, due to concerns about tool quality, academic reliability, or risks to academic integrity.

These differences should not be understood simply as variations in individual teacher attitudes, but are closely related to the specific conditions of AI use in Chinese higher education. Some teachers noted that international AI tools are not always conveniently accessible in China, while domestic alternatives may not yet fully meet the needs of teaching and research in terms of academic depth, accuracy, and reliability. Therefore, teachers' adoption of AI faces three types of practical barriers: barriers to tool accessibility, barriers related to tool quality, and barriers related to academic trust.

Nevertheless, despite these constraints, teachers are not simply rejecting AI. The interviews show that many teachers have already begun to actively adjust their teaching and assessment practices. The most prominent change is a shift from outcome-oriented assessment to process-oriented assessment. Some teachers explicitly stated that, in a context where AI can generate high-quality texts and assignments, evaluating only final products is no longer sufficient to judge students' actual level of learning. Compared with final grades, teachers are paying greater attention to whether students have gone through the processes of information collection, viewpoint formation, knowledge digestion, structural integration, and personal expression.

Table 1.3 Major Findings from Interviews with Chinese University Teachers

Theme	Teacher Experience	Interpretation
Differences in tool adoption	Teachers' use of Al ranges from frequent use to almost no use	Al use is influenced by teaching experience,discipline, tool experience, accessibility, and level of trust
Barriers in the local context	International tools have limited accessibility,while domestic tools show unstable academic performance	Al applications in education need to consider adaptation to institutional, linguistic,platform-based, and academic contexts
Process-oriented teaching	Teachers pay greater attention to preparation,research, integration, and expression processes	Al is pushing teachers to search again for evidence that learning has genuinely occurred
Co-construction of rules between teachers and students	Some teachers suggest developing Al-use frameworks together with students	This recognizes that students are already using Al and incorporates such use into course governance
Open-ended task design	Creative and contextualized tasks are used to reduce the risk of Al substitution	The focus of assessment shifts toward critical thinking, problem solving, and original synthesis

2.5 From Detecting AI Use to Reconstructing Assessment Validity

The most prominent concerns expressed in the teacher interviews centred on assessment. Generative AI has made it more difficult to judge the authenticity of students' assignments and papers. Teachers generally recognize that students can not only use AI to generate texts, but also make such texts appear closer to human writing by modifying prompts, rewriting style, or engaging in multiple rounds of polishing. As a result, traditional assessment approaches that rely heavily on final texts are facing a clear crisis of validity. In practice, teachers have already developed several response strategies. For example, teachers may identify abnormal performance by drawing on their long-term understanding of students' learning levels; use their reading experience to identify common features of AI-generated texts, such as structured, repetitive, and formulaic expressions; use detection tools as auxiliary evidence; or require students to give oral presentations, participate in defenses, or submit learning process materials.

Table 1.4 Main Strategies Used by Teachers to Respond to AI-Generated Content

Response Strategy	Main Function	Limitation
Familiarizing students' baseline abilities	Judging whether students' work is clearly in consistent with their usual level	Relies on long-term teacher-student interaction and is difficult to implement in large classes
Identifying AI writing styles	Detecting structured, repetitive, and formulaic expressions	Becomes increasingly difficult as the quality of AI-generated texts improves
Using detection tools	Providing auxiliary evidence for teachers' judgment	Tool reliability is limited and should not be used as the sole basis for judgment
Oral presentations and defenses	Examining whether students truly understand the content of their work	Time-consuming and difficult to implement at scale
Process-oriented assessment	Focusing on preparation, research, revision, and reflection processes	Requires support from course assessment systems and workload arrangements
Open-ended task design	Enhancing the authenticity, contextualization,and creativity of tasks	Places higher demands on teachers' design capacity

These strategies show that assessment challenges in the age of AI cannot be solved by detection alone. Detection tools can only indicate whether a text may have been generated by AI, but they cannot adequately determine whether students have genuinely learned, developed understanding, demonstrated creativity, or exercised ethical judgment. Therefore, the focus of assessment reform should shift from to reconstructing assessment validity.

2.6 Teacher Professional Development Requires Systemic Coordination among Policy, Training, Tools, and Educational Values

Both the international seminars and interviews with Chinese teachers indicate that teacher' use of AI cannot rely solely on individual exploration, but requires systemic support. First, schools and educational administrative departments need to develop clear and operational policies on the use of AI. Such policies should not remain at the level of general principles; rather, they should specify acceptable, restricted, and prohibited uses of AI in different teaching scenarios and provide teachers with course-level reference examples.

Second, teachers need continuous, stratified, and practice-oriented professional development support. Training content should not be limited to tool operation, but should include the evaluation of AI-generated outputs, prompt design, the reconstruction of instructional tasks, the design of process-oriented assessment, academic integrity governance, data ethics, and guidance for developing students' AI literacy. For teachers from different disciplines, with different lengths of teaching experience, and with different levels of digital competence, training should also be differentiated and customizable. Third, teachers need reliable technological and resource support, including accessible, compliant, and stable AI tools; detection systems that can assist but not replace teachers' judgment; and open repositories of teacher resources and practice cases. For example, the open resource centre for teachers proposed by UNESCO IITE's Generation AI project both reflect the international emphasis on resource support for teachers and equity-oriented professional development. At a deeper level, teachers also need philosophical and ethical guidance. Some teachers in the Chinese interviews emphasized that education should always remain concerned with human development, and that however advanced technology becomes, it should serve human growth.

3. Students' Use Habits of Intelligent Tools and Demands for Digital Competence

3.1 AI is Changing Learning Behaviors and Cognitive Engagement

The international seminar on learners emphasized that AI is not an ordinary educational technology. Expert from UNESCO MGIEP pointed out that AI is changing social values, power relations, and even human ways of thinking, while global education systems are not yet fully prepared to respond to these changes. The impact of AI on students' learning behaviors should not be understood merely from the perspective of tool efficiency, but should be analyzed within the frameworks of cognitive development, educational equity, and learner agency. A repeatedly discussed risk in the seminar was cognitive offloading. Learners may tend to delegate difficult mental tasks to AI, thereby reducing their own intellectual effort. Citing related research, Shitanshu Mishra noted that excessive use of AI may lead to a decline in writing ability, increased risks of misinformation and hallucination, and reduced meta-cognitive awareness. The key question is not whether AI can improve learning performance, but whether performance alone is sufficient to measure education. At the same time, international experts also emphasized the asymmetry brought about by AI. This inequality exists not only between the Global North and the Global South, but also within countries and regions, as reflected in differences in tool accessibility, digital infrastructure, AI literacy, and policy guidance. For students with sufficient resources, AI may become a tool for enhancing learning; for students lacking connectivity or literacy, AI may become a new mechanism of exclusion.

3.2 Learners Are Moving from “Being Shaped by AI” to “Shaping AI”

The seminar did not portray students simply as passive consumers of AI. Xu Jia, a student representative from Zhejiang University, proposed a distinction between being shaped by AI and shaping AI. The former refers to students treating AI as a tool for quickly completing assignments, generating summaries, or replacing thinking; the latter refers to students starting from authentic problems, using AI to design meaningful solutions, and becoming co-creators of technology applications. The Beyond Test project introduced by Xu Jia takes examination pressure as its point of departure. Rather than simply using AI to require students to learn more, the project uses smartwatches and plush robots to identify anxiety, provide comfort, and guide breathing exercises, designing AI as a friend rather than a teacher. This case suggests that personalized learning should not focus only on content recommendation and achievement improvement, but should also attend to emotional regulation, learning motivation, psychological safety, and overall well-being. This perspective is particularly important for understanding students’ developmental needs. In the age of AI, students need not only more powerful learning tools, but also the capacity to critically select, adapt, and creatively use AI in response to authentic problems. Students should become agents in AI use rather than recipients of algorithmic outputs.

3.3 Strategic and Dependent Uses of AI Coexist among Students

Interviews with Chinese university students show that generative AI has become a common tool in postgraduate learning and academic activities. Students use tools such as ChatGPT, Kimi, Gemini, Perplexity, Moonshot, Grammarly, QuillBot, Elicit, and ChatPDF to support writing, translation, literature reading, summary generation, coding assistance, and information retrieval. Their frequency of use ranges from several times per week to daily use. However, students’ modes of use vary significantly. Some students are strategic users: they first develop their own ideas and then use AI for language polishing, structural optimization, supplementary information, and comparison of viewpoints. These students are more likely to regard AI as a learning scaffold or cognitive partner, and they are able to promote reflection by comparing AI outputs with their own understanding. Other students, however, show tendencies toward dependent use: they directly delegate tasks to AI to generate first drafts, answers, or even complete assignments, and acknowledge that they have become less willing to think independently.

Table 1.5 Types of Students' AI Use Behaviors

Type	Typical Behaviours	Potential Impacts
Strategic users	First develop personal viewpoints, and then use Al for polishing, supplementation, comparison, and optimization	May enhance the quality of expression, broaden perspectives, and promote reflection
Dependent users	Directly ask Al to generate first drafts, answers, or complete assignments	May weaken independent thinking, deep reading, and original expression
Verification-oriented users	Repeatedly check Al outputs and compare original sources with Al-generated results	Helps develop source awareness, evidence judgment,and critical thinking
Passive recipients	Lack judgment capacity and directly adopt Al-generated outputs	Are vulnerable to misinformation, fabricated references, and superficial answers

Prompting competence plays an important role in students' learning experiences. The interviews show that students who are able to ask specific, detailed, and contextualized questions tend to obtain more useful AI-generated outputs and maintain higher levels of engagement. By contrast, students who provide vague prompts are more likely to receive generalized, low-quality, or irrelevant responses, which may lead to frustration. This suggests that prompt design is not merely a technical detail, but an important component of students' digital literacy in the age of AI. Students also generally recognize that AI-generated outputs are not always reliable. Fabricated references, misinformation, outdated knowledge, and overly general responses have led many students to develop varying degrees of verification behaviour. However, whether students can effectively verify AI outputs depends on whether they possess the relevant background knowledge, disciplinary judgment, and information literacy. Without foundational knowledge, students find it difficult to determine whether AI-generated outputs are correct.

3.4 Limitations of Current AI Tools in Immediate Support,Linguistic Equity and Deep Adaptation

Students generally acknowledge the value of AI as an always-available learning assistant. AI can respond to questions immediately, provide repeated explanations, and does not display fatigue, impatience, or judgmental attitudes. It therefore offers students a form of low-pressure, repeatable, and non-judgmental learning support. For students who are reluctant to frequently seek help from teachers or peers, such support significantly lowers the psychological threshold for help-seeking in learning. Language support is an important need for Chinese university students, especially for those who are non-native English speakers.

Table 1.6 Students' Personalized Learning Needs and the Limitations of Current AI Support

Type of Need	Support Provided by AI	Main Limitations
Immediate question answering	Answering questions at any time, providing repeated explanations, and reducing help-seeking pressure	May provide generalized or incorrect responses
Language support	Translation, polishing, terminology explanation, and optimization of academic expression	May alter the original meaning or obscure students' authentic expressive ability
Research support	Literature summary, outline generation,information retrieval, and idea expansion	Fabricated references, omission of key literature, and lack of disciplinary depth
Emotional support	Non-judgmental responses, companion-like interaction, and stress relief	Data privacy concerns, risk of dependence, and weakening of interpersonal connection
Personalized pathways	Providing suggestions and learning steps based on questions	Insufficient understanding of course objectives,individual proficiency levels, and learning contexts

AI can help students understand complex English-language literature, translate academic concepts, revise less fluent sentences, suggest more formal academic expressions, and support students' entry into English-speaking academic communities. From the perspective of educational equity, such language support is not merely a matter of convenience, but an important condition for lowering the threshold of academic participation. However, current AI-enabled personalization still has clear limitations. Students reported that AI responses often lack an understanding of specific courses, disciplines, research stages, and task requirements. In advanced statistical modelling, frontier research, and highly specialized questions, AI may generate erroneous code or inaccurate suggestions. In academic writing, AI may still fabricate references or provide overly generalized content. Therefore, deep personalization remains an aspiration rather than a reality.

3.5 Comprehensive Competency Development: Creativity, Critical Thinking, and Ethical Judgment

The international seminars and student interviews jointly indicate that AI has a dual impact on students' comprehensive competency development. On the one hand, AI can provide new perspectives, help students compare viewpoints, inspire ideas for writing, and support creative expression. On the other hand, over reliance on AI may weaken originality, independent reasoning, deep reading, and long-term memory. In terms of creativity, most students believe that as long as they first develop their own ideas and then use AI for optimization, AI does not necessarily undermine creativity; instead, it may stimulate more diverse forms of expression and design ideas.

However, if students directly ask AI to complete entire tasks, this may lead to homogenized expression, reduced originality, and the proliferation of texts with an AI-like style. In terms of critical thinking, AI similarly shows a paradoxical impact. Students who use AI actively may treat it as a debate partner, identifying gaps, revising viewpoints, and broadening their thinking by comparing their own analyses with AI-generated analyses. Students who passively depend on AI, however, may reduce independent analysis and become less willing to engage with complex texts and difficult problems over an extended period. In terms of ethical judgment, students generally need clearer institutional guidance. Many students do not want universities simply to prohibit AI use; rather, they hope to receive explicit rules: which uses constitute reasonable assistance, which uses require disclosure, and which uses already amount to substitutive completion or academic misconduct.

Table 1.7 Major Gaps in Students' Comprehensive Competency Development

Competency Area	Risks Reported by Students	Educational Responses
Deep reading	AI-generated summaries reduce the motivation to read full papers and may lead students to miss context and details	Preserve close reading, annotation, no-AI summary practice, and text-based discussion
Independent reasoning	Students may find it difficult to develop arguments from scratch without AI	Emphasize problem formulation, drafting processes, and the development of personal viewpoints
Source evaluation	AI may generate fabricated references and misinformation	Strengthen training in literature verification, evidence awareness, and source validation

Long-term memory	Heavy reliance on Al may weaken knowledge retention	Combine closed-book tasks, oral explanation, concept mapping, and spaced review
Sustained effort	Al provides quick answers, reducing the time students spend engaging with difficult problems	Design learning tasks that require iteration, reflection,and long-term engagement

4. Intelligent Technologies Embedded into Teachers' and Students' Everyday Learning

4.1 AI has Become an Important Part of Educational Practice

Students commonly use AI for writing, translation, information organization, paper reading, code generation, brainstorming, and learning-related question answering. Some students have already developed relatively stable AI use habits, and even use generative AI tools in their daily academic tasks. For non-native English-speaking students, AI plays a particularly important role in language support by helping them understand complex English-language literature, revise academic expressions, improve writing fluency, and lower the threshold for participating in English-speaking academic environments.

Teachers have also begun to use AI in lesson preparation, teaching resource generation, classroom activity design, assignment grading, the development of assessment criteria, and student feedback. Some teachers believe that AI can save time, improve the efficiency of resource generation, and help them design richer learning materials. However, some teachers remain cautious about the accuracy, academic reliability, and educational value of AI, especially because they worry that students may use AI as a shortcut to replace thinking. It can therefore be seen that AI has entered educational practice on both the student and teacher sides. On the student side, it is mainly reflected in learning support and task completion; on the teacher side, it is mainly reflected in instructional assistance and the reconstruction of assessment. Together, these developments show that AI has become a real variable in the operation of teaching and learning in higher education, rather than an external add-on.

Table 1.8 Main Scenarios of AI Use by Teachers and Students

User Group	Main Use Scenarios	Typical Value	Main Risks
Students	Literature summarization, language polishing, writing	Immediate feedback, reduced language barriers,	Over reliance, reduced deep reading,

User Group	Main Use Scenarios	Typical Value	Main Risks
	ideation, coding assistance, information retrieval, and learning-related question answering	improved task efficiency, and personalized explanations	fabricated references, and insufficient originality
Teachers	Lesson preparation, resource generation, classroom activity design, development of assessment rubrics, assignment feedback,and academic integrity judgment	Time savings, enriched teaching resources, support for differentiated teaching, and assistance with process-oriented assessment	Weakened professional judgment, unstable tool quality, and challenges to assessment authenticity

4.2 Digital Learning Behaviors Show Strategic and Dependent Use

Students do not use AI in the same way. Some students are able to first develop their own viewpoints and then use AI for language polishing, structural optimization, supplementary information, and comparison of perspectives. These students are more likely to regard AI as a cognitive partner or learning scaffold, and can promote reflection and critical thinking by comparing AI outputs with their own understanding. Other students tend to directly delegate tasks to AI, asking it to generate first drafts, answers, or even complete assignments. Although this mode of use improves task completion efficiency, it may weaken students' deep reading, independent reasoning, and original expression. Some students also acknowledged that AI has made them less willing to spend time reading full papers or thinking independently about complex problems, and that they may even find learning difficult in contexts where AI is not available. Teachers' observations echo students' self-reports. Teachers generally perceive that AI has created challenges for traditional assessment of assignments and papers. Students' submitted texts may be fluent in language and complete in structure, but they may not genuinely reflect students' level of understanding. As a result, some teachers have begun to place greater emphasis on learning processes, classroom presentations, oral defenses, and open-ended tasks in order to judge whether students have genuinely engaged in the process of knowledge construction.

4.3 Pedagogical Models Shifting to Process-Oriented Approaches

In response to the reality that AI can rapidly generate texts, answers, and works, teachers have begun to rethink the focus of teaching and assessment. Traditional assessment approaches centred on final texts, papers, or assignment products are becoming increasingly inadequate for judging students' actual learning engagement and cognitive development. Accordingly, process-oriented teaching and process-oriented assessment have become important trends. Teachers are paying greater attention to whether students have gone through the processes of problem understanding, information collection, viewpoint formation, knowledge integration, reflective revision, and expressive presentation. Some teachers emphasized that, compared with final grades, what matters more is how much genuine effort students invest in preparing, researching, digesting, and constructing knowledge. This change means that pedagogical innovation in the age of AI is not merely about introducing new tools, but about redesigning learning tasks so that students must demonstrate their thinking pathways, reasoning processes, and personal understanding. Process records, draft submissions, reflective journals, oral presentations, learning portfolios, and classroom defenses are becoming important ways to resist AI-substituted learning.

Table 1.9 Assessment Shifts under the Intervention of AI

Dimension of Change	Traditional Orientation	New Orientation in the Age of AI
Assessment object	Final papers, assignments, answers, or products	Learning processes, thinking pathways, use of evidence, reflective revision, and expressive presentation
Teaching focus	Knowledge transmission and task completion	Problem inquiry, knowledge construction, process demonstration, and human-AI collaboration
Competency focus	Memory, understanding, and standardized expression	Critical thinking, creative problem solving, ethical judgment and meta-cognition
Assessment methods	Standardized tests, written assignments, and uniform grading	Process materials, oral defenses, project-based products, learning portfolios and open-ended tasks

4.4 Demand for Personalized Support Has Increased Significantly

Students generally recognize the value of AI in providing immediate feedback and personalized support. AI can answer questions at any time; it does not become tired or impatient, nor does it create psychological pressure associated with being judged or embarrassed. For students with weaker academic foundations, insufficient language proficiency, or reluctance to frequently seek help from teachers, AI provides a form of low-pressure, repeatable, and immediately accessible learning support. However, students also pointed out that the personalization currently provided by AI remains limited. AI often gives overly generalized answers and lacks a precise understanding of specific course requirements, disciplinary backgrounds, research stages, and individual learning levels. In higher-order academic tasks, AI may generate erroneous code, fabricated references, outdated information, or explanations that appear reasonable but lack depth. Teachers face similar issues. AI can assist with lesson preparation and resource generation, but the generated content may not necessarily align with course objectives, student characteristics, or teaching contexts. Therefore, for both teachers and students, the value of AI depends on whether users possess sufficient background knowledge, judgment capacity, and task design competence.

4.5 Systemic Tensions Shared by Teachers and Students

Although teachers' and students' experiences are located in different positions within educational activities, together they reveal a series of systemic tensions arising from the entry of AI into higher education. These tensions cannot be resolved through a single tool, a one-off training session, or simple prohibition. Instead, they require the coordinated development of curriculum, assessment, teacher development, student support, and school governance.

Table 1.10 Major Tensions in Teachers' and Students' Digital Learning Experiences

Tension	Teacher-Side Manifestation	Student-Side Manifestation	Systemic Response
Efficiency improvement and deep learning	AI saves time in lesson preparation and grading, but may weaken professional judgment	AI rapidly generates answers, but may reduce reading, thinking, and trial-and-error processes	Transform efficiency gains into higher-quality feedback, reflection, and deep-learning tasks
Autonomy and dependence	Teachers use AI to improve efficiency, but must not lose instructional leadership	Students receive immediate support, but may rely on AI to complete cognitive tasks	Emphasize human-in-the-loop, thinking before AI, and meta-cognitive reflection
Detecting AI use and assessing genuine learning	Teachers find it difficult to judge whether students' work truly reflects their abilities	Students are uncertain about the boundary between AI assistance and misconduct	Shift from text detection to process-oriented,authentic, and comprehensive assessment

Tool access and educational equity	Teachers have unequal access to tools,training, and resources	Students receive different levels of support due to differences in language, economic conditions, and digital literacy	Provide compliant, low-cost, and accessible tools, together with stratified training
Global technologies and local contexts	International tools have limited accessibility, while local tools vary in quality	Students switch among different platforms without clear guidance	Promote a localized, discipline-specific, and compliant Al application ecosystem
Technological innovation and educational values	Tool diffusion is faster than the clarification of educational purposes	Students may mistake task completion for learning completion	Use human development, learner agency, and educational equity as criteria for evaluating Al applications

First, there is a fundamental tension between efficiency and deep learning. The most readily perceived value of AI lies in time savings, yet the value of education cannot be equated with the speed of task completion. Deep learning requires reading, reasoning, expression, trial and error, and reflection. If efficiency becomes the sole objective, both teachers and students may unconsciously reduce their cognitive engagement. Second, there is a paradox between autonomy and dependence. AI appears to enhance students' capacity for self-directed learning by enabling them to obtain support at any time. However, if students use AI as a substitute for thinking, such autonomy may turn into dependence. The same applies to teachers: AI can support teaching work, but it cannot replace teachers' professional judgment. Third, academic integrity issues are being transformed into issues of assessment validity. Traditional approaches tend to ask,"Was this written by AI?"Yet the more fundamental question is,"Has the student genuinely learned?"This requires assessment to move from checking final products toward examining learning processes, evidence of thinking, and authentic performance. Fourth, educational equity is taking on new forms. AI may help disadvantaged students gain access to language support and immediate tutoring, but it may also widen inequalities due to differences in tool accessibility, ability to pay, digital literacy, and policy guidance. Equity is no longer only about whether students have devices and internet connectivity; it also concerns whether they can use AI safely, effectively, and responsibly.

02

PART TWO

International Consensus

Concepts and Frameworks of Digital Literacy

PART II

1. Tracing the Conceptual Origins of Digital Literacy

1.1 The Emergence and Evolution of Digital Literacy

The concept of “digital literacy” emerged against the backdrop of the rapid integration of digital technologies into social life. As digital technologies continue to reshape how people access information, represent knowledge, engage in social interaction and participate in public life, the foundational competencies required of individuals have also evolved. Correspondingly, the meaning of digital literacy has expanded and deepened over time.

Early studies moved beyond the narrow understanding of digital literacy as merely the ability to operate computers. Eshet-Alkalai (2004) was among the first to propose a conceptual framework for digital literacy, defining it as a set of composite capabilities required for individuals to live and develop in digital environments. These capabilities include photo-visual literacy, reproduction literacy, branching literacy, information literacy, and socio-emotional literacy. From the perspective of transformations in digital media, Lanham (1995) argued that literacy in the digital age includes not only conventional reading and writing skills, but also the ability to understand, express and communicate information through digital media. Gilster (1997) defined digital literacy as the ability to use and evaluate digital resources, tools and services appropriately and to apply them in lifelong learning processes, underscoring the importance of digital technologies as a “basic life skill”. These early discussions suggest that, from its inception, digital literacy has referred not only to access to technologies and the use of tools, but also to the understanding, judgement and application of digital information.

Since the beginning of the 21 century, the accelerating development of digital technologies has further extended digital literacy from basic skills to a broader set of integrated competencies. Kenton and Blummer (2010) noted that early literature still tended to understand digital literacy largely in terms of basic technical skills, such as word processing and spreadsheet use, and that the conceptual boundaries of digital literacy required further clarification. In 2011, UNESCO subsequently noted that digital literacy goes well beyond basic computer operation and encompasses the use and production of digital media, information processing and retrieval, knowledge creation and sharing through social networks, as well as professional computing skills. The American Library Association also defines digital literacy as the ability to use information and communication technologies to find, understand, evaluate, create and communicate information (American Library Association, n.d.). JISC further emphasizes that digital literacy represents a set of essential capabilities that individuals need for learning, working and living in a digital society, linking it closely with developments in higher education and further education (Joint Information Systems Committee, 2014).

In recent years, the meaning of digital literacy has continued to expand towards the dimensions of safety, ethics, responsibility and civic participation. In its Statement on Digital Literacy, the International Federation of Library Associations and Institutions (2017) pointed out that digital literacy includes not only basic skills such as computer operation, information search and the use of e-government services, but also an understanding of how the internet functions, data security and privacy protection, as well as the capacity to use technology creatively, comply with legal and ethical norms, and develop a sense of global citizenship. The UNESCO Institute for Statistics (2018) further incorporated the "safe, appropriate and responsible use of digital technologies" into the core domains of the global digital literacy reference framework.

Since then, digital literacy has become increasingly recognized as a foundational capability for citizenship in digital society. The Australian Government regards digital literacy as the fourth set of basic qualities and capabilities that every citizen should possess, following literacy, language and numeracy (Australian Government, 2020). China's Outline for Enhancing Digital Literacy and Skills for All also clearly states that digital literacy is an integrated competence required for citizens to learn, work and live in digital society (Central Cyberspace Affairs Commission, 2021). Overall, the concept of digital literacy has evolved from operational skills for using tools, to the ability to understand and judge information, and further towards participation in digital society, ethical responsibility and lifelong development. It is no longer a single technical skill, but an integrated set of competencies that enables individuals to adapt to digital society, participate in digital life and pursue continuous development.

1.2 Conceptual Clarification of Related Terms

From the perspective of the conceptual development of digital literacy, its meaning is not limited to the use of digital tools. Rather, it has incorporated the core elements of a range of related concepts, including media literacy, computer literacy, information literacy, internet literacy, digital literacy and AI literacy. As a result, digital literacy has acquired a more comprehensive character. Table 2.1 presents the evolution and conceptual distinctions among these related concepts.

Table 2.1 Evolution and Distinctions of Concepts Related to Digital Literacy

Concept	Core Focus	Main Competencies	Contribution to Digital Literacy
Computer literacy	Operational use of computers and software	Device operation, software application, technical knowledge	Lays the technical and operational foundation for digital literacy
Information literacy	Accessing, evaluating, managing and creating information	Information retrieval, information evaluation, information management, knowledge construction	Constitutes the core of information processing and knowledge construction within digital literacy
Internet literacy	Communication, collaboration and development in online environments	Online communication, networked collaboration, social participation, online existence	Extends digital literacy into the dimensions of online interaction and social participation
Digital literacy	Integrated capacity for learning, working and living in digital environments	Technology use, information processing, content creation, ethical responsibility, critical reflection	Serves as an integrated concept formed through the evolution and convergence of multiple related literacy
Digital competence	Effective application of digital technologies in authentic contexts	Contextual application, problem solving, collaborative communication, professional practice	Reflects the practical, standardized and assessable orientation of digital literacy
AI literacy	Understanding, collaboration, judgement and reflection in intelligent technology environments	Human–AI collaboration, algorithmic understanding, intelligent decision-making, ethical judgement	Extends digital literacy towards algorithmic awareness and ethical governance in the intelligent era

Media literacy emerged in the 1930s. It generally refers to individuals' capacity to select, understand, question, evaluate, disseminate and produce media information, with an emphasis on media participation, meaning-making, and the use of media for self-development and social progress (Qiu Xiaochun & Xiao Longhai, 2021; Wu Shujuan, 2016). Compared with other related concepts, media literacy places greater emphasis on cultural meaning, value judgement and social participation in the circulation and communication of information.

Computer literacy emerged in the 1980s. It mainly refers to individuals' ability to understand and use computers and related software, highlighting technical knowledge and computer application. It laid the technological foundation for the subsequent development of information literacy, internet literacy and digital literacy. However, its meaning is relatively concentrated on the operational use of tools.

Information literacy emerged against the backdrop of the rapid development of the information society. Its core lies in individuals' ability to identify information needs, and to search for, evaluate, organize, use and create information. In the Framework for Information Literacy for Higher Education, the Association of College and Research Libraries conceptualizes information literacy as a set of abilities, practices and dispositions that enable individuals to participate in information ecosystems, conduct critical evaluation of information, manage information, and create knowledge through community-based learning. This indicates that the scope of information literacy has expanded from information access and processing to the broader information ecosystem (Association of College and Research Libraries, 2014).

Internet literacy emerged in the 1990s. It mainly refers to individuals' integrated capacity to learn, work, communicate, collaborate and develop in online environments. Building on information literacy, it further emphasizes online existence, digital interaction, collaborative participation and social development, reflecting a further expansion of the competencies required of individuals in internet-mediated environments.

Digital literacy also took shape in the 1990s. It is a comprehensive concept that gradually developed on the basis of computer literacy, information literacy, media literacy and internet literacy. Existing studies suggest that digital literacy is a comprehensive, dynamic and open-ended concept, representing the aggregation of elements that have evolved from multiple forms of literacy. Digital competence, by contrast, places greater emphasis on individuals' practical ability to use information society technologies confidently and critically in work and communication (Wang Youmei et al., 2013). At the same time, concepts such as digital literacy, digital skills, digital intelligence and digital competence are often used interchangeably in academic and policy texts, and the boundaries among them remain to some extent ambiguous (Pettersson, 2018; Brown & Xiao Junhong, 2018).

AI literacy is a more recent concept that has emerged in the context of the intelligent era. It focuses primarily on individuals' ability to understand, use, judge and critically reflect on intelligent technologies as they become increasingly embedded in social systems and everyday life. Compared with digital literacy, AI literacy gives greater emphasis to human–AI collaboration, algorithmic understanding, intelligent decision-making, ethical awareness and technological reflection. It thus represents a further extension of digital literacy in the age of AI.

To better distinguish the meanings of these related concepts, Peng Hongchao and colleagues adopt the perspective of the Data–Information–Knowledge–Wisdom (DIKW) model. They argue that data, information, knowledge and wisdom constitute a cognitive hierarchy from lower to higher levels, and that digital literacy can be understood as an integrated capacity running through this process of transformation, while information literacy and data literacy each emphasize different levels of competence within this process (see Figure 2.1) (Peng Hongchao & Zhu Kaige, 2024).

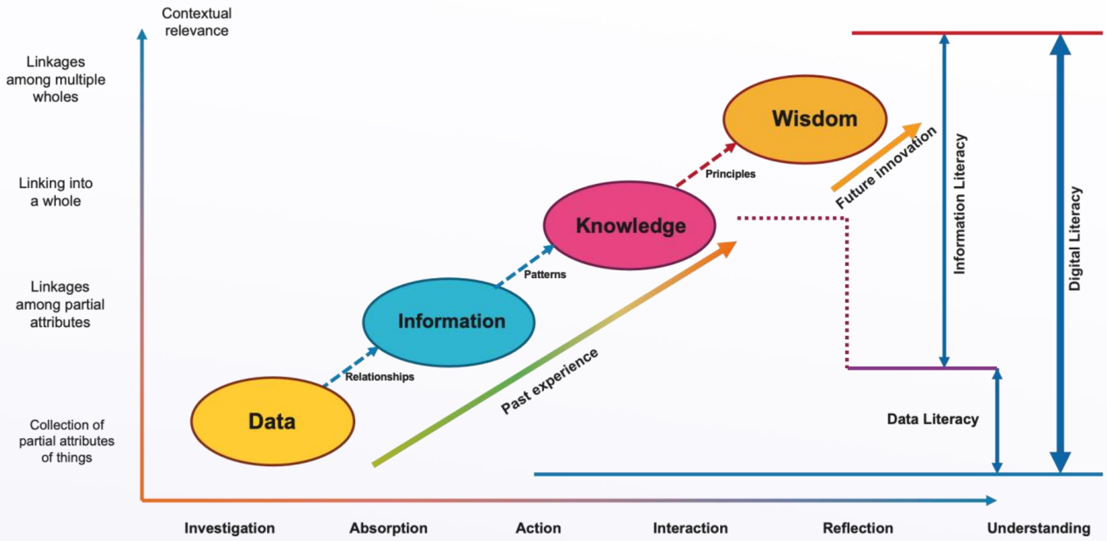


Figure 2.1 Relationship between Digital Literacy, Information Literacy and Data Literacy

In this framework, information literacy refers to the attitudes and abilities required for individuals to appropriately use information technologies to access, manage, express, integrate and evaluate information, as well as to construct new knowledge, analyse and solve problems, and engage in social interaction (Ministry of Education of the People's Republic of China, 2018). Information, in this sense, refers to meaningful content formed by establishing relationships among data (Wallace, 2007), and may be represented through graphics, text, sound, images and tables. Data literacy mainly refers to individuals' integrated capacity to appropriately access, understand, evaluate and manage data, and to transform data into meaningful information. Its core lies in extracting patterns, trends and evidence from data in order to support problem analysis and practice improvement. Compared with information literacy, which mainly focuses on information access, evaluation and use, digital literacy further incorporates data processing, the use of digital tools, online collaboration, and safety and ethics. It therefore demonstrates a stronger degree of comprehensiveness and contextual extensibility.

There are currently more than 100 models and frameworks of digital literacy (Brown & Xiao Junhong, 2018), and their formulations and definitions vary considerably. Overall, the related literacy concepts discussed above do not stand in a simple relationship of replacement. Rather, they have evolved, accumulated and expanded in response to changes in technological environments and social needs.

2. Defining the Meaning of Teachers' Digital Literacy

2.1 Academic Definitions of Teachers' Digital Literacy

The meaning and frameworks of teachers' digital literacy have largely been developed on the basis of the broader concept of digital literacy. Compared with the digital literacy of students or citizens in general, teachers' digital literacy is usually understood as a more complex system of competencies. First, as learners, teachers need to receive appropriate ICT education and acquire basic digital literacy. Second, as educators, teachers should also be able to use digital devices for teaching. In this sense, they need to develop digital teaching competence, enabling them to use digital technologies to support instructional delivery, improve teaching efficiency and enhance teaching effectiveness (Song Lingqing, 2023).

Existing studies have conceptualized teachers' digital literacy from different perspectives. Li Fang argues that, from its inception, teachers' digital literacy has referred to an integrated set of competencies encompassing knowledge, skills, emotions, attitudes, values and culture. While grounded in technical skills, it continuously incorporates humanistic values such as digital attitudes, digital awareness and a digital spirit, and therefore has both instrumental and humanistic dimensions (Li Fang, 2025). Marta Durán Cuartero defines teachers' digital literacy as the set of knowledge, skills and attitudes required for teachers to use digital technologies effectively in relation to technology, information, multimedia, communication, collaboration and social responsibility (Durán Cuartero, 2019). Kasperski et al. further point out that teachers' digital literacy refers to teachers' comprehensive capacity to use devices, technologies and software critically in order to access, manage, integrate, evaluate and communicate digital information; to reorganize learning environments; to process and create digital resources; and to promote the deep integration of technology and pedagogy, thereby improving teaching effectiveness and the capacity for knowledge innovation (Kasperski et al., 2022).

Other studies suggest that teachers' digital literacy is reflected in teachers' ability to draw on complex cognitive, social and emotional capabilities to enhance understanding and communicate ideas in digital environments (Kong Lingshuai & Wang Nannan, 2023). Liu Baocun and colleagues define teachers' digital literacy as a set of knowledge, abilities, awareness and ethical attitudes that enable teachers to use digital technologies in education and teaching. Teachers are expected not only to use digital technologies for educational and instructional purposes, but also to foster students' digital literacy (Liu Baocun & Yi Xuejin, 2024).

In addition to defining teachers' digital literacy as an extension of general digital literacy, some studies also emphasize its internal relationship with information literacy and data literacy. In this regard, teachers' data literacy refers to the integrated capacity to appropriately access, understand, evaluate and manage educational data, and to transform such data into information (Li Xin et al., 2019). Mandinach and Gummer further argue that the core of data literacy lies in extracting evidence from data that can improve instructional processes and optimize learning outcomes (Mandinach & Gummer, 2016). This means that, as the digital transformation of education continues to advance, the requirements for teachers' ICT-based teaching competence have changed. They have expanded from information literacy to digital literacy. Teachers are no longer expected only to produce courseware or use information tools such as Office software; they are also expected to collect, analyse and interpret educational data, and to use intelligent or digital tools such as smart boards, dot-matrix pens and electronic class signs to support educational and teaching practice and to optimize and innovate instructional processes (Peng Hongchao & Zhu Kaige, 2024).

Overall, although academic definitions of teachers' digital literacy have not yet converged into a single formulation, several areas of consensus have become relatively clear. First, teachers' digital literacy is an expansion and extension of digital literacy in the field of education. It inherits the basic principles of general digital literacy while embedding the professional characteristics of teaching contexts, instructional practice and teacher development (Wu Di et al., 2023). Second, teachers' digital literacy is not a single form of technical operational ability. Rather, it is an integrated form of professional literacy that combines knowledge, skills, awareness, attitudes, ethical responsibility and humanistic values. Third, the value of teachers' digital literacy does not lie merely in enhancing individual teachers' ability to use digital technologies. More importantly, it lies in supporting instructional improvement, promoting student development and advancing educational innovation.

At the same time, because countries and regions differ in their stages of education digitalization, policy objectives and teacher professional development needs, academic understandings of the specific meaning of teachers' digital literacy still vary to some extent. Therefore, to accurately clarify the conceptual meaning of Chinese teachers' digital literacy, it is necessary to return to the process of education digitalization in China and examine the historical evolution of literacy-related requirements for teachers.

2.2 The Evolutionary Logic of Chinese Teachers' Digital Literacy

As the integration of technology with education and teaching has continued to advance, China's requirements for teacher workforce development, as well as the priorities attached to it, have been adjusted across different periods. This process has also driven the continuing evolution of the meaning of teacher-related competencies. Overall, the requirements for teachers in China have broadly evolved from "educational technology competence" to "information technology application competence", then to "information literacy", and further to "digital literacy" (see Figure 2.2) (Wu Di et al., 2023). This process not only reflects the phased characteristics of technology integration into education and teaching, but also demonstrates a broader trend in teacher development: from an emphasis on technical operation towards an orientation to integrated competencies.

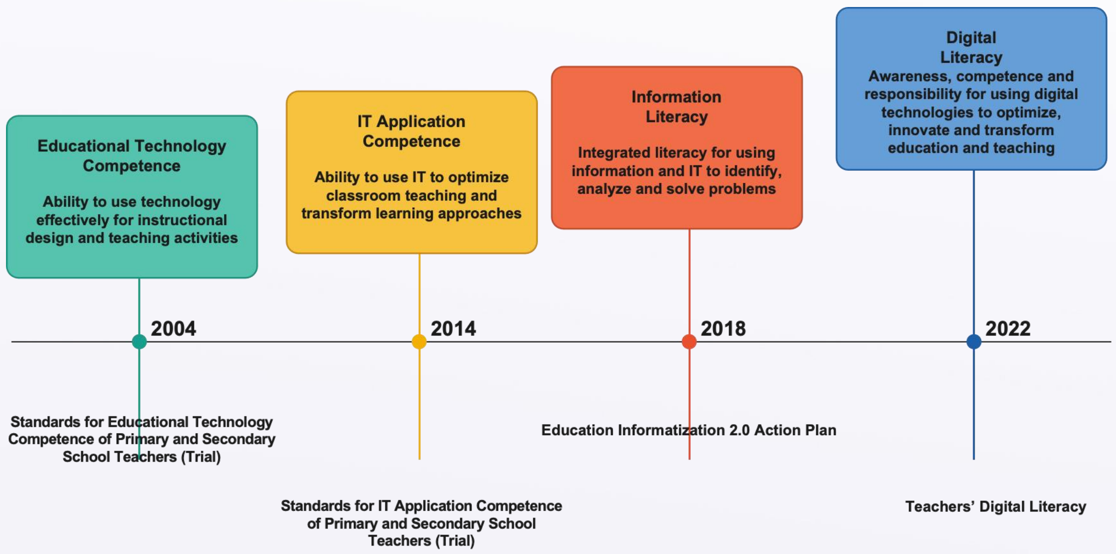


Figure 2.2 Changes in Teacher Development Requirements across Different Stages

In the early stage of integrating information technology with education and teaching, China's requirements for teacher development mainly focused on educational technology competence. In 2004, the Ministry of Education issued the Standards for Educational Technology Competence of Primary and Secondary School Teachers (Trial) (Ministry of

Education of the People's Republic of China, 2004). In 2005, it launched the National Programme for Developing Educational Technology Competence among Primary and Secondary School Teachers, emphasizing that teachers should be able to use technology for teaching (Ministry of Education of the People's Republic of China, 2005). During this period, the core meaning of teacher-related competencies was mainly reflected in the foundational ability to apply technology to instructional design, implement teaching activities and support classroom teaching (He Kekang, 2006).

As the integration of information technology with education and teaching continued to deepen, China's requirements for teacher development gradually shifted towards information technology application competence. Against the backdrop of the development and application of the "Three Connections and Two Platforms", information technology gradually penetrated instructional design, teaching implementation, assessment feedback and other processes, becoming an important support for transforming classroom teaching and learning approaches (Ren Youqun & Gu Xiaoqing, 2019). To promote the deep integration of information technology with education and teaching, the Ministry of Education launched the National Programme for Enhancing Primary and Secondary School Teachers' Information Technology Application Competence in 2013 (Ministry of Education of the People's Republic of China, 2013), and issued the Standards for Primary and Secondary School Teachers' Information Technology Application Competence (Trial) in 2014 (General Office of the Ministry of Education, 2014). At this stage, the focus of teacher development was no longer limited to "being able to use technology". Greater emphasis was placed on using information technology to optimize classroom teaching, improve pedagogical approaches and promote changes in learning.

As the influence of information technology on education and teaching moved from superficial application to deeper transformation, profound changes took place in educational environments, educational models, educational concepts and educational cultures (Yang Zongkai et al., 2019). China's requirements for teacher development were further elevated to information literacy. In 2018, the Ministry of Education issued the Education Informatization 2.0 Action Plan, which explicitly proposed a shift from improving teachers' and students' information technology application competence to comprehensively enhancing information literacy (Ministry of Education of the People's Republic of China, 2018). Compared with the information technology application competence emphasized in the previous stage, information literacy places greater emphasis on teachers' integrated capacity to appropriately use information and information technologies to identify, analyse and solve problems in education and teaching (Wu Di et al., 2020).

With the transition to the stage of digital transformation in education, digital technologies have become more deeply embedded in all elements, processes and dimensions of education, thereby promoting systemic transformation in education and teaching (Huang Ronghuai & Yang Junfeng, 2022). In this context, digital literacy has become a key competence required of teachers in the digital age. Existing studies note that digital literacy represents the extension and development of information literacy in the digital era, and that the main difference between the two lies in the different emphases placed on literacy content and competency requirements in different historical periods (Wu Di et al., 2020).

In 2022, the Ministry of Education issued the education sector standard Teachers' Digital Literacy, which defines teachers' digital literacy as the awareness, ability and responsibility that enable teachers to appropriately use digital technologies to access, process, use, manage and evaluate digital information and resources; to identify, analyse and solve problems in education and teaching; and to optimize, innovate and transform educational and teaching activities (Ministry of Education of the People's Republic of China, 2022). This marked a further shift in China's requirements for teacher development: from educational technology competence, information technology application competence and information literacy towards a digital literacy orientation that integrates digital awareness, competence and responsibility.

3. Mainstream Frameworks of Teachers’ Digital Literacy

3.1 Teachers’ Digital Literacy Frameworks from International Organizations

UNESCO: The Continuing Evolution of ICT Competency Framework

In the process of promoting the standardization and systematization of teachers' digital literacy, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has played a foundational role. Between 2008 and 2018, UNESCO successively released three versions of the ICT Competency Framework for Teachers, gradually establishing a digital competency framework system oriented towards teacher professional development. While maintaining the underlying logic that teacher competencies can support educational transformation, the three versions have continuously responded to emerging demands arising from the rapid iteration of digital technologies, educational equity, teacher professional development and alignment with national policies.

Subsequently, with the rapid development of new technologies such as generative AI, UNESCO further released the AI Competency Framework for Teachers in 2024, advancing the framework of teachers' digital competencies from ICT integration in a general sense to a new stage of reconstructing teacher competencies in the age of AI (see Table 2.2). This framework is not a simple repetition of the ICT-CFT. Rather, it is a new framework specifically designed for the age of AI and focused on teachers' AI competencies. UNESCO positions it as a global framework intended to help define the knowledge, skills and values that teachers should acquire in the AI era. It identifies five dimensions and 15 competencies. The five dimensions are: a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning.

Compared with the previous three versions, the particular significance of the 2024 framework lies in the fact that it shows that UNESCO's understanding of teachers' digital competencies has moved beyond ICT integration in a general sense towards the reconstruction of teacher competencies in the intelligent era. In other words, teachers' digital literacy is no longer manifested only as the ability to use technology to support teaching. It has further expanded into an integrated set of competencies that enables teachers to exercise educational judgement, engage in ethical governance, innovate pedagogy and pursue professional development in AI-enabled environments.

Table 2.2 The AI competency framework high-level structure: aspects and progression levels

Aspects	Progression		
	Acquire	Deepen	Create
1. Human-centred mindset	Human agency	Human accountability	Social responsibility
2. Ethics of AI	Ethical principles	Safe and responsible use	Co-creating ethical rules
3. AI foundations and applications	Basic AI techniques and applications	Application skills	Creating with AI
4. AI pedagogy	AI-assisted teaching	AI–pedagogy integration	AI-enhanced pedagogical transformation
5. AI for professional development	AI enabling lifelong professional learning	AI to enhance organizational learning	AI to support professional transformation

European Union: Digital Competence Framework for Educators

As a regional community for economic cooperation and governance, the European Union has consistently regarded education and training as an important area of investment for enhancing regional competitiveness, promoting social cohesion and responding to digital transformation. As early as 2006, the European Union developed a framework of key competences, identifying eight key competences required by European citizens in the twenty-first century, among which digital competence was included.

With regard to teachers' digital literacy, the European Framework for the Digital Competence of Educators (DigCompEdu), released in 2017, represents the most influential core outcome (European Commission's Joint Research Centre, 2017). Unlike many frameworks that emphasize technical skills, DigCompEdu does not focus primarily on training educators to master specific tools. Rather, it aims to support educators in enhancing professional engagement in digital environments, improving instructional design and implementation, optimizing assessment practices, empowering learners, and fostering learners' digital competence.

Structured around educators' professional practice, DigCompEdu establishes a framework comprising six competence areas and 22 competences (see Figure 2.3). The six competence areas are: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. Professional engagement mainly concerns teachers' digital participation in professional communication, collaboration, reflection and professional development. Digital resources focuses on how teachers select, create, adapt and share digital resources. Teaching and learning focuses on teachers' integration of digital technologies into instructional design, classroom organization and learning activities. Assessment emphasizes the use of digital technologies to support both formative and summative assessment. Empowering learners concerns the use of digital technologies to promote inclusion, equity, personalization and learners' active participation. Facilitating learners' digital competence further emphasizes that teachers should help students develop information and media literacy, digital communication and creation, safety awareness, and the capacity to use digital technologies responsibly.

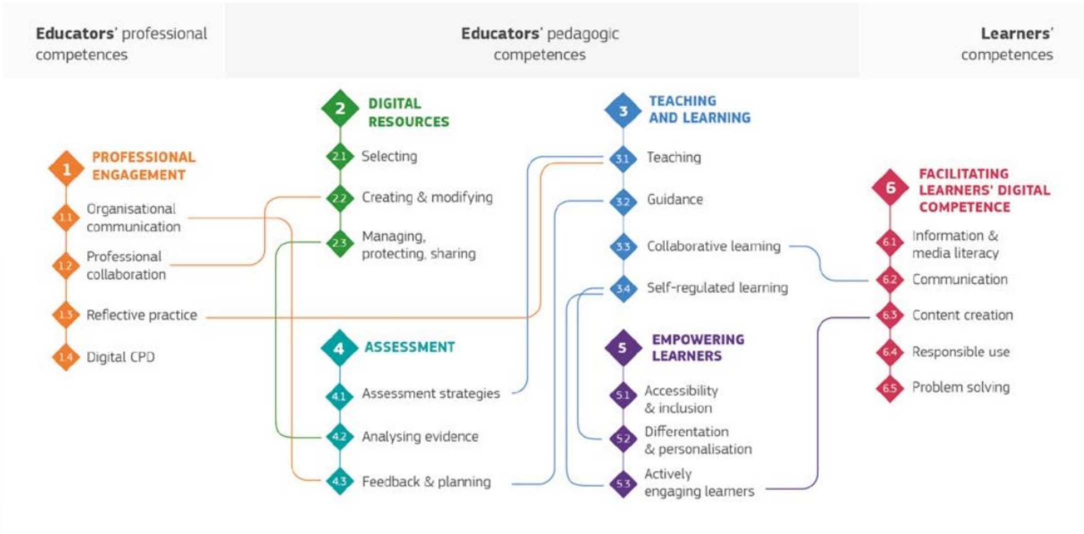


Figure 2.3 European Framework for the Digital Competence of Educators

This structure has two notable features. First, it focuses not only on teachers' own digital competence, but also incorporates support for learners' digital competence development as an important component of teachers' digital competence, reflecting a clear learner-centred orientation. Second, it systematically organizes teachers' digital competence across resource use, instructional implementation, assessment and feedback, professional development and learner empowerment. In this way, digital literacy is no longer understood as a collection of discrete skills, but as an integrated competence system closely connected with teachers' professional activities.

OECD: A Survey Framework for Teacher Professional Development and the Use of Digital Technologies

The Teaching and Learning International Survey (TALIS), initiated and implemented by the Organisation for Economic Co-operation and Development (OECD), is one of the most influential international survey programmes on teachers and school leaders worldwide. To date, four cycles have been conducted, in 2008, 2013, 2018 and 2024 (Ainley & Schulz, 2025).

Unlike the teacher digital literacy competency frameworks issued by UNESCO, the European Union and other organizations, TALIS is not a dedicated standard for teachers' digital literacy. Rather, through large-scale international surveys, it provides an evidence base for understanding the development of teachers' digital competence from the perspectives of teacher professional development, classroom practice, school environments and institutional conditions.

The TALIS 2024 conceptual framework (see Table 2.3) focuses on teachers and their teaching conditions. Its core themes include teachers' educational background and initial preparation, professional development, classroom practice, well-being and job satisfaction, autonomy, employment status, and intention to remain in the teaching profession (OECD, 2024a). In the 2024 survey cycle, TALIS pays particular attention to four issues: diversity and equity, the use of technology in education, social and emotional learning, and environmental and sustainability education. Among these, "the use of technology in education" is directly related to teachers' capacity to teach in digital environments, support learning and promote student development (Ainley & Schulz, 2025). At the same time, TALIS 2024 introduced a dedicated Teacher Knowledge Survey (TKS) module, which incorporates "using technology to support teaching" as an important component of teachers' general pedagogical knowledge. This indicates that, although TALIS is not a teachers' digital literacy framework in the narrow sense, it can serve as an important international survey framework for examining the development status of teachers' digital literacy, their professional support needs, and the institutional environments of schools.

Table 2.3 Components of TALIS 2024

Theme	Issue / Feature	Domain
Contemporary issues affecting teachers, teaching and learning	Diversity and equity	—
	Technology use in education	—
	Social and emotional learning	—
	Environmental and sustainability education	—
Enduring characteristics of teachers, teaching and learning	Teacher learning and development	Initial teacher education
		Continuous professional learning
	Teachers' work practices	Teaching practices
		Professional practices
	Occupational perceptions	Job satisfaction, occupational well-being, and perceived value of teaching
		Teacher self-efficacy
	Institutional environment for teaching	School leadership
		School climate

(Source: Teaching and Learning International Survey (TALIS) 2024 Conceptual Framework (p. 23), by J. Ainley and W. Schulz, 2025, OECD Publishing (https://doi.org/10.1787/7b8f85d4-en))

UNICEF: Framework for Educators in Sub-Saharan Africa

In 2026, the United Nations Children's Fund (UNICEF) released Pathways: A Digital Competence Framework for Educators in Sub-Saharan Africa. This is a regionally adapted framework for educators' digital competence, designed for educational contexts in Sub-Saharan Africa. Unlike comprehensive frameworks developed for regions with relatively well-established foundations for digital education, this framework responds specifically to real-world conditions characterized by low resources, limited connectivity, constrained access to devices and restricted infrastructure. It emphasizes how educators can use digital tools to support effective teaching and learning in resource-constrained settings.

The framework applies not only to teachers, but also to classroom facilitators, school leaders, local education officials and ICT support personnel. It comprises 14 competence areas: foundational skills in device use; foundational practices for digital learning; using technology for communication and collaboration; creating and adapting digital resources; using and managing digital content; professional development in digital practice; managing and maintaining digital infrastructure; leading technology use in schools; using technology for teaching; pedagogical uses of technology in specific contexts; collecting and using digital evidence of learning; using technology for learners with disabilities and learning support needs; use of AI; and supporting the development of learners' digital literacy.

The framework describes the development of educators' digital competence through three progression levels: "explore", "embed" and "extend" (see Table 2.4). "Explore" mainly refers to educators developing basic awareness, understanding relevant concepts and trying to use digital technologies with support. "Embed" indicates that educators are able to use digital technologies more independently and consistently in teaching or management practice. "Extend" emphasizes educators' capacity to use digital technologies in more strategic, creative and collaborative ways to improve teaching practice and organizational development.

Table 2.4 Progression Levels in UNICEF's Digital Competence Framework for Educators in Sub-Saharan Africa

Competence Level	Level Description	Descriptor	Typical Verbs	Typical Actions
Explore	This is the introductory level of	Developing awareness and beginning to take	Ask, describe, discuss, consider, explore, follow, identify, list, observe, recognize, explain, try, use	Discuss possible options; begin to try things out; use basic functions of a tool for the first time; complete

Competence Level	Level Description	Descriptor	Typical Verbs	Typical Actions
	information and awareness for any competence.	action, sometimes with support.	with support, and functional verbs related to basic tasks.	functional tasks with guidance or support; know when and where to seek help.
Embed	This is the minimum level of independent competence or performance for any competence.	Taking action with increasing confidence, independence and purpose.	Adjust, adapt, apply, choose, demonstrate, encourage, explain, manage, plan, select, solve, support, troubleshoot, use appropriately, and functional verbs related to higher-level tasks.	Use digital tools independently; adjust actions according to goals or contexts; begin to support others; reflect on choices and outcomes.
Extend	This is a visionary and higher level of competence or performance for any competence.	Applying skills in strategic, creative or collaborative ways to improve practice.	Advocate, anticipate, create, design, develop, embed, evaluate, improve, initiate, integrate, lead, maintain, model.	Create new uses or approaches; support or guide others; improve processes; combine tools to achieve more effective outcomes.

ISTE: Association-led Framework for Teachers' Digital Literacy

The United States has not established a unified national framework for teachers' digital literacy issued by the federal government. Instead, such frameworks have mainly been developed and promoted by professional associations. Among them, the most representative and influential framework is the ISTE Standards for Educators issued by the International Society for Technology in Education (ISTE) (see Figure 2.4). ISTE positions the standards as a framework that guides educators in using technology for learning, teaching and leading change, and notes that the standards have been widely adopted across all U.S. states and in multiple countries.

Between 1993 and 2017, five versions of ISTE-E were successively released in the United States. The ISTE Standards for Teachers, released in 2008, focused mainly on how teachers in the digital age could facilitate students' creativity, design digital learning experiences, build digital learning environments, cultivate digital citizenship, and engage in professional growth. In 2017, ISTE made a major revision to the teacher standards and officially released the ISTE Standards for Educators. This revision responded to changes in classroom technology environments and learning approaches, and sought to promote a shift from teachers who use technology to educators who redesign learning through technology.

This framework does not understand teachers' digital literacy as a set of isolated technical skills. Instead, it defines teachers' professional competencies in the digital age through a reconstruction of professional roles. Its overall structure consists of two major domains and seven roles. The first domain is empowered professional, which includes the roles of learner, leader, citizen and collaborator. The second domain is learning catalyst, which includes the roles of designer, facilitator and analyst.

In terms of its core emphases, the U.S. framework for teachers' digital literacy reflects at least four major features. First, it highlights the professional growth dimension of teachers' digital literacy. Teachers are expected to continuously set professional learning goals, participate in learning communities, and reflect on the effectiveness of technology-supported teaching. This is mainly reflected in the roles of learner and leader. Second, it emphasizes digital citizenship and a sense of responsibility, requiring teachers to attend to equity, inclusion, ethics and responsible participation in the use of digital tools and resources. This is concentrated in the role of citizen. Third, it highlights instructional design and learning facilitation. Teachers are expected to design digital learning activities, create learning environments that support students' active construction of knowledge, and facilitate students' self-directed, collaborative and inquiry-based learning with the support of technology. This is mainly reflected in the roles of designer and facilitator. Fourth, it emphasizes data-informed instructional improvement. Teachers are expected to use data and digital evidence to understand learning processes, support assessment and optimize decision-making. This is concentrated in the role of analyst.

Figure 2.4 ISTE Standards for Educators (2017 Edition)

3.2 Teachers' Digital Literacy Frameworks in Selected Countries

China: National Standardized Framework

In 2022, the Ministry of Education of China issued the education sector standard Teachers' Digital Literacy. The standard defines "teachers' digital literacy" as "the awareness, ability and responsibility that enable teachers to appropriately use digital technologies to access, process, use, manage and evaluate digital information and resources; to identify, analyse and solve problems in education and teaching; and to optimize, innovate and transform educational and teaching activities". The framework comprises five first-level dimensions: digital awareness, digital technology knowledge and skills, digital application, digital social responsibility, and professional development. It further includes 13 second-level dimensions and 33 third-level dimensions, providing comprehensive guidance and support for enhancing teachers' digital literacy (see Figure 2.5).

Among these dimensions, digital awareness mainly emphasizes teachers' understanding of the value of digital technologies, trends in digital transformation, and their impact on education and teaching, as well as teachers' willingness and disposition to actively adapt to and participate in the digital transformation of education. Digital technology knowledge and skills focus on teachers' mastery of digital tools, digital resources and related technological knowledge, which constitutes the competency foundation for teachers' digital teaching practice. Digital application is directly oriented towards educational and teaching practice. It emphasizes teachers' use of digital technologies to optimize instructional design, innovate instructional processes, enhance assessment and analytical capacities, and improve approaches to educating students. Digital social responsibility is a distinctive feature of China's framework. It stresses that teachers should attend to responsibility requirements related to equity, inclusion, green development, openness and cooperation, as well as data security and ethical norms in digital education practice. Professional development emphasizes that teachers should continuously enhance their digital literacy through digital professional learning, collaborative teaching research and reflective practice.

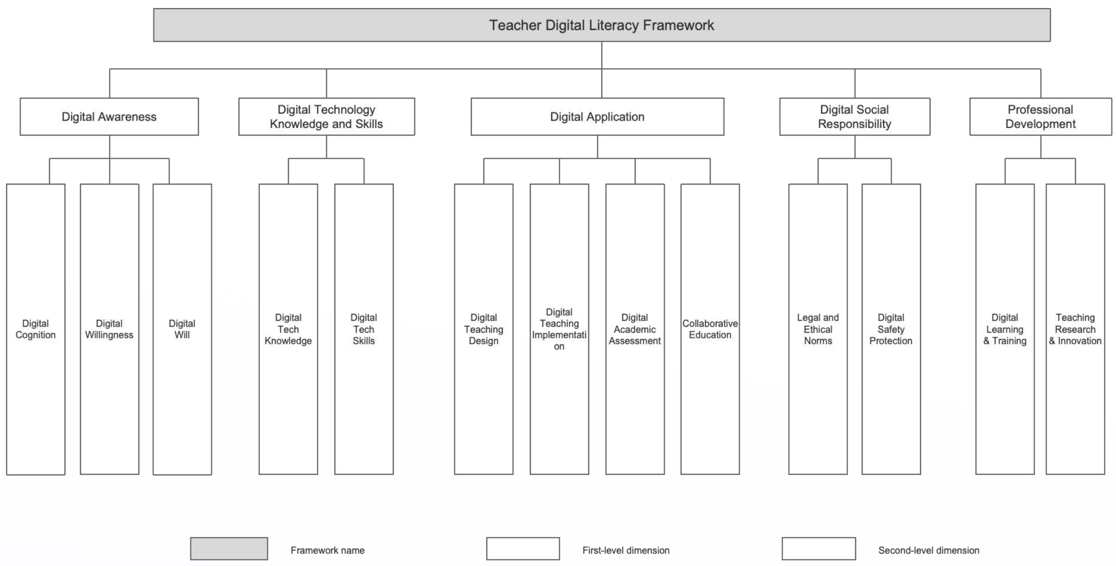


Figure 2.5 Framework for Teachers' Digital Literacy (2022)

Compared with many international frameworks, China's Teachers' Digital Literacy standard demonstrates at least four distinctive features. First, it has a high degree of standardization. Issued formally as an education sector standard, it marks the transition of teachers' digital literacy development from policy advocacy to institutional regulation. Second, it has a clear orientation towards professional practice. The standard is consistently organized around the core task of enabling teachers to use digital technologies to optimize, innovate and transform educational and teaching activities, rather than remaining at the level of general digital skills. Third, it gives prominence to the responsibility dimension. By establishing "digital social responsibility" as a core dimension in its own right, the standard reflects China's strong emphasis on teachers' digital ethics, educational equity and responsibility for safety and security. Fourth, it is closely aligned with the national strategy for education digitalization. The issuance of the standard itself serves the national strategic action for education digitalization, and therefore has a clear policy-supporting function and practical orientation.

United Kingdom: Practice-oriented Framework by Stakeholders

The framework landscape for teachers' digital literacy in the United Kingdom is characterized by the joint participation of multiple stakeholders. Rather than having a single, unified national standard for teachers' digital literacy, the UK has developed related frameworks through the contributions of different institutions, which address teaching practice, organizational development, foundational skills and digital safety from complementary perspectives.

Among these frameworks, the one most directly oriented towards teachers' instructional practice is the Digital Teaching Professional Framework (DTPF), released in 2018 by the Education and Training Foundation (ETF). Based on the European Union's three-level structure of A, B and C, the DTPF divides teachers' digital literacy into three stages of development. The first stage is "exploring", in which teachers learn new digital technologies and engage in basic digital practices. The second stage is "adopting", in which teachers apply digital technologies to relevant practices and continuously expand their use. The third stage is "leading", in which teachers are able to critically reflect on existing digital practices and, on this basis, develop new digital practices and disseminate new knowledge.

Another highly influential framework for teachers' digital capabilities in the UK (see Figure 2.6) is the Digital Capabilities Framework, released in 2023 by the Joint Information Systems Committee (JISC) (JISC, 2023). Unlike the ETF framework, which focuses more directly on classroom teaching practice, the JISC framework pays greater attention to what "digital capability" means for individuals across different educational contexts. It understands digital capability as an integrated competence that varies according to role, discipline, profession and context. Its core consists of six elements: digital proficiency and productivity; digital creation, problem-solving and innovation; digital learning and development; information, data and media literacy; digital communication, collaboration and participation; and digital identity and digital well-being. At the same time, the framework divides capability development into two levels, ordinary and advanced, in order to support the identification and enhancement of teachers' capabilities at different stages of development.

In terms of its core emphases, three aspects of the JISC framework are particularly noteworthy. First, it highlights information, data and media literacy, extending teachers' digital literacy beyond the use of classroom tools to broader areas such as resource evaluation, data use and media judgement. Second, it incorporates digital well-being into the core of the framework, emphasizing the impact of technology use on psychological, physical, social and emotional health. Third, it emphasizes organizational support, pointing out that the development of teachers' digital literacy is not merely a matter of individual capability, but is also closely related to institutional culture, policy support and infrastructural conditions.

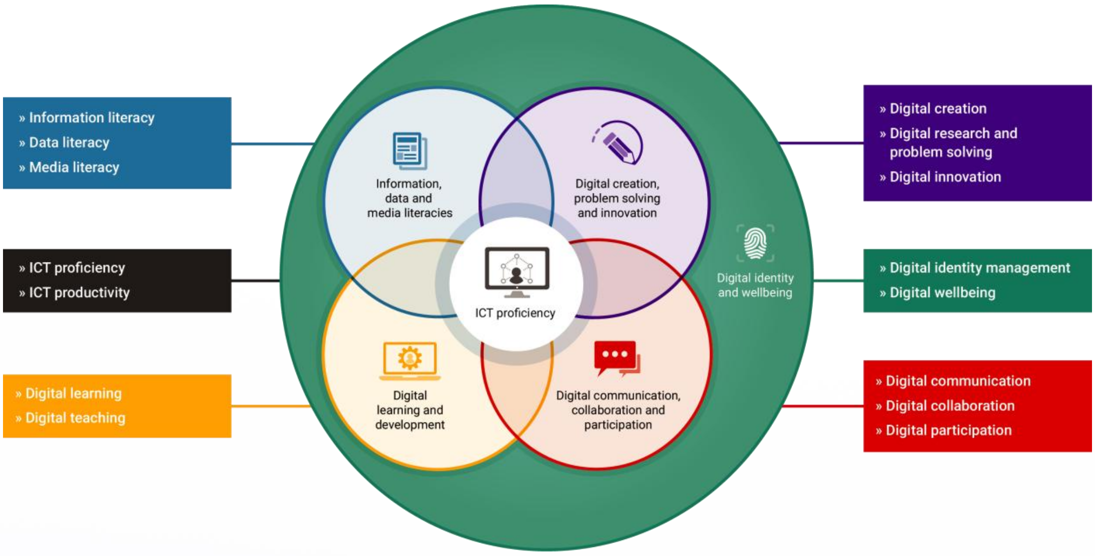


Figure 2.6 Digital Capabilities Framework for Higher Education Teachers (2023 Edition)

Taken together, UK frameworks related to teachers' digital literacy demonstrate at least four distinctive features. First, they reflect multi-stakeholder co-construction. The UK does not have a single, unified national standard for teachers' digital literacy; instead, ETF, JISC, government departments and other stakeholders jointly advance this agenda from the perspectives of teaching practice, organizational development, foundational skills and online safety. Second, they demonstrate a strong practice orientation. This is particularly evident in the ETF framework, which emphasizes that digital capabilities should serve authentic teaching activities rather than remain at the level of technical skills. Third, they emphasize a broad understanding of digital capability. By incorporating information, data, media, digital identity and digital well-being into the scope of teachers' digital capabilities, the JISC framework indicates that the UK's understanding of teachers' digital literacy has moved beyond simple ICT integration. Fourth, they attach importance to digital citizenship and responsibility for online safety. Through the Education for a Connected World framework and related online safety guidance, the UK further strengthens teachers' responsibilities in digital ethics, cybersecurity and support for students' digital lives.

Norway: Framework Characterized by Professionality

A representative framework for teachers' digital literacy in Norway is the Professional Digital Competence Framework for Teachers, released in 2017 (see Figure 2.7) (Kelentri et al., 2017). In terms of its positioning, the framework has two core purposes: first, to support teacher professional development; and second, to support teachers' professional practice itself.

Figure 2.7 Visualisation of the Professional Digital Competence Framework for Teachers

Unlike some frameworks that understand teachers' digital literacy as a collection of technical skills, the most distinctive feature of the Norwegian framework is that it defines teachers' digital literacy as an extension and reconstruction of teachers' overall professional competence in the digital age. In other words, digital competence is not an external addition to the teaching profession; rather, it is embedded in the core structure of teachers' professional practice.

In terms of content design, the framework adopts a clear two-dimensional structure. The first dimension consists of seven competence areas: subjects and basic skills; school and society; pedagogy and subject didactics; ethics; interaction and communication; leadership of learning processes; and change and development. The second dimension elaborates each area through the categories of knowledge, skills and competence. The significance of this structure lies in the fact that it does not break teachers' digital literacy down into fragmented tool-based abilities. Instead, it directly connects digital competence with the key dimensions of teachers' professional practice, thereby constructing a framework for teachers' professional digital competence in the full sense.

Overall, the framework demonstrates four notable features. First, it highlights the professional nature of teachers' digital literacy, emphasizing that digital competence is an important component of teachers' overall professional competence. Second, it adopts an integrated structure. Its seven areas cover subject knowledge, society, pedagogy, ethics, communication, leadership of learning and change-oriented development, reflecting a digital understanding of the full landscape of the teaching profession. Third, it emphasizes development and practice. The framework serves teacher education, continuing professional development and digital teaching practice, while also supporting self-assessment, surveys and the subsequent development of assessment tools. Fourth, it attaches particular importance to ethics, citizenship and social responsibility. Compared with frameworks that focus only on teaching integration or tool use, it therefore has a stronger value orientation and a clearer public education perspective.

Spain: Reference Framework for Teachers' Digital Literacy

Spain's framework for teachers' digital literacy is characterized by a continuing evolution from a common framework to a reference framework. The former mainly served as a shared reference for the development, assessment and certification of teachers' digital competence, while the latter constitutes the current national reference framework, developed through localized adaptation on the basis of the European Union's DigCompEdu. The two frameworks have a clear line of continuity and, taken together, illustrate the broader shift in Spain's teacher digital competence framework from descriptive construction to institutionalized implementation.

In 2017, Spain's National Institute of Educational Technologies and Teacher Training (INTEF) released the Common Digital Competence Framework for Teachers. Drawing primarily on the five competence areas of the European Digital Competence Framework for Citizens, the framework constructed a digital competence system for teachers. It comprised five areas: information and information literacy, communication and collaboration, digital content creation, safety, and problem solving. These were further specified into 21 competences and organized into six proficiency levels, thereby supporting teachers' competence assessment and continuous improvement.

In 2022, Spain formally released the Spanish Framework for the Digital Competence of Teachers (SFDCT) through its official state gazette (see Table 2.5). The framework was developed and explained by the National Institute of Educational Technologies and Teacher Training (INTEF), which is part of Spain's education administration system (INTEF, 2022). Compared with the 2017 version, the 2022 framework no longer primarily draws on the citizen-oriented digital competence framework. Instead, it is explicitly based on the European Union's European Framework for the Digital Competence of Educators (DigCompEdu), and has been adapted to the Spanish context in light of Spanish education legislation, teachers' statutory responsibilities and stages of teacher professional development. It has thus become the current national reference framework for developing teachers' digital competence in Spain.

In terms of structure, the 2022 version consists of six areas and 23 competences, further accompanied by stages, levels, achievement indicators and performance statements. Its overall system is therefore clearly more complete than that of the 2017 version. The six areas are: professional engagement, digital content, teaching and learning, assessment and feedback, empowering learners, and facilitating learners' digital competence. Overall, the core focus of the 2022 version is no longer to establish a general and shared list of digital competences, but to construct a framework for teachers' professional digital competence centred on teaching practice and learner development.

Table 2.5 Spain's Common Digital Competence Framework for Teachers (2022 Edition)

Area	Main Competences
Area 1: Professional Engagement	Organizational communication; participation, collaboration and professional coordination; reflective practice; continuous digital professional development; protection of personal data, privacy, safety and digital well-being
Area 2: Digital Content	Searching for and selecting digital content; creating and modifying digital content; copyright and licensing; organizing, protecting, managing and sharing content
Area 3: Teaching and Learning	Teaching; learning guidance and support; collaborative learning; self-regulated learning
Area 4: Assessment and Feedback	Assessment strategies; analysing evidence; feedback, planning and decision-making
Area 5: Empowering Learners	Accessibility and inclusion; addressing students' individual learning differences; promoting students' active engagement in learning
Area 6: Facilitating Students' Digital Competence	Information and data literacy; digital communication and collaboration; digital content creation; responsible use; digital problem-solving

Austria: Framework Covering Professional Trajectory of Teachers

A representative framework for teachers' digital literacy in Austria is the teacher digital competence model, digi.kompP Kompetenzmodell (The University College of Virtual Teacher Education, 2016). The model was led by the Austrian University College of Virtual Teacher Education (Virtuelle Pädagogische Hochschule) and developed under the commission of the Austrian Federal Ministry of Education. Its Version 1.0 was released in 2016, with the aim of serving as a tool for teachers' self-assessment and continuing professional development.

Unlike some frameworks that focus primarily on the integration of technology into classroom teaching, digi.kompP places greater emphasis on the comprehensive professional nature of teachers' digital literacy. It brings digital social life, resource design, instructional implementation, subject teaching, school management, the school community and professional development into a unified framework. Its overall structure adopts a design of "eight categories (A-H) plus two phases (Phase 1/Phase 2)". The former defines the main areas of teachers' digital literacy, while the latter reflects the continuity of teachers' digital competence development. In terms of the categories, Category A focuses on the foundations of teachers' digital competence and informatics education. Category B emphasizes teachers' understanding of digital social life and media environments. Category C focuses on the collection, processing and sharing of digital resources. Categories D and E correspond respectively to the integration of digital technologies in general teaching contexts and subject-specific teaching contexts. Category F concerns digital management affairs in schools. Category G emphasizes digital communication and collaboration within the school community. Category H focuses on teachers' own continuing professional growth.

At the same time, the framework uses behavioral descriptions characterized by "can-do statements", enabling teachers to conduct competence diagnosis and development planning on the basis of specific performance indicators. In terms of phases, Phase 1 mainly corresponds to competence acquisition during teacher education and pre-service preparation, while Phase 2 places greater emphasis on the deepening and continued expansion of practice after entry into the profession. From a more complete developmental perspective, the model is in fact oriented towards teachers' continuous growth across the early stage of teacher preparation, the teacher education stage, and the first five years after entering the profession.

This design indicates that Austria does not regard teachers' digital literacy as a set of knowledge and skills to be mastered once and for all. Rather, it views it as a dynamic competence that runs through the full process of teacher preparation, induction and professional development. Subsequently, Austria updated the model in 2019 and made further adaptive adjustments in later versions. The updated version generally maintains the comprehensive professional orientation of the original framework, while further refining competence descriptors and specific requirements. It places stronger emphasis on teachers' practical application capacities in digital teaching, school collaboration and professional development (see Figure 2.8).

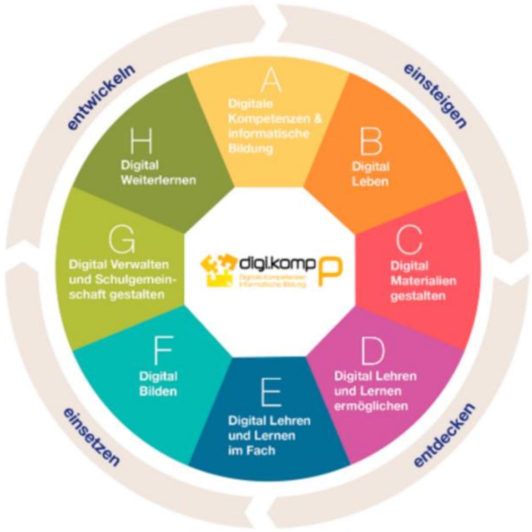


Figure 2.8 Teacher Digital Competence Model (2019 Revised Edition)

3.3 Comparative Analysis and Feature Synthesis of Mainstream International Frameworks

From a horizontal comparative perspective, the teachers' digital literacy frameworks developed by UNESCO, the European Union, Spain, Austria, Norway, the United Kingdom, the United States and China have all moved beyond a narrow focus on tool operation. They increasingly situate teachers' digital literacy within professional practice, instructional improvement, learner development, educational responsibility and systemic transformation.

UNESCO's ICT-CFT was among the earlier frameworks to adopt an education system transformation perspective. It connected teachers' ICT competencies with policy understanding, curriculum and assessment, pedagogy, organization and administration, and teacher professional learning. The 2024 AI Competency Framework for Teachers further responds to the age of AI by emphasizing human-centred values, AI ethics, AI applications, AI pedagogy and competencies for professional transformation. The European Union's DigCompEdu is structured around educators' professional activities. It forms a framework comprising "professional engagement—digital resources—teaching and learning—assessment—empowering learners—facilitating learners' digital competence", highlighting the embedding of digital competence in teaching practice and a logic of progressive development. The Spanish framework reflects an evolutionary transition from general digital competence to teachers' professional digital competence. The 2017 version mainly inherited the European framework for citizens' digital competence, emphasizing foundational capabilities such as information processing, communication and collaboration, content creation, safety and problem solving. The 2022 version, by contrast, is based on DigCompEdu and further highlights teachers' professional practice, teaching assessment, learner empowerment and the development of students' digital competence.

Austria's digi.kompP covers the full professional trajectory of teachers. It integrates digital social life, resource design, digital teaching, school management, the school community and continuing professional learning into a unified framework. Norway's Professional Digital Competence Framework for Teachers embeds digital competence within teachers' professional structures, including subject areas, pedagogy, ethics, interaction and communication, leadership of learning processes, and change and development. It emphasizes that digital literacy is an important component of teachers' professional competence. The UK frameworks are characterized by multi-stakeholder co-construction. The ETF's Digital Teaching Professional Framework places greater emphasis on the embedding of digital technologies in practical processes such as teaching planning, pedagogical methods, assessment and self-development. The JISC framework, meanwhile, gives greater attention to integrated capabilities such as information, data and media literacy, digital creation, digital communication and collaboration, digital identity and digital well-being. The U.S. ISTE Standards for Educators highlight the reconstruction of teachers' roles. Through the roles of learner, leader, citizen, collaborator, designer, facilitator and analyst, the standards emphasize the responsibilities that teachers assume in the digital age, including continuous learning, guiding digital citizenship, designing learning, facilitating learning and analysing data. China's Teachers' Digital Literacy framework is distinguished by national standardization and a strong responsibility orientation. It establishes a systematic structure across digital awareness, digital technology knowledge and skills, digital application, digital social responsibility and professional development. In particular, it emphasizes teachers' sense of responsibility, ethical norms, safety awareness and collaborative educational functions in the digital transformation of education. A comparative analysis of mainstream international frameworks for teachers' digital literacy is presented in Table 2.6.

Table 2.6 Comparative Analysis of Mainstream International Frameworks

Dimension	UNESCO	EU	Spain	Spain	Austria	Norway	UK	UK
	AI Competency Framework for Teachers	European Framework for the Digital Competence of Educators	Common Digital Competence Framework for Teachers	Framework for the Digital Competence of Teachers	Teacher Digital Competence Model	Professional Digital Competence Framework for Teachers	Digital Teaching Professional Framework	Digital Capabilities Framework: Higher Education Teacher Version

	2024	2017	2017	2022	2019	2017	2018	2023	2017	2022
Information and data literacy	△	√	√	√	√	△	—	√	△	√
Digital safety	√	√	√	√	√	√	△	√	√	√
Digital content creation	√	√	√	√	√	△	△	√	√	√
Digital teaching	√	√	△	√	√	√	√	△	√	√
Digital communication and collaboration	△	√	√	√	√	√	△	√	√	√
Digital professional development	√	√	△	√	√	√	√	√	√	√
Facilitating learners' digital learning	√	√	△	√	√	√	√	√	√	√
Digital problem solving	△	△	√	√	△	△	△	√	△	√
Digital assessment	△	√	—	√	√	△	√	△	√	√
Digital management	△	△	△	△	√	△	—	△	△	√
Digital awareness	√	√	△	√	√	√	△	√	√	√
Digital collaborative education	△	△	△	√	√	√	△	√	√	√

Note： √ indicates that the framework includes an explicit corresponding dimension or core competence; △ indicates that the framework includes related content, but not as an independent dimension, or that the content is reflected only indirectly; — indicates that no explicit corresponding content is identified

Overall, international understandings of teachers' digital literacy no longer remain at the level of the ability to use digital technologies. They have gradually shifted towards an integrated system of professional competencies that encompasses pedagogical transformation, learner development, ethical governance and continuous professional growth. Its main features can be summarized in the following six respects.

First, professionalization. Across frameworks developed by UNESCO, the European Union and individual countries, one of the most salient common trends is that teachers' digital literacy is no longer understood as a set of technical skills external to the teaching profession. Rather, it is widely defined as an important component of teachers' professional competence. From the outset, UNESCO's ICT-CFT situated teachers' digital competence within key elements of education reform, including curriculum, pedagogy, organization and administration, and professional learning. The European Union's DigCompEdu directly defines educators' digital competence as a professional capacity oriented towards professional engagement, teaching practice and learner support. Norway more explicitly proposes the concept of teachers' professional digital competence, emphasizing that digital competence is an extension of teachers' overall professional competence in the digital age. China's Teachers' Digital Literacy standard is likewise not a simple transfer of general citizens' digital competence into the teaching profession; instead, it is specifically constructed around teachers' educational and instructional responsibilities, professional development and digital practice. This indicates that teachers' digital literacy is undergoing a transition from a "technical requirement" to a "professional requirement".

Second, integration. Another common feature of mainstream international frameworks is that their content structures have continuously expanded from single-tool use to multidimensional and integrated systems. Early frameworks focused more on technology access and basic operation, whereas current frameworks generally incorporate teaching, assessment, collaboration, organization, ethics, well-being and professional development into a unified structure. The six areas of the European Union's DigCompEdu cover professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learners' digital competence. Spain's 2022 framework further specifies these into six areas and 23 competences. Norway and Austria integrate digital literacy with schools, society, communication, change, the school community and professional growth. The UK Jisc framework also incorporates digital identity and digital well-being as core elements. In this sense, teachers' digital literacy has expanded from the question of "whether teachers can use technology" to the broader capacity of "how teachers fulfil their professional responsibilities digitally within complex educational ecosystems".

Third, developmental progression. Most of these frameworks are not static lists of competencies, but developmental frameworks with a clear logic of growth. UNESCO constructs a basic model for the progressive enhancement of teachers' digital competence through three development pathways: technology literacy, knowledge deepening and knowledge creation. The European Union's DigCompEdu and Spain's MRCDD adopt an A1–C2 level model, providing a clear progression pathway and basis for assessment. The UK ETF framework divides teachers' digital literacy into three stages: exploring, adopting and leading. Austria emphasizes the continuity of teachers' digital competence across pre-service preparation and post-entry professional development through Phase 1 and Phase 2. Although China's standard is not presented through an A1–C2 model, its dimensions and indicator system similarly reflect an orientation towards cultivation, assessment and continuous improvement. This suggests that international frameworks for teachers' digital literacy generally regard teachers' digital competence as a dynamic developmental process, rather than a fixed skill acquired once and for all.

Fourth, practice orientation. Current frameworks increasingly emphasize that teachers' digital literacy must be embedded in the full process of teaching and in authentic educational contexts, rather than remaining at the level of abstract competency descriptions or technical training. The ETF's Digital Teaching Professional Framework most clearly reflects this feature, as its structure is directly organized around teaching planning, pedagogical approaches, assessment, inclusion and self-development. The European Union's DigCompEdu also takes teaching and learning, assessment and empowering learners as core areas. Spain's updated framework further strengthens the professional practice requirements for teachers in digital teaching, resource use, learning support and feedback. The U.S. ISTE standards incorporate technology integration, learning design and data-supported practice into teachers' everyday work through roles such as designer, facilitator and analyst. These examples show that mainstream international frameworks generally stress that the value of teachers' digital literacy does not lie in technology itself, but in whether teachers can effectively translate it into concrete teaching actions and educational improvement.

Fifth, responsibility orientation. Ethics, responsibility and safety have become high-frequency areas of consensus in contemporary frameworks for teachers' digital literacy. UNESCO's 2018 ICT-CFT had already incorporated principles such as inclusion, equity and non-discrimination into the framework, while the 2024 AI Competency Framework for Teachers directly establishes "human-centred mindset" and "ethics of AI" as core dimensions. The European Union's DigCompEdu and its overarching frameworks also consistently emphasize privacy, safety and well-being. Spain's 2022 framework gives particular attention to data protection, privacy, safety and digital well-being. Norway lists "ethics" as an independent competence area. China establishes "digital social responsibility" as one of its five major dimensions. This shows that teachers' digital literacy is no longer regarded as a neutral technical capability, but as a professional competence that must be bounded by responsibility, norms and public values. This shift indicates that teachers' roles in digital environments are not limited to being technology users; they are also ethical decision-makers, guardians of safety and practitioners of digital governance.

Sixth, learner-centredness. The ultimate orientation of these frameworks is almost never teachers' individual digital skills in themselves, but the use of enhanced teacher competence to support learner development and educational transformation. UNESCO repeatedly emphasizes that the purpose of teachers' ICT use is not only to improve teaching methods, but also to cultivate students' collaboration, problem-solving and knowledge creation capacities. The European Union's DigCompEdu directly establishes "empowering learners" and "facilitating learners' digital competence" as two core areas. National frameworks such as those of Spain and China continue this orientation. The UK pays attention to learner support, employability skills and digital safety. The U.S. ISTE standards further emphasize that teachers should help students become learners who can actively drive their own learning. In other words, the ultimate significance of teachers' digital literacy lies in promoting student growth through teachers' professional action, supporting educational equity, enhancing the quality of learning and advancing deeper transformation in education in the digital age.

03

PART THREE

Assessment Approaches

International Instruments for Assessing Teachers' Digital Competence

Part III

Teachers' digital competence has become a critical foundation for advancing digital transformation in education. As Hu Ermei and Nie Yong (2024) argue, assessment provides the essential basis and prerequisite for improving teachers' digital competence. Internationally, a comprehensive methodological landscape and a wide range of assessment instruments have been developed to evaluate teachers' digital competence. In terms of assessment approaches, existing practices can generally be categorised into two broad types: self-report measures and performance-based assessments. From the perspective of instrument design, assessment tools can further be classified into direct instruments that assess teachers or educators themselves and indirect indicators that capture the enabling environment for teachers' digital competence through national-level statistics or students' perspectives. While the former aim to provide precise assessments of individual teachers' digital competence, the latter evaluate the institutional conditions and broader ecosystem that support teachers' digital competence development.

This chapter reviews eight representative international assessment frameworks and instruments. The direct assessment tools include the OECD Teaching and Learning International Survey (TALIS), the European Commission's DigCompEdu Check-In self-assessment tool, the International Computer and Information Literacy Study (ICILS) conducted by the International Association for the Evaluation of Educational Achievement (IEA), and UNESCO's AI Competency Framework for Teachers (AI CFT). The indirect indicators include student survey data from PISA 2022, the teacher ICT-related indicators in the UNESCO Institute for Statistics (UIS) database, and two international studies published by Pearson , Assessment Evolved and Asking to Learn. These instruments are compared across four dimensions: target population, assessment domains, level of analysis, and suitability for cross-national comparison.

1. Direct Assessment Instruments for Teachers or Educators

1.1 TALIS: Assessing Teachers' Digital Competence in the Teaching and Learning International Survey

TALIS is a large-scale international survey of teachers and school leaders initiated by the OECD. It collects quantitative data at the teacher, school, and national levels through standardised questionnaires. Its distinctive feature lies in the fact that it not only assesses teachers' digital competence directly, but also examines technology use within broader contexts such as teaching practices, professional development, and working environments. TALIS 2024 introduced a dedicated teacher knowledge survey module and incorporated topics related to AI use, thereby supporting cross-national comparison and time-series analysis, with the aim of providing evidence-based support for education policy.

Target Population and Assessment Method

TALIS explicitly targets teachers and school leaders. Taking TALIS 2024 as an example, the survey covers teachers and principals at ISCED Level 2, namely lower secondary education, with optional extensions to ISCED Level 1, primary education, and ISCED Level 3, upper secondary education (ILSA Gateway, 2025). In terms of assessment method, TALIS mainly adopts a questionnaire-based approach, with teachers and school leaders completing structured questionnaires separately. The questionnaires cover multiple dimensions, including teaching practices, professional development, working environments, and professional attitudes. Quantitative data are collected through closed-ended questions and Likert-scale items. The uniqueness of TALIS is that it is not merely a survey about teachers, but a systematic investigation of teaching and learning. It situates teachers' individual practices within the broader framework of school contexts, policy environments, and national education systems.

Assessment Content

TALIS does not assess teachers' digital competence as an isolated set of technical skills. Instead, it embeds digital competence within the wider context of teaching practice. In the TALIS 2024 conceptual framework, content directly related to teachers' digital competence is mainly distributed across the following dimensions. First, the dimension of professional development. TALIS investigates the frequency, content, and perceived effectiveness of teachers' participation in ICT-related professional training. It examines the areas of digital skills in which teachers have received systematic training and whether such training has been effectively translated into classroom practice. According to TALIS 2024 findings, three-quarters of teachers work in schools with mentoring programmes, yet only one-quarter of teachers actually receive mentoring support. Second, the dimension of classroom practice. TALIS examines teachers' actual use of digital technologies in classroom teaching, including the modes, frequency, and purposes of technology-supported instruction. The questionnaire explores whether teachers are able to use digital technologies to design learning activities, manage classrooms, assess students, and promote students' active learning. Third, the contextual dimension of technology use. TALIS focuses on the availability and usability of technology within school environments, including ICT infrastructure, technical support services, and policy orientations for integrating technology into teaching. These contextual factors have an important influence on how teachers' digital competence is enacted in practice. Fourth, the dimension of emerging technologies. TALIS 2024 specifically includes topics related to the use of AI, focusing on teachers' current use of AI in teaching, their attitudes towards AI, and the challenges they face. The inclusion of this dimension reflects TALIS's responsiveness to frontier issues in digital education.

Data Levels

TALIS data are collected at three levels. Individual-level data are derived from teacher and school leader questionnaires, reflecting teachers' teaching practices, professional development needs, job satisfaction, and related information. School-level data are generated from school leader questionnaires and aggregated teacher responses, reflecting the teaching environment, management approaches, and resource conditions at the school level. National-level data are produced through statistical analysis based on individual- and school-level data, presenting an overall picture of national education systems. This data structure enables TALIS to support micro-level analysis of individual teachers, meso-level comparison across schools, and macro-level cross-national comparison.

Feasibility of Cross-National Comparison

TALIS has a high degree of feasibility for cross-national comparison, owing to several design features. First, TALIS adopts a unified survey instrument and standardised implementation procedures. All participating countries use the same questionnaire framework and item design, ensuring data comparability. Second, the OECD has developed a rigorous conceptual framework and indicator construction methodology for TALIS, with all indicators undergoing multiple rounds of expert review and pilot testing. Third, TALIS data collection and processing follow unified technical standards, including sampling criteria, data cleaning rules, and weighting procedures. Fourth, TALIS is conducted on a regular cycle, approximately every five years, which supports longitudinal comparison over time. By TALIS 2024, dozens of countries and economies had participated in the survey, forming a global teacher data network. Such cross-national comparative data provide important evidence for education policymaking across countries.

Assessment Findings

According to the OECD report Results from TALIS 2024: The State of Teaching, the teaching profession remains broadly resilient worldwide. Nearly 90% of teachers report being satisfied with their work. In South Africa, teacher job satisfaction has increased by nearly eight percentage points since 2018, while in Colombia, 90% of teachers say they would choose teaching again. In terms of social recognition, more than 92% of teachers in Viet Nam feel valued by society, and teachers' perceived social value has increased by at least 19 percentage points in Saudi Arabia, Bulgaria, and Denmark. The use of AI is spreading rapidly. In Singapore and the United Arab Emirates, around 75% of teachers report using AI in teaching, and teachers in these countries are also among the most likely to have received relevant professional training. However, workload remains a major source of pressure. Although teachers' weekly working hours in Japan have fallen from nearly 60 hours to around 55 hours, Japan still reports the highest level globally. Overall, TALIS 2024 shows that teachers demonstrate a high level of professional commitment, but sustained policy support is needed to balance technology integration with teachers' professional well-being.

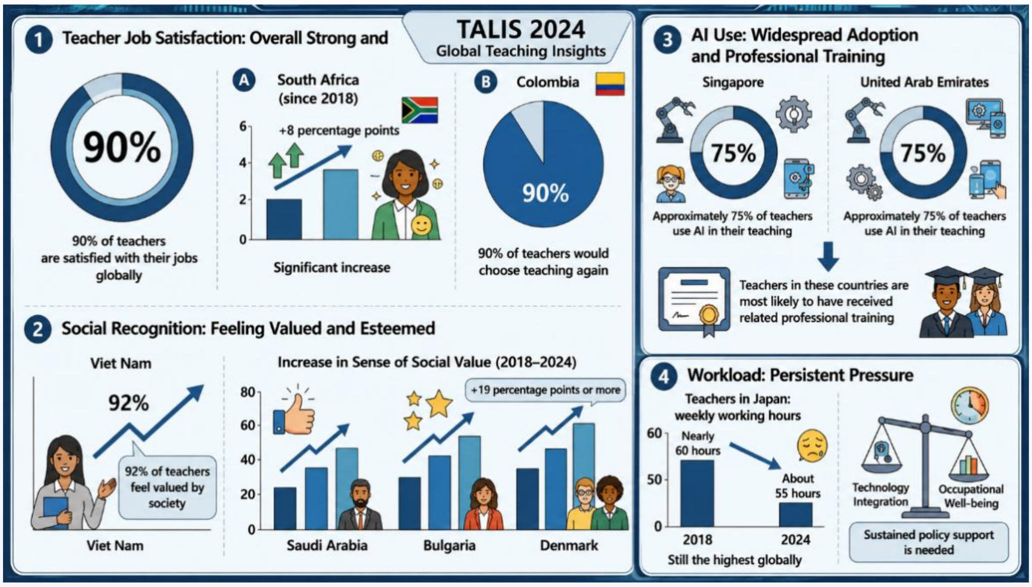


Figure 3.1 Analysis of Key Findings from TALIS 2024

（Source: Ainley, J., & Schulz, W. (2025). Teaching and Learning International Survey (TALIS) 2024 Conceptual Framework (p. 23). OECD Publishing. https://doi.org/10.1787/7b8f85d4-en）

1.2 DigCompEdu Self-Assessment Tool: Assessing Teachers' Digital Competence through the European Framework

The DigCompEdu Self-Assessment Tool is based on the European Framework for the Digital Competence of Educators (DigCompEdu). It is an online self-assessment instrument designed for educators across all educational sectors and covers 22 competences organised into six dimensions. Its primary purpose is to help educators identify their strengths and areas for further development in digital competence. Upon completion, users receive an instant diagnostic report together with personalised recommendations for professional development. The instrument has been validated in multiple countries, is freely accessible, and is available in several languages, making it suitable for both individual self-assessment and group-level competence profiling.

Target Population and Assessment Method

The DigCompEdu Self-Assessment Tool is intended for educators at all levels, including early childhood education, primary education, secondary education, initial vocational education and training, and higher education. It can also be used by teacher educators and professional trainers to understand the digital competence profile of the teachers they support and to design targeted professional development programmes. To facilitate teachers' understanding of the DigCompEdu framework and enable an initial assessment of their strengths and learning needs, the Joint Research Centre (JRC) of the European Commission developed an online self-assessment tool. The tool is freely available and has been translated into multiple languages. Ghomi and Redecker (2019) reported the development and validation of the instrument using a sample of 335 primary, secondary, and vocational education teachers in Germany. Internal consistency was examined using Cronbach's alpha, while construct validity was evaluated through hypotheses based on known group characteristics using the Mann–Whitney U test and Spearman's rank correlation.

The results demonstrated significant, although relatively small, differences between STEM and non-STEM teachers, as well as between computer science teachers and teachers from other disciplines. Teachers holding negative attitudes towards the educational benefits of technology scored significantly lower than those with neutral or positive attitudes. In addition, teachers who reported frequent and confident use of technology in classroom teaching achieved significantly higher competence scores. Overall, the findings indicate that the DigCompEdu Self-Assessment Tool is a reliable and valid instrument for measuring educators' digital competence.

The DigCompEduSAT project (2017–2019) further developed an online self-assessment tool based on the DigCompEdu framework for teachers in primary education, secondary education, initial vocational education and training, and higher education. After completing the online questionnaire, participants immediately receive a diagnostic report that outlines their overall digital competence profile, highlights existing strengths, identifies areas for improvement, and suggests possible pathways for professional development. The prototype was translated into several European languages and piloted with approximately 900 teachers across Italy, Spain, Portugal, Estonia, and Finland.

In addition, other researchers have developed self-assessment instruments grounded in the DigCompEdu framework. One representative instrument expands the original 22 competences into 38 indicators describing how digital competence is demonstrated in educational practice. Respondents evaluate each indicator from two perspectives: its importance in the educational process and the frequency with which they apply it in their own teaching. The instrument was developed and validated through four research cycles, including pilot testing with 30 compulsory education teachers, focus group discussions involving seven teacher professional development experts, and large-scale validation with 414 teachers participating in professional development programmes.

Assessment Content

The DigCompEdu framework defines 22 educator-specific digital competences organised into six dimensions, forming a comprehensive model of teachers' digital competence.

Dimension 1: Professional Engagement. This dimension focuses on educators' use of digital technologies for professional communication, collaboration, and continuous professional development. It includes organisational communication, professional collaboration, reflective practice, and lifelong professional learning.

Dimension 2: Digital Resources. This dimension addresses educators' ability to identify, create, adapt, manage, protect, and share digital educational resources. It includes resource selection and evaluation, content creation and modification, as well as responsible sharing and management.

Dimension 3: Teaching and Learning. As the core dimension of the framework, it focuses on educators' ability to design, implement, and manage teaching and learning activities using digital technologies. It covers instructional design, classroom implementation, learner guidance and support, collaborative learning, and self-regulated learning.

Dimension 4: Assessment. This dimension examines educators' ability to enhance assessment practices through digital technologies, including assessment strategies, evidence analysis, and the provision of timely feedback.

Dimension 5: Empowering Learners. This dimension emphasises the use of digital technologies to support personalised learning and learner engagement. It includes accessibility and inclusion, differentiation and personalisation, and active learner participation.

Dimension 6: Facilitating Learners' Digital Competence. This dimension concerns educators' capacity to foster students' digital competence, including information and media literacy, digital communication and collaboration, digital content creation, responsible use of digital technologies, and digital problem solving.

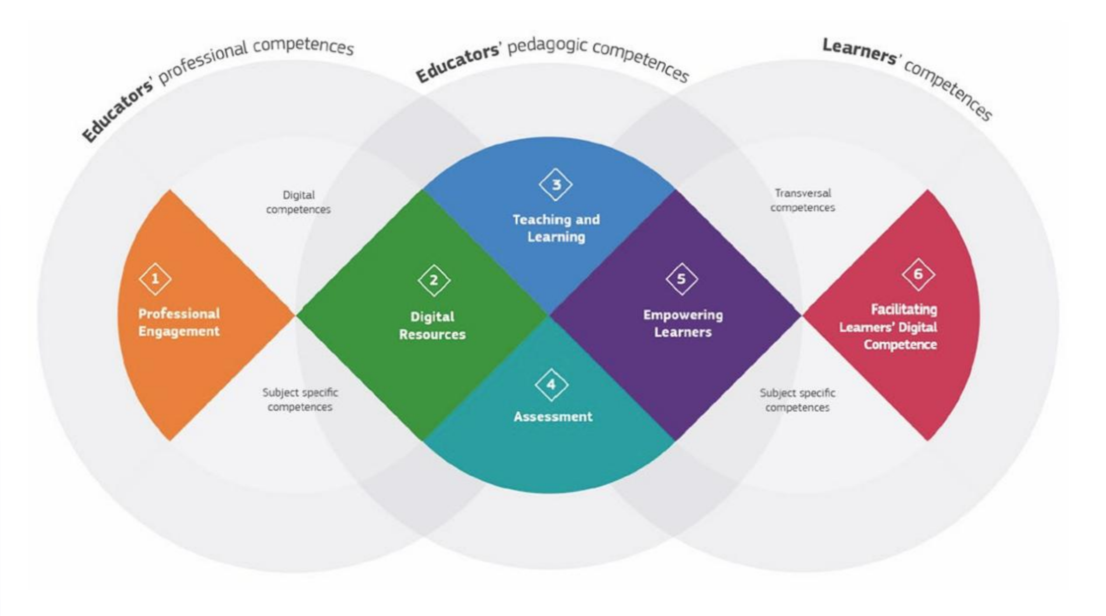


Figure 3.2 DigCompEdu Areas and Scope

（Source: Redecker, C. (2017). European Framework for the Digital Competence of Educators: DigCompEdu. Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC107466.）

Data Levels

The DigCompEdu Self-Assessment Tool primarily collects data at the individual level in the form of educators' self-reported digital competence scores. These data can support individual self-reflection and professional development planning, while also being aggregated at the school, regional, or national level to analyse the overall distribution and characteristics of teachers' digital competence. It should be noted, however, that the framework does not require centralised data collection or storage. Teachers may complete the assessment independently, and the extent to which data are collected systematically depends on the specific implementation context.

Feasibility of Cross-National Comparison

The DigCompEdu framework was designed as a common reference framework applicable across countries, providing a shared conceptual basis for international comparison. Its implementation in multiple European countries has laid the groundwork for comparative studies. Nevertheless, several challenges remain.

First, the reliability and validity of self-assessment may vary across different linguistic and cultural contexts. Although the DigCompEduSAT project translated the instrument into several European languages and tested it in five countries, cultural differences in self-reporting behaviour may introduce systematic bias. Teachers in some cultures may underestimate their competence, whereas those in others may be more inclined to provide favourable self-assessments, thereby affecting cross-national comparability.

Second, the DigCompEdu Self-Assessment Tool has so far been used primarily within Europe and has not yet developed a global, standardised data collection system comparable to TALIS. Consequently, the empirical basis for large-scale international comparison remains relatively limited. Even so, DigCompEdu serves as a valuable conceptual framework that provides countries with a common theoretical foundation for developing context-specific instruments for assessing teachers' digital competence. Its emphasis on local adaptation reflects both the flexibility and applicability of the framework, making it an important reference for establishing national standards for teachers' digital competence.

Assessment Findings

Validation studies conducted across multiple countries have demonstrated that self-assessment instruments based on the DigCompEdu framework possess satisfactory reliability and validity. Ghomi and Redecker (2019), using data from 335 primary, secondary, and vocational education teachers in Germany, found significant but relatively small differences in digital competence between STEM and non-STEM teachers, as well as between computer science teachers and teachers from other subject areas. Teachers holding negative attitudes towards the educational value of technology also reported significantly lower competence levels than those with positive attitudes.

The DigCompEduSAT project further evaluated the instrument with approximately 900 teachers from Italy, Spain, Portugal, Estonia, and Finland. The results indicate that the tool effectively identifies educators' digital competence profiles and distinguishes different stages of professional development, ranging from Newcomer to Pioneer.

1.3 ICILS: International Computer and Information Literacy Study

The International Computer and Information Literacy Study (ICILS), organised by the

International Association for the Evaluation of Educational Achievement (IEA), is currently the world's only large-scale international assessment dedicated specifically to digital literacy education. Its distinguishing feature is that it directly assesses Grade 8 students through computer-based testing to evaluate their computer and information literacy (CIL) and computational thinking (CT). At the same time, comprehensive contextual data are collected through questionnaires completed by teachers, school principals, and ICT coordinators, covering teachers' ICT use, school resource provision, and instructional practices.

Target Population and Assessment Design

ICILS 2023 targets Grade 8 students (i.e., students in their eighth year of formal schooling, typically aged 13.5 years or above), together with their classroom teachers, school ICT coordinators, and principals. The study adopts a two-stage stratified probability sampling design. In the first stage, schools are randomly selected using probability proportional to size (PPS) sampling. In the second stage, one intact class is randomly selected from each participating school for student assessment (Fraillon & Rožman, 2025). For the teacher survey, up to 15 teachers teaching the target grade are randomly selected from each participating school.

The assessment combines computer-based testing with contextual questionnaires. All participating students complete a 60-minute Computer and Information Literacy (CIL) assessment, consisting of seven modules, with each student randomly assigned two modules, followed by a 20-minute student background questionnaire. In education systems participating in the international Computational Thinking (CT) option, students also complete an additional 50-minute CT assessment, comprising four modules, with two modules randomly assigned to each student. Teachers, ICT coordinators, and school principals complete online questionnaires to provide school-level contextual information. The principal questionnaire also includes an optional module, newly introduced in ICILS 2023, focusing on the use of generative AI (AI), including tools such as ChatGPT.

Assessment Framework

ICILS 2023 assesses students across two core domains: Computer and Information Literacy (CIL) and Computational Thinking (CT). According to Fraillon and Rožman (2025), Computer and Information Literacy (CIL) is defined as "an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society." The CIL assessment framework comprises four dimensions.

Dimension 1: Understanding Computer Use – covering foundational knowledge of computers and appropriate practices for computer use;

Dimension 2: Gathering Information – encompassing the access, evaluation, and management of information;

Dimension 3: Producing Information – focusing on the transformation and creation of information;

Dimension 4: Digital Communication – addressing information sharing as well as the safe and responsible use of digital information.

Computational Thinking (CT) is defined as "an individual's ability to recognise real-world problems that are appropriate for computational formulation, and to evaluate and develop algorithmic solutions that can be operationalised using a computer." The CT framework consists of two dimensions:

Dimension 1: Conceptualising Problems – including understanding digital systems, analysing and formulating problems, and collecting and representing relevant data;

Dimension 2: Operationalising Solutions – involving the planning and evaluation of solutions, as well as the development of algorithms, programs, and user interfaces.

The assessment includes a diverse range of task types. For CIL, tasks comprise information-response tasks, skills tasks, and authoring tasks. For CT, tasks include non-linear system transformation tasks, simulation tasks, and algorithm construction and debugging tasks based on modular programming. All assessment tasks are embedded within authentic real-world scenarios, such as creating a promotional webpage for a school band or planning a class excursion.

Table 3.1 Structure of ICILS 2023 Assessment Tasks

Domain / Dimension	Number of Tasks
Computer and Information Literacy (CIL)	
Dimension 1: Understanding Computer Use	
1.1 Foundations of Computer Use	3
1.2 Conventions for Computer Use	9
Subtotal (Dimension 1)	12
Dimension 2: Gathering Information	
2.1 Accessing and Evaluating Information	18

Domain / Dimension	Number of Tasks
2.2 Managing Information	9
Subtotal (Dimension 2)	27
Dimension 3: Producing Information	
3.1 Transforming Information	16
3.2 Creating Information	31
Subtotal (Dimension 3)	47
Dimension 4: Digital Communication	
4.1 Sharing Information	11
4.2 Using Information Safely and Responsibly	10
Subtotal (Dimension 4)	21
Computational Thinking (CT)	
Dimension 1: Conceptualising Problems	
1.1 Knowing and Understanding Digital Systems	5
1.2 Formulating and Analysing Problems	2
1.3 Collecting and Representing Data	3
Subtotal (Dimension 1)	10
Dimension 2: Operationalising Solutions	
2.1 Planning and Evaluating Solutions	8
2.2 Developing Algorithms, Programs, and Interfaces	12
Subtotal (Dimension 2)	20

(Source: Fraillon, J., & Rožman, M. (Eds.). (2025). IEA International Computer and Information Literacy Study 2023: Assessment Framework. Springer Nature. https://doi.org/10.1007/978-3-031-61194-0. Copyright by 2025 IEA.)

Data Structure

The ICILS 2023 database comprises four interconnected levels of data collection: Student level, including students' CIL and CT assessment results, together with information collected through the student questionnaire on demographic characteristics, ICT use, attitudes, and self-efficacy; Teacher level, including teachers' background characteristics, ICT use, professional development, and instructional practices, collected through the teacher questionnaire; School level, including school characteristics, ICT infrastructure and resources, leadership, and school policies, collected through the principal and ICT coordinator questionnaires; National level, including information on education system structures, curriculum policies, and educational reforms, collected through the National Context Survey. This multi-level data structure enables researchers to examine how factors operating at different levels—from individual students to national education policies—are associated with students' performance in Computer and Information Literacy (CIL) and Computational Thinking (CT).

Cross-national Comparability

ICILS provides a highly robust basis for cross-national comparison. First, all participating education systems adopt a common assessment framework, standardised computer-based assessment procedures, and contextual questionnaires, ensuring that data are collected under consistent technical standards and implementation protocols.

Second, as an internationally recognised educational assessment organisation, the International Association for the Evaluation of Educational Achievement (IEA) has established rigorous sampling requirements, data processing procedures, and quality assurance mechanisms for ICILS. For example, participating education systems are required to achieve minimum participation rates of 75% for schools and 75% for teachers. Detailed technical reports are also published to ensure the comparability, reliability, and transparency of the data.

Third, more than 20 education systems participated in ICILS 2023, spanning Europe, Asia, the Americas, and other regions, thereby providing a broad international evidence base for comparative research. Since its first administration in 2013, ICILS has also established a strong foundation for trend analyses across assessment cycles. The CIL assessment supports trend comparisons over the ten-year period from 2013 to 2023, while the CT assessment supports comparisons between 2018 and 2023. In addition, international options—such as the CT assessment module and the optional principal questionnaire on generative AI—provide participating education systems with greater flexibility for conducting extended comparative analyses.

Assessment Findings

According to the ICILS 2023 International Report, substantial differences exist both across and within participating education systems in students' performance in Computer and Information Literacy (CIL) and Computational Thinking (CT).

For CIL, national average scores ranged from approximately 300 to 560 points, with the international scale centred at 500 points. Within individual education systems, the performance gap between students in the lowest and highest deciles generally exceeded 200 points. In terms of proficiency, only 1% of students reached CIL Level 4, demonstrating the ability to critically evaluate information with precision and exercise sophisticated control in digital environments. Approximately 14% reached Level 3, indicating the capacity to independently locate, evaluate, and critically use digital information, while around 51% of students performed at Level 2 or below.

A similarly wide variation was observed in CT performance across education systems. Trend analyses further showed that, among the seven education systems participating in CT trend comparisons between 2018 and 2023, one demonstrated a statistically significant improvement, five remained stable, and one experienced a decline.

Gender differences were also evident. Female students generally outperformed male students in CIL, whereas male students achieved slightly higher scores in CT. Nevertheless, the gender gap in CT performance narrowed compared with the results reported in 2018.

ICILS 2023 also highlights the importance of digital resources and prior experience. Students with two or more computers at home and more than five years of computer experience consistently achieved significantly higher scores in both CIL and CT than students with more limited access to digital resources.

Regarding generative AI, responses from principals in the 12 education systems that participated in the optional AI module indicate widespread concern about its potential impact. More than 80% of principals expressed high levels of concern regarding issues such as academic plagiarism, AI-generated misinformation, and the possible decline in students' capacity for independent learning.

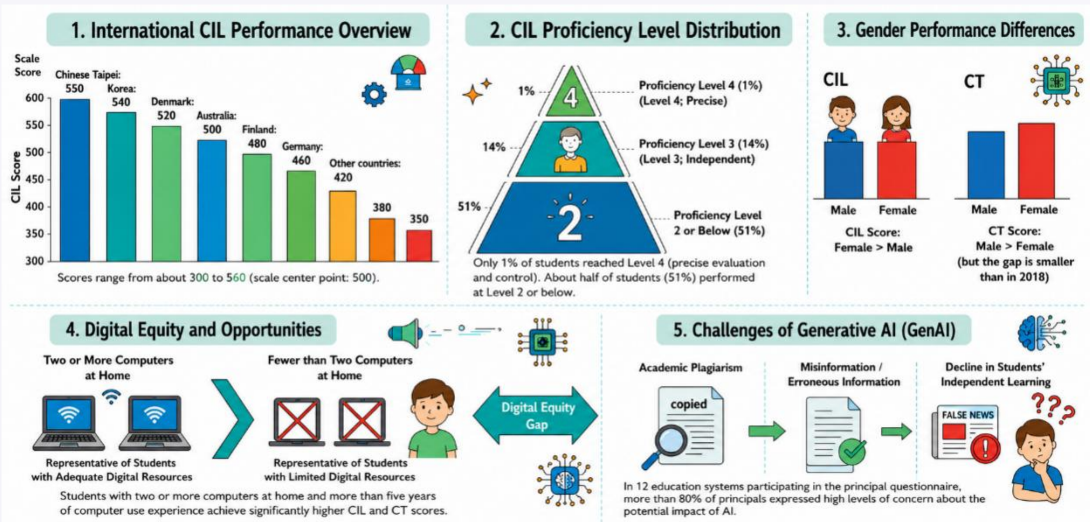


Figure 3.3 Assessment Findings from ICILS 2023

(Source: IEA International Computer and Information Literacy Study 2023: Assessment framework, by J. Fraillon and M. Rožman (Eds.), 2025, Springer Nature (https://doi.org/10.1007/978-3-031-61194-0). Copyright 2025 by IEA.)

1.4 UNESCO AI Competency Framework for Teachers (AI CFT)

The AI Competency Framework for Teachers (AI CFT), published by UNESCO in 2024, is the world's first international reference framework to systematically define teachers' competencies for the effective and responsible use of AI in education. The framework is organised around five competency domains, which are Human-centred Mindset, AI Ethics, AI Foundations and Applications, AI Pedagogy, and AI for Professional Development—and adopts a three-level developmental progression (Acquire, Deepen, and Create) to establish 15 assessable AI competencies for teachers.

Rather than serving as a standardised assessment instrument, AI CFT provides an internationally recognised competency framework that supports the development of national and institutional assessment tools, including self-assessment scales, classroom observation instruments, certification examinations, and other evaluation approaches. The framework is intended to assist policymakers, teacher education institutions, and teachers in integrating AI into educational practice in a safe, effective, ethical, and responsible manner, thereby facilitating the transition from general ICT competence to specialised AI literacy within teachers' professional development.

Target Population and Assessment Approach

Unlike conventional standardised assessments, AI CFT is a competency framework rather than a testing instrument. Its primary users include teacher educators, education policymakers, curriculum developers, and professional development providers, while its ultimate beneficiaries are both pre-service and in-service teachers across all levels of education. The framework does not prescribe mandatory data collection from individual teachers. Instead, it encourages countries and institutions to develop context-specific assessment tools aligned with its competency structure. Accordingly, AI CFT supports multiple implementation pathways.

At the national level, countries may establish AI competency certification examinations or incorporate AI competencies into teacher registration and professional standards to support large-scale assessment. At the institutional level, schools and teacher education providers may develop AI competency self-assessment questionnaires, classroom observation protocols, or portfolio-based evaluations centred on AI-supported instructional design. At the individual level, teachers are encouraged to use the framework's 15 competency modules to conduct self

-assessments and develop personalised professional learning plans. For example, teachers may identify one or two competencies—such as prompt engineering or AI bias identification and mitigation—as annual professional development goals.

The framework further emphasises that developing AI competencies is a continuous, lifelong professional learning process. Consequently, its assessment philosophy is primarily formative, supporting teachers in strengthening their AI competencies through ongoing reflection and authentic classroom practice rather than through one-time summative evaluation.

Data Structure

As a competency framework, AI CFT does not prescribe a fixed data collection architecture. However, assessment instruments developed based on the framework can generate competency data at multiple levels.

At the individual teacher level, schools and teacher education providers may develop self -assessment or peer-assessment instruments covering the framework's 15 competency modules. Using Likert-scale ratings, these instruments can measure teachers' perceived competency levels across different domains. Performance-based assessments, such as situational judgement tests, may also be employed to capture evidence of teachers' practical competence—for example, evaluating whether the use of AI in instructional scenarios is pedagogically appropriate, ethical, and effective.

At the school or institutional level, aggregated teacher data can be used to develop AI competency profiles for schools or districts. These profiles support the identification of professional learning needs and enable the evaluation of professional development programmes through pre- and post-intervention comparisons.

At the national or regional level, policymakers may employ standardised AI CFT-based assessment instruments to conduct nationwide or representative sample surveys, generating macro-level evidence on teachers' AI competencies to inform national AI education strategies and targeted funding policies.

As the framework was released only in 2024, systematic national-level data collection has not yet been widely implemented internationally. Nevertheless, the framework has established a standardised structure capable of supporting future cross-level data accumulation and comparative analysis.

Cross-national Comparability

AI CFT was conceived from the outset as an internationally applicable reference framework. One of its primary objectives is to support countries in moving from a common international reference toward context-sensitive national implementation. However, given its recent publication in 2024, the development of systematic national assessments and international comparative studies based on AI CFT remains at an early stage. Consequently, conditions for large-scale statistical comparisons across countries have not yet fully matured. At present, the framework primarily contributes to international comparability in three ways.

First, it provides a shared conceptual language for international policy dialogue and knowledge exchange. Countries can describe teachers' AI competencies using the same competency domains, proficiency levels, and competency descriptors. Second, it supports regional and thematic comparative studies. Countries participating in collaborative initiatives may adopt AI CFT-based assessment instruments to collect nationally contextualised data while maintaining common measurement principles for descriptive comparisons.Third, AI CFT serves as a methodological reference for national adaptation. Countries may develop locally relevant competency frameworks that reflect their own educational systems and cultural contexts while maintaining alignment with the original AI CFT competency structure. Such alignment creates the potential for building internationally comparable datasets over time.The framework also notes that China's Teachers' Digital Competency Standard, issued in 2022, already incorporates AI-related competencies, providing an important national reference for alignment with AI CFT.

Overall, the international comparability of AI CFT lies primarily in its role as a common reference framework that supports mutual recognition and aligned competency development, rather than as a basis for immediate cross-national ranking or statistical comparison.

Assessment Findings

A review of AI CFT and its emerging global implementation reveals several key findings. First, substantial policy gaps remain in the development of teachers' AI competencies worldwide. At the time of the framework's publication, only seven countries had established government-recognised AI training programmes for teachers, representing less than 4% of UNESCO Member States. Most countries continue to lack comprehensive policy frameworks, implementation strategies, and resource allocation mechanisms for teacher AI competency development. This finding underscores both the urgency and the necessity of establishing AI CFT. Second, AI Ethics occupies a central position within the competency framework. UNESCO identifies AI Ethics as a core competency domain alongside AI Foundations and Applications, emphasising that teachers should not only master

AI technologies but also be able to recognise algorithmic bias, protect privacy and personal data, understand accountability mechanisms, and exercise informed human oversight when using AI systems. The framework further notes that approximately 80% of existing national teacher ICT competency frameworks provide insufficient coverage of AI ethics, highlighting the distinctive contribution of AI CFT in addressing this critical gap. Third, AI competency development should follow a progressive learning pathway. The framework's three-level progression—Acquire, Deepen, and Create—encourages teachers to advance from foundational AI literacy to the integration of AI into everyday teaching and, ultimately, to leadership in AI-enabled curriculum innovation and school-wide transformation. The framework also stresses that professional learning pathways should accommodate teachers' diverse starting points and differentiated learning needs. Fourth, AI CFT has already entered the stage of policy translation and pilot implementation in multiple countries. Since its publication, education authorities and teacher education institutions have begun incorporating the framework into the development of national AI teacher training programmes, while exploring applications in AI competency certification, curriculum integration, and evaluation of professional learning outcomes.

Overall, as the world's most authoritative international reference framework for teachers' AI competencies, AI CFT is driving the evolution of teacher digital competency assessment from general ICT competence toward specialised AI competence, thereby supporting the systematic transformation of teacher professional development in the age of AI.

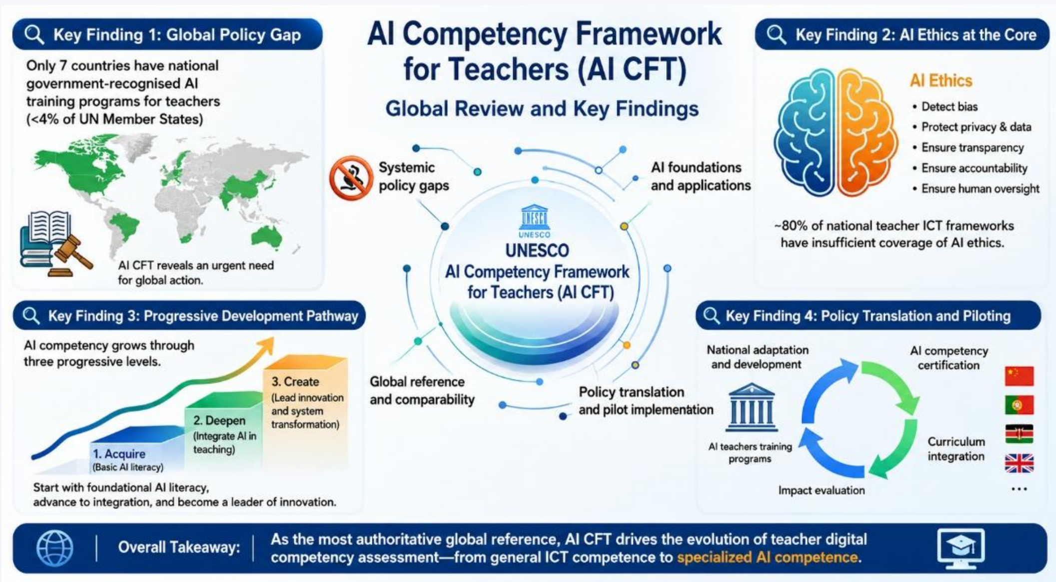


Figure 3.4 AI CFT Analysis Results

1.5 Assessment Instruments for Teachers' Digital Competence in China

Target Population and Assessment Approach

Assessment instruments for teachers' digital competence in China primarily target primary and secondary school teachers. Among the most representative instruments is the Digital Competence Test for Primary and Secondary School Teachers, developed by Song Lingqing (2023). The instrument was administered to 9,405 teachers from eastern, central, and western China, covering both primary and junior secondary education and providing a nationally representative sample.

The instrument adopts an online questionnaire survey using a five-point Likert scale to collect teachers' self-reported data. In addition, Peng Hongchao and Zhu Kaige (2024) developed another assessment instrument based on the same national standard. Their questionnaire comprises 35 items and was validated using 690 valid responses, also employing a five-point Likert scale.

Both instruments rely primarily on teacher self-assessment, making them suitable for large-scale administration due to their simplicity and efficiency. The assessment process emphasises anonymity and response authenticity to enhance data reliability. Furthermore, both instruments are explicitly designed to reflect the professional contexts and cultural characteristics of Chinese teachers, with assessment items closely aligned with teachers' everyday instructional practice.

Assessment Framework

Both assessment instruments are explicitly aligned with the Teachers' Digital Competence industry standard issued by China's Ministry of Education in 2022, covering five core competency domains.

The instrument developed by Song Lingqing (2023) includes:

Digital Awareness (6 items), comprising digital cognition, digital willingness, and digital commitment;

Digital Knowledge and Skills (7 items), including digital technology knowledge and technical skills;

Digital Application (18 items), covering digital instructional design, digital teaching implementation, digital learning assessment, and digitally enabled collaborative education;

Digital Social Responsibility (10 items), including legal and ethical responsibilities as well as digital safety and security;

Professional Development (8 items), including digital learning, professional development, digital pedagogical research, and innovation.

The questionnaire developed by Peng Hongchao and Zhu Kaige (2024) retains the same five-domain framework while reducing the total number of items to 35, including 8 items on Digital Awareness, 3 items on Digital Knowledge and Skills, 16 items on Digital Application, 5 items on Digital Social Responsibility, and 6 items on Professional Development.

Both instruments adopt a comprehensive perspective on teachers' digital competence. Beyond assessing technical knowledge and operational skills, they place particular emphasis on the pedagogical integration of digital technologies, ethical responsibility, and continuous professional learning, reflecting a progressive transition from technology use to technology integration, and ultimately to innovation and instructional leadership.

Data Structure

Data collection using China's teacher digital competence assessment instruments is primarily conducted at the individual teacher level, generating overall digital competence scores together with scores for each competency domain.

These individual-level data can be aggregated to produce statistical indicators at the school, regional, or national levels. For example, Song Lingqing (2023) conducted multi-level analyses comparing teachers across eastern, central, and western China, as well as across urban and rural areas, school levels, and gender groups.

Similarly, the instrument developed by Peng Hongchao and Zhu Kaige (2024) supports teachers' self-assessment, pre- and post-training evaluations, and large-scale surveys at both school and regional levels.

Although China has not yet established a standardised multi-level data collection system comparable to TALIS, integrating teacher-, school-, and national-level data, the current assessment framework has been designed to facilitate upward aggregation. Consequently, it supports cross-level analyses ranging from individual teacher profiles to broader population trends.

Cross-national Comparability

China's teacher digital competence assessment instruments have been developed based on nationally defined competency standards while maintaining a considerable degree of compatibility with international frameworks such as DigCompEdu and the UNESCO ICT Competency Framework for Teachers (ICT CFT).

During instrument development, Peng Hongchao and Zhu Kaige (2024) explicitly drew upon five internationally recognised assessment instruments, including ACDC, DigCompSAT, DigCompEdu, TET-SAT, and SRDL, preserving conceptual alignment with these international frameworks in the design of assessment items.

Nevertheless, direct cross-national comparisons should be interpreted with caution because of cultural differences and potential biases associated with self-report measures. To date, China's assessment instruments have not been incorporated into large-scale international surveys such as TALIS, and therefore lack internationally standardised cross-cultural calibration procedures.

Despite this limitation, the Teachers' Digital Competence standard demonstrates substantial conceptual alignment with the six competency domains of the UNESCO ICT Competency Framework for Teachers, including policy understanding, curriculum and assessment, pedagogy, digital skills, organisation and administration, and professional learning.

Future efforts to enhance international comparability may include collaborative international studies and the incorporation of common scenario-based assessment tasks that facilitate cross-cultural benchmarking.

Assessment Findings

Based on assessment data collected from 9,405 primary and secondary school teachers nationwide, Song Lingqing (2023) found that Chinese teachers demonstrated an overall high level of digital competence, with an average score of 3.98 out of 5, while fewer than 5% of teachers scored below 3.0.

Across competency domains, teachers achieved their highest scores in Digital Social Responsibility (4.115), followed by Professional Development (4.066) and Digital Awareness (4.056). Comparatively lower scores were observed in Digital Knowledge and Skills (3.891) and Digital Application (3.874).

Significant group differences were also identified. Teachers in eastern China demonstrated significantly higher levels of digital competence than those in central China, while teachers in western China also outperformed those in the central region (Eastern > Western > Central). Primary school teachers achieved significantly higher scores than secondary school teachers, whereas no statistically significant differences were found between urban and rural teachers or between male and female teachers.

The validation study conducted by Peng Hongchao and Zhu Kaige (2024) further confirmed the instrument's excellent psychometric properties, reporting an overall Cronbach's α of 0.97. Their findings likewise identified Digital Application as the weakest competency domain among Chinese teachers.

Taken together, these findings suggest that future efforts to improve teachers' digital competence in China should move beyond strengthening basic digital awareness and instead focus on achieving substantial improvements in the pedagogical application of digital technologies.

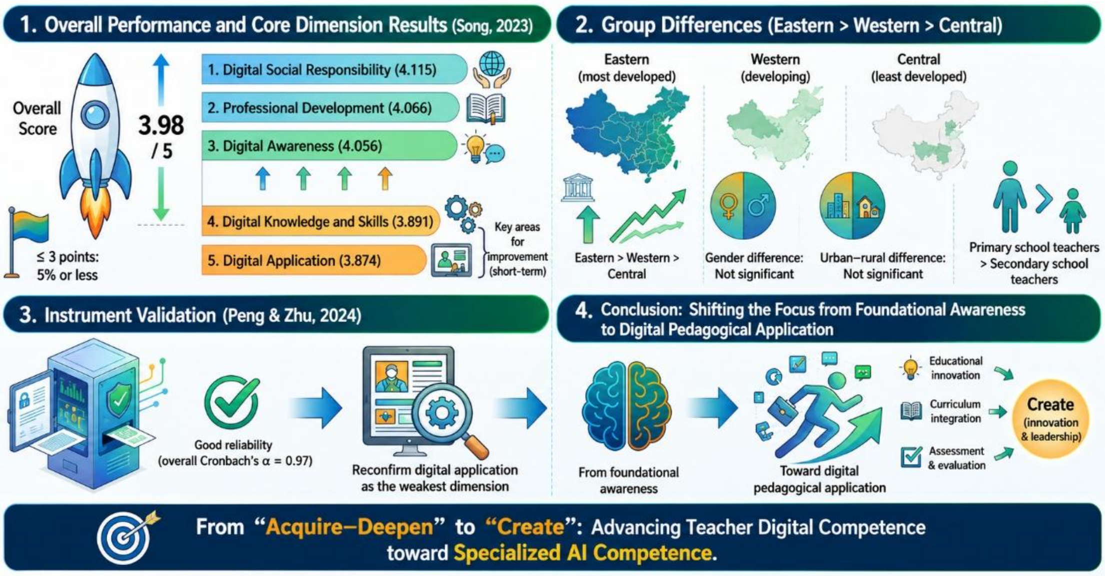


Figure 3.5 Analysis of Findings from China's Teacher Digital Competence Assessment Instruments

(Source: Song, L. (2023). The Current Status and Pathways for Improving Digital Competence among Primary and Secondary School Teachers in China: Evidence from an Assessment of 9,405 Teachers Nationwide. China Educational Technology, (12), 113–120; Peng, H., & Zhu, K. (2024). Localising a Digital Competence Assessment Questionnaire for Primary and Secondary School Teachers: Based on the Teachers' Digital Competence Industry Standard. Modern Distance Education Research, 36(5), 72–82.)

2. International Indicators Indirectly Reflecting Digital Education and the Teacher Competency Environment

2.1 PISA 2022: The Teacher Digital Competency Environment from the Student Perspective

PISA 2022 indirectly reflects the digital teaching competency environment through student questionnaires and school questionnaires (completed by principals). Its distinctive feature lies in assessing teachers' use of ICT, instructional practices, and schools' digital learning environments from the perspective of learners. Although PISA does not directly measure teachers' individual digital competencies, it provides valuable evidence on the relationship between teachers' digital competence and students' learning outcomes. Supported by its rigorous cross-national comparative framework, PISA offers a macro-level snapshot of digital education environments across participating education systems and enables analyses of the extent to which teachers integrate technological knowledge with pedagogical knowledge through ICT-related indices.

Target Population and Assessment Approach

The primary target population of PISA 2022 consists of 15-year-old students enrolled in formal education. However, PISA evaluates students' competencies within a broader educational context by collecting extensive information on learning environments and instructional practices through student questionnaires and school questionnaires, which are generally completed by school principals. These contextual questionnaires include several items that indirectly reflect teachers' digital competencies.

Specifically, PISA 2022 captures information related to teachers' digital competence through three principal sources. Student questionnaires, which collect students' perceptions of teachers' use of ICT in classroom instruction; School questionnaires (principal questionnaires), which gather information on school ICT infrastructure and principals' evaluations of teachers' ICT competencies; Teacher questionnaires, administered in a subset of participating education systems, although these are not part of PISA's standard international data collection. Findings from PISA 2022 indicate a significant positive association between students' computer-based problem-solving performance and teachers' ability to solve problems in technology-rich learning environments, providing further evidence that teachers' digital competence contributes directly to students' competency development.

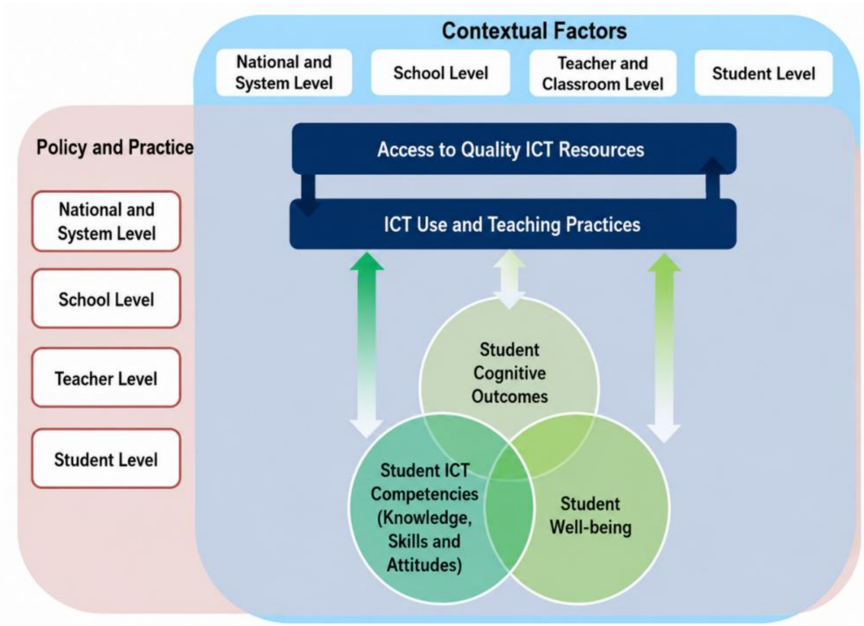


Figure 3.6 PISA 2022 ICT Framework

（Source： PISA 2022 ICT Framework, by OECD, 2023, in PISA 2022 Assessment and Analytical Framework, OECD Publishing (https://doi.org/10.1787/dfe0bf9c-en). Copyright 2023 by OECD.）

Data Structure

PISA collects data across multiple levels, including the student level (student achievement and background information), the school level (principals' questionnaire responses), the teacher level (available in selected participating education systems), and the national level (education policies and resource environments).

This multilevel data structure enables researchers to examine how factors operating at different levels influence students' learning outcomes, including the mediating role of teachers' digital competence in shaping student achievement.

Cross-national Comparability

PISA is one of the world's most well-established international large-scale assessments, providing highly robust evidence for cross-national comparison. It employs standardised assessment instruments and contextual questionnaires, while all participating education systems follow common sampling procedures, implementation protocols, and data processing standards. OECD regularly publishes comprehensive technical documentation describing data collection and analytical procedures, thereby ensuring the scientific validity, reliability, and transparency of international comparisons.

Nevertheless, PISA 2022 has certain limitations in assessing teachers' digital competence.

First, the primary focus of PISA is student assessment. Information regarding teachers is derived largely from students' perceptions and principals' reports, rather than from direct and systematic assessment of teachers themselves.

Second, the teacher questionnaire is administered only in selected participating education systems and is therefore unavailable for many countries. Consequently, PISA should be regarded as providing an indirect indicator of teachers' digital competence rather than a direct assessment of individual teachers' capabilities.

Assessment Findings

PISA 2022 data indicate substantial improvements in teachers' digital readiness across OECD countries. Between 2018 and 2022, the proportion of principals reporting that teachers possessed sufficient skills to use digital devices for teaching increased from 64.5% to 87.6%.

The assessment also identified a significant positive relationship between students' computer-based problem-solving performance and teachers' competence in technology-rich learning environments.

Further analyses based on 53,908 student records revealed that digitalisation does not exert a significant direct positive effect on educational outcomes. Rather, its influence is mediated through teachers' instructional practices and students' learning behaviours, highlighting the importance of pedagogical integration rather than technology adoption alone.

Finally, the Technological Knowledge (TK) scales (TC176 and TC220) together with the Technological Pedagogical Knowledge (TPK) scales developed from PISA questionnaire data provide valuable methodological tools for assessing teachers' capacity to integrate digital technologies into teaching and learning.

2.2 UNESCO UIS: Teacher ICT Dimension in World Education Statistics 2025

The Teacher ICT Dimension in UNESCO Institute for Statistics (UIS) World Education Statistics 2025 is a macro-level monitoring framework designed to indirectly reflect the digital competence of the teaching workforce through nationally reported official statistics. Its distinguishing feature lies in using adults with completed tertiary education as a representative proxy for the teacher population. Based on the internationally harmonised framework developed by the International Telecommunication Union (ITU), ICT skills are organised into five domains: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving.

Drawing on multiple national data sources—including population censuses, labour force surveys, and Education Management Information Systems (EMIS)—the framework produces internationally comparable macro-level indicators. These indicators provide an authoritative benchmark for monitoring generational progress and regional disparities in teachers' ICT skills worldwide, tracking progress towards Sustainable Development Goal (SDG) Target 4.c, and informing evidence-based policies for strengthening teachers' digital competence.

Target Population and Assessment Approach

The UIS Teacher ICT Dimension primarily concerns teachers working in pre-primary, primary, lower secondary, and upper secondary education.

Data are collected through a multi-source approach that combines administrative records with household survey data. Information on teachers' qualifications and professional training is primarily obtained from national Education Management Information Systems (EMIS), while data relating to teachers' ICT skills—such as the ability to use computers, the Internet, and a range of software applications—are generally derived from national population censuses or labour force surveys containing dedicated ICT skills modules.

In addition, UIS collaborates with international large-scale assessment programmes, including the Programme for the International Assessment of Adult Competencies (PIAAC), to obtain standardised evidence on the digital competence of adults, including teachers where applicable.

This integrated data collection strategy balances comprehensiveness, international comparability, and national feasibility, enabling a more accurate representation of teachers' ICT competencies at the global level.

Assessment Framework

The UIS framework assesses ICT skills among youth and adults aged 15–64 years, focusing on both the types of ICT skills acquired and levels of proficiency. Although UIS does not establish a dedicated indicator specifically for teachers' ICT competencies, teachers, as a highly educated professional group, are represented indirectly through statistics for adults who have completed tertiary education.

Following the International Telecommunication Union (ITU) ICT Skills Framework, ICT competencies are organised into five domains.

Information and Data Literacy, including activities such as verifying the reliability of online information, searching for information on goods and services, and accessing digital newspapers and online publications.

Communication and Collaboration, including sending messages with attachments, participating in video conferencing, and engaging with social networking platforms.

Digital Content Creation, including using copy-and-paste functions, producing electronic presentations, and participating in programming or coding activities.

Safety, including implementing effective cybersecurity measures and managing privacy settings.

Problem Solving, including connecting and installing new devices, searching for and installing software, conducting online banking transactions, completing online courses, and engaging in online shopping.

Together, these competencies span the continuum from basic operational skills to advanced digital applications, providing a comprehensive measure of individuals' ability to use digital technologies effectively in everyday work and life. As teachers increasingly rely on these competencies in professional practice, the framework offers an indirect indicator of teachers' preparedness for teaching in digitally enabled learning environments (UNESCO-UIS, 2025).

Table 3.2 ICT Skill Domains Indirectly Reflecting Teachers' Digital Competence in World Education Statistics 2025

Domain	Skill Description
Information and Data Literacy	Verifying the reliability of online information
	Obtaining information about goods or services
	Reading or downloading newspapers, magazines, or e-books in digital format
	Seeking health-related information (e.g., illness, injury, or nutrition)
Communication and Collaboration	Sending messages with attachments (e.g., documents, images, or videos via email, instant messaging, or SMS)

	Making voice or video calls over the Internet (VoIP), using applications such as Skype or WhatsApp
	Participating in social networking platforms
	Participating in online consultations or voting on civic or political issues
Digital Content Creation	Using copy-and-paste functions to copy or move data, information, and digital content
	Using basic arithmetic formulas in spreadsheets
	Creating electronic presentations using presentation software, including text, images, audio, video, and charts
	Programming or coding in digital environments (e.g., software or application development)
	Editing text documents, spreadsheets, or presentations using Internet-based software
	Uploading self-created or user-generated content to websites for sharing
Safety	Configuring effective security measures (e.g., strong passwords or login alerts) to protect devices and online accounts
	Changing privacy settings on devices, accounts, or applications to restrict the sharing of personal information (e.g., name, contact details, or photographs)
Problem Solving	Connecting and installing new devices via wired or wireless technologies (e.g., modems, cameras, or printers)
	Searching for, downloading, installing, and configuring software and applications
	Transferring files or applications between devices, including through cloud

	storage services
	Using online banking services
	Participating in online courses (in any subject area)
	Purchasing or ordering goods and services online

（Source：World Education Statistics 2025 by UNESCO Institute for Statistics (UIS), 2025, Montreal: UNESCO Institute for Statistics.）

Data Structure

The teacher ICT indicators developed by UIS are organised within a clearly defined multilevel data structure. At the most fundamental level, data are collected at the individual teacher level, where information is gathered on whether each teacher possesses specific ICT skills (recorded as Yes/No responses).

These individual responses can subsequently be aggregated to produce statistics at the school, regional, and national levels, such as the proportion of teachers at a particular level of education who possess a given ICT skill.

At a broader scale, national statistics are further aggregated to generate estimates at the regional level (e.g., Sub-Saharan Africa, Central and Southern Asia) and ultimately at the global level, supporting the monitoring of worldwide trends and regional disparities in ICT competencies.

This bottom-up multilevel framework satisfies the needs of evidence-based policymaking at the national level while simultaneously providing the macro-level indicators required to monitor progress towards Sustainable Development Goal 4 (SDG 4).

Cross-national Comparability

To ensure robust international comparability, UIS adopts a standardised framework of ICT skill definitions and classifications, supported by a common core questionnaire used across participating countries.

First, in collaboration with the International Telecommunication Union (ITU), UIS provides clear, operational definitions and illustrative examples for each ICT skill. For instance, the indicator sending messages with attachments explicitly refers to sending documents, images, or videos via email, instant messaging services, or text messaging. Such standardised descriptions help minimise measurement bias arising from linguistic or cultural differences.

Second, the framework encompasses ICT skills that are broadly relevant across countries at different stages of economic and technological development, thereby reducing comparability issues associated with rapidly evolving digital technologies.

Nevertheless, differences in national ICT infrastructure may influence the interpretation of certain indicators. Skills such as participating in online courses or using online banking services may not accurately reflect teachers' underlying digital competence in countries where Internet access remains limited.

Overall, through its standardised measurement instruments and rigorous methodological framework, the UIS Teacher ICT Dimension achieves a high degree of cross-national comparability across diverse educational contexts.

Assessment Findings

According to World Education Statistics 2025, substantial regional disparities exist in ICT skills among young people and adults worldwide.

In East and South-East Asia, as well as Europe and Northern America, individuals across all age groups generally demonstrate relatively high levels of ICT proficiency. In many other regions, however, young people aged 15–24 years consistently outperform older adults, reflecting significant generational progress in digital competence.

Across specific skill domains, basic communication skills, such as sending electronic messages, together with participation in social networking platforms, exhibit relatively high levels of adoption. In contrast, more advanced competencies—including programming, participation in online learning, and engagement in online civic consultations—remain far less common.

Of particular relevance is the report's analysis of adults with completed tertiary education, the population used by UIS as a representative proxy for teachers. The findings indicate that, even within this highly educated group, the proportion meeting the minimum digital competency threshold remains relatively low, generally below 40%. For example, in Hungary, only 28% of adults with tertiary education met the benchmark for digital skills relevant to teaching.

These findings carry important implications for teacher workforce development. Although most teachers possess tertiary qualifications, many continue to lack advanced digital competencies. The results therefore underscore the urgent need to systematically integrate ICT competency development into both initial teacher education and continuing professional development programmes (UNESCO-UIS, 2025).

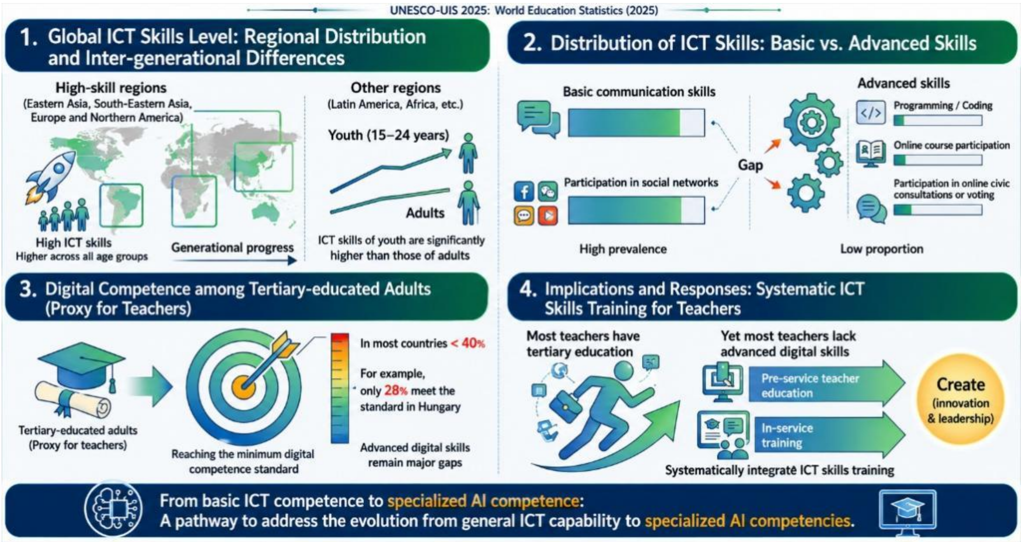


Figure 3.7 Analysis of UNESCO UIS Findings

（Source： World Education Statistics 2025 by UNESCO Institute for Statistics (UIS), 2025, Montreal: UNESCO Institute for Statistics.）

2.3 Assessment Evolve: Teachers' Cognitive Readiness for Formative Assessment in the Age of Generative AI

Assessment Evolved, published by Pearson in late 2025, is a specialised research framework designed to examine the impact of generative AI (GenAI) on formative assessment and teachers' readiness to respond to this transformation. Its distinguishing feature lies in its systematic measurement of five key dimensions: teachers' familiarity with GenAI, attitudes towards GenAI, perceived vulnerability of assessment tasks to AI, perceptions of institutional policy environments, teachers' own use of GenAI, and concerns about students' use of AI.

Using standardised Likert-scale questionnaires, the study collected individual-level data from more than 1,000 K–12 and higher education educators in the United States and the United Kingdom. Beyond identifying the structural tension between familiarity and acceptance, as well as shortcomings in institutional policy support, the framework proposes an evidence-based pathway for rethinking formative assessment by shifting its emphasis from product-oriented evaluation towards process-oriented assessment. It therefore serves as both a diagnostic framework and an action guide for educational institutions, policymakers, and teacher educators responding to assessment reform in the age of AI.

Target Population and Assessment Approach

The framework targets two principal groups. The first comprises educators in the United States and the United Kingdom, including secondary school teachers (Grades 6–12 in the United States and Key Stages 3–5 in the United Kingdom) together with higher education faculty members and lecturers. The second consists of international experts in AI and educational assessment, including practitioners with extensive experience integrating GenAI into classroom teaching and assessment.

The study adopts a mixed-methods research design. Its primary data collection instrument is an online questionnaire, from which more than 1,000 valid responses were obtained, including 505 K–12 educators and 524 higher education educators. The survey measures teachers' familiarity with GenAI, attitudes towards AI, frequency of AI use, perceptions of the susceptibility of different assessment tasks to AI, and views regarding students' use of GenAI.

To complement the survey findings, the study also conducted semi-structured interviews with international experts to obtain forward-looking perspectives on assessment reform.

The research focuses specifically on formative assessment rather than summative assessment, arguing that formative assessment is simultaneously the most vulnerable to AI misuse and the most promising context for pedagogical innovation in the era of generative AI.

The report is accompanied by two practical Educator Guides, one for K–12 education and one for higher education, translating the research findings into actionable classroom strategies.

Assessment Framework

The Assessment Evolved framework examines teachers' understanding, attitudes, and practices regarding the relationship between generative AI (GenAI) and formative assessment. The assessment encompasses five key indicators.

First, teachers' familiarity with and attitudes towards GenAI. The survey found that at least 85% of educators reported being moderately familiar or better with GenAI, yet only 50–58% expressed positive attitudes towards its use. This discrepancy reveals a structural tension in which familiarity does not necessarily translate into acceptance. The report therefore identifies teachers' attitudes as a key indicator of the affective dimension of digital competence.

Second, teachers' perceptions of the vulnerability of assessment tasks to GenAI misuse. Respondents were asked to evaluate the extent to which different assessment tasks could be replaced or compromised by AI. Coding assignments, writing tasks, and multiple-choice assessments were consistently perceived as the most vulnerable to GenAI misuse, whereas oral presentations and classroom presentations were regarded as relatively more resistant to AI. This indicator indirectly reflects teachers' digital competence in assessment design, specifically their ability to determine which forms of assessment remain capable of measuring authentic student learning in AI-supported environments.

Third, teachers' perceptions of institutional AI policy environments. The survey examined whether schools and higher education institutions had established formal policies governing the use of GenAI. Only 54% of K–12 teachers and 60% of higher education educators reported that their institutions had explicit AI policies. This indicator reflects the degree of institutional support available for implementing assessment practices in the age of AI.

Fourth, teachers' personal use of GenAI and its integration into instructional design. Approximately 57% of K–12 teachers and 60% of higher education educators reported actively using GenAI to support instructional design, including curriculum planning, learning activity development, and assessment design. This indicator provides a direct measure of teachers' practical integration of AI into teaching.

Fifth, teachers' concerns regarding students' use of GenAI. The findings indicate that 68% of K–12 teachers and 82% of higher education educators expressed moderate to high levels of concern about students using GenAI to complete assignments when such use was explicitly prohibited. This indicator reflects teachers' competencies in assessment ethics and academic integrity from the perspective of perceived instructional risk.

Data Structure

The Assessment Evolved framework collects data at two analytical levels.

At the individual teacher level, online questionnaires gather information on teachers' demographic backgrounds, attitudes, instructional practices, and perceptions of institutional AI policies. These data support the development of detailed teacher profiles and analyses of individual differences.

At the institutional or system level, aggregated survey responses enable comparisons across educational sectors (K–12 versus higher education) and countries (United States versus United Kingdom).

Although the study does not collect student-level primary data, it incorporates findings from Pearson's earlier survey of student AI use—which reported that 64% of students had used GenAI—as contextual evidence for interpreting teachers' responses.

Furthermore, the study does not establish a longitudinal dataset across multiple years. Instead, it provides a comprehensive cross-sectional baseline describing teachers' perceptions and practices at the time of data collection.

Cross-national Comparability

The Assessment Evolved framework demonstrates a strong capacity for cross-national comparison, owing to several features of its research design.

First, the survey was administered simultaneously in the United States and the United Kingdom using an identical set of core questionnaire items and measurement scales. Comparable sample sizes—approximately 500 respondents per country—allow direct comparisons of teachers' familiarity with, attitudes towards, and use of GenAI across the two national contexts.

Second, all indicators were measured using standardised Likert scales (e.g., five-point scales for familiarity, attitudes, and levels of concern), ensuring methodological consistency and facilitating direct comparisons of mean scores across countries.

Third, the study incorporated semi-structured interviews with international experts, including scholars and practitioners from Australia, the United Kingdom, the United States, Vietnam, and other countries. The international composition of the expert panel provides an important theoretical foundation for interpreting the survey findings across different cultural and educational contexts.

Finally, the report draws upon longitudinal evidence from the Higher Education Policy Institute (HEPI) in the United Kingdom, which documented an increase in student use of AI from 53% to 88% between 2024 and 2025. These external data enrich the comparative analysis by providing broader evidence of evolving AI adoption.

Nevertheless, because the empirical survey covers only two countries, its geographical scope is more limited than that of global large-scale assessments such as TALIS or PISA. Despite this limitation, its transatlantic comparative design offers valuable methodological insights for future international studies of teachers' AI competence and assessment practices.

Assessment Findings

The findings generated through the Assessment Evolved framework highlight several important trends.

First, a substantial gap exists between teachers' familiarity with GenAI and their acceptance of it. Although more than 85% of educators reported being familiar with GenAI, only 50–58% expressed positive attitudes towards its use. This discrepancy suggests that teachers have not yet fully progressed from awareness to acceptance, indicating that the affective dimension of AI competence should become a priority for future professional development.

Second, formative assessment exhibits structural vulnerabilities in the age of GenAI. Teachers consistently identified coding assignments, writing tasks, and multiple-choice assessments as the forms of assessment most susceptible to AI misuse, while oral reports and classroom presentations were perceived as comparatively more resistant. These findings provide empirical support for redesigning formative assessment by shifting from product-oriented evaluation towards process-oriented approaches that capture richer evidence of students' authentic thinking and learning processes.

Third, teachers express high levels of concern regarding students' use of AI, while institutional policy support remains insufficient. As many as 82% of higher education educators expressed concern about students using AI to complete assignments when such use was prohibited, yet only 60% reported that their institutions had established formal AI policies. This mismatch between institutional provision and teachers' professional needs represents a significant systemic challenge for teacher AI competence development.

Fourth, a substantial proportion of teachers have already begun integrating GenAI into instructional practice. Approximately 60% of educators reported using GenAI in instructional design, demonstrating a strong willingness to adopt AI-supported teaching practices. However, the report notes that these applications remain concentrated primarily in curriculum planning and learning activity design, while deeper integration into assessment design is still relatively limited.

Fifth, teachers generally regard AI detection tools as unreliable. Drawing upon multiple empirical studies, the report concludes that existing AI detection systems cannot reliably identify all AI-generated content and are subject to both false positives and concerns regarding procedural fairness. Consequently, the report argues that the appropriate response is to redesign assessment rather than to rely on technological surveillance, a conclusion with significant implications for the development of assessment policies in the era of generative AI.

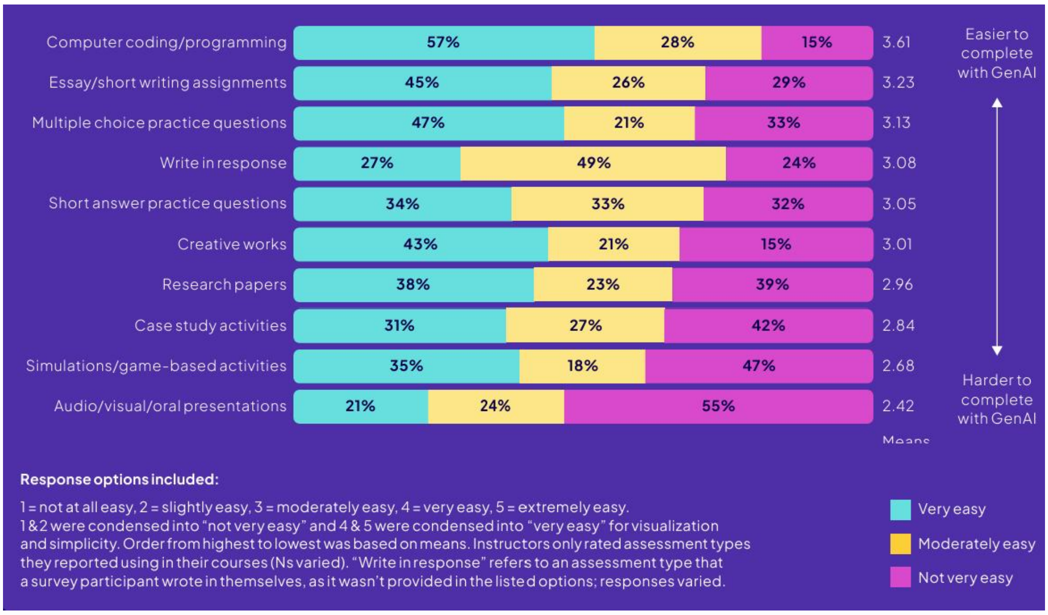


Figure 3.8 The Impact of Generative AI on Formative Assessment

(Source: Assessment evolved: Redefining formative assessment in a generative AI era" by Pearson plc, 2025, November 14 (https://plc.pearson.com/en-GB/news-and-insights/assessment-evolved-redefining-formative-assessment-in-a-generative-ai-er))

2.4 Asking to Learn: Student-Teacher Digital Competence Mapping Framework Based on AI Prompt Analysis

Asking to Learn, published by Pearson in June 2025, is an innovative research framework that indirectly evaluates teachers' instructional design and digital competence by analysing tens of thousands of authentic prompts submitted by higher education students to AI-powered learning tools. Grounded in the Revised Bloom's Taxonomy, the framework examines students' AI interactions across two core dimensions: cognitive processes (Remember, Understand, Apply, Analyse, Evaluate, and Create) and knowledge types (Factual, Conceptual, Procedural, and Metacognitive).

Its distinctive feature lies in inferring teachers' competencies in fostering higher-order thinking, integrating AI into teaching, and cultivating inquiry-oriented classroom cultures through large-scale analyses of students' learning behaviours. In doing so, the framework introduces a novel "evaluating teaching through learning" paradigm, in which evidence of students' AI-supported learning is used to infer teachers' digital competence. The methodological approach is transferable across educational systems and provides an innovative pathway for addressing the validity limitations of traditional teacher self-report instruments while advancing performance-based approaches to teacher digital competence assessment.

Target Population and Assessment Approach

The framework focuses on higher education students who used the "Explain" AI learning assistant embedded within Pearson's Campbell Biology digital textbook. Students' interactions with the AI tool are regarded as behavioural evidence reflecting their instructors' instructional design and integration of AI into teaching.

Data were collected across the Spring and Fall semesters of 2024, yielding approximately 150,000 original AI prompts from 8,681 unique users. Following data cleaning, 128,725 valid prompts were retained for analysis.

The study adopts a mixed-methods approach. First, an automated intent classifier was used to identify the purpose of each student prompt (e.g., requesting homework solutions, seeking conceptual explanations). Approximately 21,000 prompts (around 14%) that explicitly requested answers to assignments were excluded from further analysis.

Subsequently, researchers developed a coding framework using a combination of deductive and inductive content analysis. The deductive component was based on the six cognitive process categories and four knowledge dimensions of the Revised Bloom's Taxonomy, while the inductive component incorporated discipline-specific terminology from biology to improve contextual accuracy.

Fundamentally, the framework treats students' cognitive performance as a downstream indicator of instructional quality and teachers' digital competence. The underlying assumption is that when instructors intentionally cultivate higher-order thinking and effectively integrate AI into learning activities, students naturally engage with AI through more sophisticated prompts involving analysis, evaluation, and creation.

Large-scale textual analysis was conducted using Leximancer 5.0, a semi-automated content analysis platform that combines computational efficiency with the reliability of qualitative coding.

Assessment Framework

The framework assesses teachers' digital competence indirectly through two principal analytical dimensions, together with complementary behavioural indicators.

First, students' cognitive processes, based on the six levels of the Revised Bloom's Taxonomy. This dimension reflects the extent to which instructional design promotes higher-order thinking.

Remember: Students ask factual recall questions, such as "What types of cells contain mitochondria?" A predominance of such questions may indicate that teaching remains focused primarily on factual knowledge transmission, with limited emphasis on AI-supported inquiry and higher-order thinking.

Understand: Students request conceptual explanations, for example, "Explain cellular respiration." Such questions suggest that teachers have established foundational conceptual understanding but may not yet be encouraging critical inquiry.

Apply: Students use concepts in authentic contexts, for example, "How could an organism maximise its surface-area-to-volume ratio?" These prompts indicate that teachers have designed contextualised learning activities and encouraged students to use AI to support knowledge transfer, reflecting relatively advanced digital pedagogical competence.

Analyse, Evaluate, and Create: Students engage in reasoning, critical judgement, and original idea generation, for example, "How would you distinguish these two types of mycorrhizae under a microscope?" or "How well does my explanation of evolution hold up?" A higher proportion of such prompts provides strong evidence that teachers have successfully integrated inquiry-based learning, metacognitive development, and the use of AI as a thinking partner within their teaching.

Second, students' knowledge dimensions, including Factual, Conceptual, Procedural, and Metacognitive Knowledge. Of particular significance are metacognitive prompts, such as "Is my understanding correct?" or "Could you evaluate my explanation?" The frequency of these questions directly reflects whether teachers have fostered self-monitoring, reflective learning, and AI-supported metacognitive awareness, all of which represent critical aspects of teachers' capacity to empower learners through digital technologies.

Third, the intensity of students' AI use. This dimension measures behavioural engagement through indicators such as the number of prompts submitted per student each semester. Individual usage ranged up to 1,159 prompts, while 42% of students initiated five or more AI conversations. High levels of AI engagement combined with cognitively sophisticated prompts suggest that teachers not only recognise the educational value of AI but have also successfully embedded AI-supported learning activities within their courses and cultivated classroom cultures that encourage sustained inquiry.

Fourth, inferred indicators of teachers' digital competence. Although the framework does not directly collect teacher-level data, patterns in students' AI interactions enable researchers to infer aspects of teachers' instructional practice.

A predominance of Remember and Understand prompts suggests that AI has not yet been meaningfully integrated into higher-order thinking activities.

Frequent Apply and Analyse prompts indicate that teachers are likely incorporating project-based learning, case-based instruction, and other activities that promote knowledge transfer.

Frequent Metacognitive prompts strongly suggest that teachers explicitly teach reflective learning strategies and encourage students to use AI for self-assessment and self-regulated learning.

Taken together, these indicators establish a learner-to-teacher assessment framework that simultaneously provides insights into students' AI-supported learning behaviours and teachers' digital competence, thereby offering a dual perspective on teaching and learning in AI-enhanced educational environments.

Data Structure

The framework collects detailed student-level behavioural data, including each student's original AI prompts, timestamps, cognitive process classifications, and knowledge-type classifications.

These individual-level data can subsequently be aggregated at the course, class, or instructor level to generate group-level distributions of cognitive processes and knowledge types, thereby enabling inferences about teachers' instructional design and digital competence. For example, if students in one class demonstrate a substantially higher proportion of Analyse, Evaluate, and Create prompts than students in comparable classes, it is reasonable to infer that the instructor has been more effective in integrating AI into teaching and fostering higher-order thinking.

This student-to-teacher inference model represents the defining characteristic of the framework and distinguishes it from conventional teacher assessment instruments based on direct measurement.

Unlike international large-scale assessments, the framework does not collect school-level or national-level contextual variables. Nevertheless, its methodological approach provides an important reference for future research seeking to complement behavioural evidence with direct teacher-level assessment.

Cross-national Comparability

As a specialised analytical framework, Asking to Learn currently has relatively limited cross-national coverage. The empirical data are derived exclusively from students using the English-language version of Campbell Biology, primarily representing higher education institutions in English-speaking countries. Consequently, the framework has not yet been implemented through parallel data collection across multiple national contexts.

However, its methodological framework demonstrates considerable potential for international application.

First, the Revised Bloom's Taxonomy is one of the most widely adopted theoretical frameworks in educational assessment worldwide. Having been translated into dozens of languages, it provides a common conceptual foundation for international comparison.

Second, the cognitive analysis of students' AI prompts is inherently transferable across educational systems. Regardless of national context, students who regularly use AI to formulate analytical, evaluative, and creative questions are likely to have benefited from high-quality instructional guidance and effective integration of AI into teaching.

Third, Pearson's digital learning platforms are used in nearly 200 countries, providing a potential foundation for future multinational studies employing the same analytical methodology.

Accordingly, this framework is best positioned as a methodological demonstration of student–teacher digital competence mapping. Its principal contribution lies not in providing immediately comparable international statistics, but in illustrating a transferable "evaluating teaching through learning" paradigm. By analysing large-scale student–AI interaction data using a common cognitive coding framework, researchers can indirectly evaluate teachers' competence in integrating AI into teaching and fostering higher-order thinking across diverse educational contexts.

Assessment Findings

The findings generated through the Asking to Learn framework provide several important insights into the relationship between students' AI-supported learning behaviours and teachers' digital competence.

First, students' overall cognitive profiles suggest that teachers have generally achieved competence in foundational instructional design, while opportunities remain for strengthening higher-order learning. Approximately 80% of student prompts were classified within the Factual and Conceptual Knowledge dimensions, reflecting students' needs for foundational knowledge acquisition. These findings indicate that most instructors are effectively using AI to support students' mastery of core concepts and demonstrate satisfactory competence in the basic pedagogical integration of digital technologies. At the same time, the results suggest considerable room for further development in guiding students towards deep analysis, metacognitive reflection, and creative problem solving through AI.

Second, the presence of higher-order prompts demonstrates that a substantial proportion of teachers have achieved advanced levels of digital pedagogical competence. Approximately 20% of prompts involved Procedural or Metacognitive Knowledge, while roughly 33% reached the Apply level or above, and around 20% were classified at the Analyse level or higher. These findings indicate that many instructors have successfully embedded AI into inquiry-based learning activities, encouraging students to use AI to test their understanding, design solutions, and critically evaluate arguments. Such practices demonstrate not only technical proficiency with AI tools but also the successful integration of AI competence into curriculum design and assessment, reflecting advanced capability in technology-enhanced pedagogy.

Third, substantial variation in students' AI engagement reflects differences in teachers' digital competence. The number of AI prompts submitted per student ranged from 1 to 1,159, with a very large standard deviation. This variation is unlikely to be explained solely by individual student characteristics and instead suggests considerable differences among instructors in their ability to motivate students to engage actively and continuously with AI-supported learning. While 42% of students initiated five or more AI conversations, indicating that many teachers have successfully cultivated classroom cultures supporting human–AI collaboration, more than half of students engaged with AI only one to four times, implying that many instructors have yet to integrate AI meaningfully into everyday teaching. These findings identify an important priority for professional development: supporting teachers in moving from occasional experimentation towards systematic integration of AI into instructional practice.

Fourth, the research has directly informed the development of AI-supported learning tools that function as instructional scaffolds for teachers. Based on the analytical findings, Pearson introduced the Go Deeper feature, which automatically recommends higher-level follow-up questions after students submit lower-level prompts. This functionality effectively provides teachers with an instructional scaffold, enabling AI to support progressive cognitive guidance even when teachers themselves have limited experience designing sophisticated questioning sequences. The feature exemplifies a practical pathway through which human–AI collaboration can enhance teachers' digital competence and offers a scalable model for AI-focused teacher professional development.

Fifth, the framework introduces an innovative indirect approach to assessing teachers' digital competence. Conventional assessments rely predominantly on self-report questionnaires and are therefore susceptible to social desirability bias and self-perception bias. In contrast, Asking to Learn advocates an "evaluating teaching through learning" approach, inferring teachers' instructional quality and digital competence from students' cognitive performance within AI-supported learning environments. This paradigm has important implications for the future development of teacher digital competence assessments. For example, teachers could be presented with authentic classroom scenarios and asked to design a sequence of AI-supported questions that guide students towards higher-order learning. Researchers could then evaluate teachers' digital competence by analysing the cognitive sophistication of the instructional prompts they create. Such performance-based, task-driven assessment has considerable potential to overcome the validity limitations of traditional self-report instruments and represents an important direction for future innovation in teacher digital competence assessment.

	Cognitive Process Dimension					
Knowledge Dimension	Remember and Know	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	17%	15%	4%	4%	1%	1%
Conceptual Knowledge	6%	19%	3%	10%	1%	1%
Procedural Knowledge	2%	8%	5%	1%	<1%	1%
Metacognitive Knowledge	1%	1%	<1%	1%	<0.1%	<0.1%

1/3 of inputs at higher levels of cognitive complexity

20% of inputs considered consistent with critical thinking

Figure 3.9 Teaching Effectiveness Findings Based on AI Prompt Analysis

（Source： “Asking to learn: How student AI queries are shaping smarter learning tools” by D. Edwards, 2025, June 5 (https://plc.pearson.com/AskingToLearn）)

2.5 Certiport AI Teacher Certification Post-Certification Survey: Assessing

Teachers' AI Competence Based on International Certification Standards

Target Population and Assessment Approach

This evaluation is based on the AI and Digital Education Competency Enhancement Programme for Teachers, jointly launched by Certiport (a Pearson company) and the China Education Association for International Exchange (CEAIE) at the 2025 China Annual Conference for International Education (CACIE).

The target population comprises Chinese higher education and vocational education teachers who completed the training programme and successfully obtained professional certification. As of 31 March 2026, 21 teachers had completed the Generative AI Foundations Certification, while five teachers had obtained the Information Technology Specialist – AI (ITS-AI) Certification.

The evaluation adopts a dual-track assessment approach combining standardised certification examinations with post-certification self-report surveys.

The certification examinations objectively assess teachers' AI knowledge and practical competencies using internationally recognised standards aligned with the UNESCO AI Competency Framework for Students. Following certification, participants complete an online questionnaire examining how they apply the acquired competencies in practice, the extent to which the training met their expectations, barriers encountered during implementation, and unexpected benefits derived from the programme.

Together, these two components establish a comprehensive evaluation model that integrates objective competency certification with subjective perceptions of professional efficacy.

Assessment Framework

The evaluation framework consists of two complementary dimensions: AI competency certification and the practical transfer of learning into educational practice.

The Generative AI Foundations Certification assesses teachers' general competence in the educational use of generative AI. Developed collaboratively by Certiport's content specialists and psychometric experts, the certification provides a vendor-neutral international benchmark, focusing on core competencies such as prompt engineering, AI ethics, AI-assisted content generation, and critical evaluation of AI-generated outputs.

The Information Technology Specialist – AI (ITS-AI) Certification targets teachers with a stronger technical background. It focuses on the application of AI within information technology education and validates both teachers' IT expertise and specialised AI competencies.

The post-certification survey evaluates the practical application of certified competencies across five principal instructional contexts:

Curriculum planning and lesson preparation, including lesson planning and the generation of instructional activities;

Development of teaching resources, including assessment items, instructional cases, images, and multimedia materials;

Personalised student support, including adaptive learning pathways and AI-assisted tutoring;

Assessment and feedback, including assignment marking and the generation of evaluation reports;

Academic research and professional development, including literature reviews, academic writing, and improvements in administrative efficiency.

In addition, the survey gathers information on implementation barriers, unexpected benefits, alignment with institutional curricula, and future professional learning needs, thereby providing a comprehensive evaluation of the effectiveness of the certification programme.

Data Structure

The evaluation collects data at two analytical levels.

At the individual teacher level, data include each participant's certification examination results (objective assessment scores) together with responses to the post-certification survey (self-reported perceptions). These data support the development of individual competency profiles and facilitate the monitoring of professional learning outcomes over time.

At the programme level, aggregated data provide indicators such as overall participant satisfaction, implementation rates across different instructional applications, and the distribution of common implementation barriers.

Given the relatively small sample size (26 certified participants), the current dataset is intended primarily to support internal programme evaluation and continuous improvement, rather than national or regional benchmarking. Nevertheless, the certification programme's standardised scoring system establishes a robust technical foundation for future large-scale data aggregation and comparative analysis.

Cross-national Comparability

This evaluation framework demonstrates considerable potential for cross-national comparison, owing to three principal characteristics.

First, internationally aligned certification standards. Both the Generative AI Foundations Certification and the Information Technology Specialist – AI (ITS-AI) Certification are aligned with the UNESCO AI Competency Framework for Students. As part of Certiport's global certification portfolio, the Generative AI Foundations Certification adopts a vendor-neutral, internationally standardised competency framework that is independent of specific AI tools or commercial platforms, thereby supporting equivalent comparisons across countries.

Second, standardised certification mechanisms. The certification examinations are developed by Pearson's global assessment team using common examination specifications, scoring criteria, passing standards, and item banks. These standardised procedures ensure the technical comparability of certification outcomes across different national contexts.

Third, strong cross-cultural applicability. Although the current post-certification survey has been conducted only in China, Certiport offers equivalent certification programmes in numerous countries worldwide. This provides a foundation for future international comparative research based on a common assessment framework.

At present, the principal limitations relate to the single-country implementation and relatively small sample size. Nevertheless, as the programme expands internationally, its capacity to support robust cross-national comparisons is expected to increase substantially.

Assessment Findings

Based on data collected up to 31 March 2026, the evaluation yielded several key findings.

First, a high level of transfer into practice was observed. Teachers reported successfully applying the competencies acquired through certification across most of the instructional contexts they had anticipated before training. In particular, strong alignment was evident in curriculum planning and lesson preparation, development of teaching resources, and academic research and professional learning.

Second, participants reported a range of unexpected benefits. Beyond their initial expectations, many teachers indicated that the programme had strengthened their awareness of AI ethics, encouraged interdisciplinary collaboration, and broadened their understanding of AI-supported teaching and learning.

Third, implementation barriers were primarily institutional rather than technical. The most frequently reported challenges included the absence of clear institutional policies governing AI-supported teaching, limited instructional time for integrating AI into existing curricula, and the lack of professional communities for sharing effective practices. By contrast, technical operation of AI tools was seldom identified as a major obstacle.

Fourth, the programme demonstrated a high level of curricular relevance. Most participants reported that the certification content aligned closely with their institutions' existing curricula and strategic priorities for educational development.

Fifth, teachers expressed clear priorities for further professional learning. Areas identified for continued development included AI-supported advanced instructional design, learning analytics based on student behavioural data, and classroom strategies for implementing AI ethics and promoting academic integrity.

Overall, the programme provides a replicable model for AI competency certification and continuous professional development for university and vocational education teachers in China, while offering valuable experience for the international development of AI-focused teacher certification programmes.

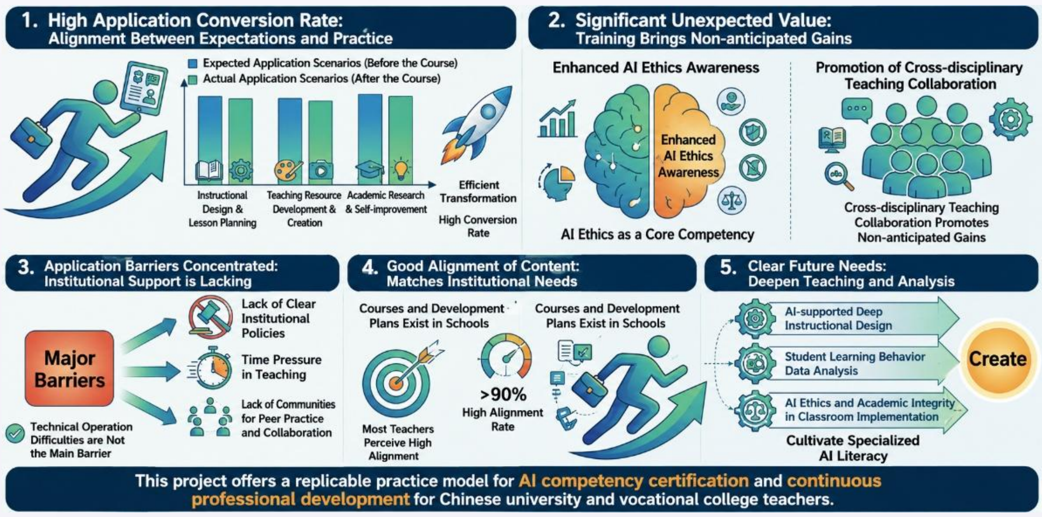


Figure 3.10 Analysis of Findings from the Certiport AI Teacher Certification Survey

3. Comparative Analysis of the Ten Assessment Instruments

3.1 Assessment Populations Span Multiple Stakeholders

The ten assessment instruments collectively cover a wide range of stakeholders, including individual teachers, students, school leaders, and national education systems.

TALIS focuses primarily on teachers and school principals in basic education, while DigCompEdu targets individual educators across all educational sectors. ICILS directly assesses eighth-grade students and simultaneously collects contextual data from teachers, principals, and ICT coordinators. As a competency framework, UNESCO AI CFT serves teachers indirectly by providing internationally recognised competency standards rather than administering assessments itself.

PISA 2022 assesses 15-year-old students and indirectly reflects teachers' digital competence through student and principal questionnaires. UNESCO UIS World Education Statistics adopts the nation as its statistical unit and uses ICT skill data from adults with completed tertiary education as a proxy for the teaching workforce. Assessment Evolved directly surveys K–12 and higher education teachers in the United States and the United Kingdom, whereas Asking to Learn analyses higher education students' AI-supported learning behaviours. China's teacher digital competence assessment instruments focus on primary and secondary school teachers, while the Certiport AI Teacher Certification Survey targets certified teachers from Chinese universities and vocational colleges.

Collectively, these instruments establish a four-dimensional assessment ecosystem encompassing teachers, students, education systems, and professional certification.

3.2 Assessment Frameworks Encompass Four Complementary Approaches

The assessment content of the ten instruments can be broadly classified into four complementary approaches.

The first approach focuses on teachers' self-reported competencies and professional practices. TALIS measures the frequency of digital technology use and AI-supported teaching practices; DigCompEdu evaluates teachers' self-perceived digital competence across six competency areas comprising 22 competencies; UNESCO AI CFT defines 15 competencies organised within five domains, including human-centred mindset and AI ethics; and China's teacher digital competence instruments are aligned with the Teachers' Digital Competence standard, covering Digital Awareness, Digital Knowledge and Skills, Digital Application, Digital Social Responsibility, and Professional Development.

The second approach evaluates students' digital competence and learning outcomes. ICILS directly measures students' Computer and Information Literacy (CIL) and Computational Thinking (CT), while PISA 2022 collects student-reported information regarding teachers' ICT integration practices.

The third approach examines teachers' AI competence and students' AI-supported learning behaviours. Assessment Evolved measures teachers' familiarity with GenAI, attitudes towards AI, and perceptions of assessment vulnerability. Asking to Learn analyses students' AI prompts using the Revised Bloom's Taxonomy to infer teachers' digital pedagogical competence. The Certiport AI Teacher Certification Survey combines certification examinations with post-certification questionnaires to evaluate the practical application of teachers' AI competencies.

The fourth approach consists of macro-level statistical indicators and contextual measures. UNESCO UIS World Education Statistics monitors ICT competencies across five domains: Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Safety, and Problem Solving.

3.3 Data Structures Form a Multi-level Evidence Chain from Individual Assessment to National Monitoring

The ten assessment instruments collectively provide evidence spanning the full continuum from individual-level assessment to national-level monitoring.

TALIS, ICILS, and PISA 2022 support data aggregation across the individual, school, and national levels, providing the strongest capacity for multilevel analysis. DigCompEdu primarily collects individual-level data but can also support aggregation to higher organisational levels. Assessment Evolved focuses on individual teachers while also supporting institutional and national comparisons between the United States and the United Kingdom. Asking to Learn centres on individual students, with findings aggregated to the instructor or course level. UNESCO UIS World Education Statistics provides macro-level indicators primarily at the national level. Although UNESCO AI CFT does not itself collect assessment data, it provides a common competency framework for assessments conducted at different levels. China's teacher digital competence instruments focus primarily on individual teachers while supporting aggregation to school, regional, and national levels. The Certiport AI Teacher Certification Survey currently operates mainly at the individual and programme levels, although its standardised scoring system provides a technical foundation for future large-scale aggregation.

Overall, TALIS and ICILS offer the most comprehensive multilevel data structures by integrating individual, school, and national levels. In contrast, the Chinese enterprise-based assessment initiatives still have considerable potential for expanding upward data aggregation.

3.4 Cross-national Comparability Depends on the Degree of Standardisation and the Breadth of International Participation

The ten assessment instruments differ substantially in their capacity to support cross-national comparison.

TALIS, ICILS, and PISA represent internationally standardised large-scale assessments led by the OECD and the IEA. Through common assessment instruments, rigorous sampling procedures, and broad international participation, these programmes provide highly comparable data across countries.

UNESCO UIS World Education Statistics, supported by the official statistical system of the United Nations, covers more than 200 countries and territories and employs internationally standardised indicator definitions, making it highly suitable for cross-national comparison.

Although UNESCO AI CFT, introduced in 2024, remains at an early stage of international implementation, it provides a common conceptual language for international policy dialogue and future comparative assessment.

DigCompEdu was explicitly designed as an internationally applicable framework. However, its comparability is moderated by cultural differences in self-reporting and the absence of a global standardised data collection system.

Assessment Evolved currently covers only the United States and the United Kingdom, while Asking to Learn is largely confined to English-language higher education contexts. Although both have limited international coverage, their underlying methodological frameworks are readily transferable to other educational systems.

China's teacher digital competence assessment instruments are based primarily on national standards. While they draw upon international competency frameworks, they have not yet been incorporated into major international assessment programmes, and direct cross-national comparisons should therefore be interpreted cautiously.

The Certiport AI certification framework adopts internationally recognised certification standards aligned with UNESCO frameworks and employs globally standardised examination procedures, giving it considerable potential for international comparison. However, the current empirical evidence is derived exclusively from Chinese participants, and broader international implementation will be required before robust comparative analyses become possible.

Overall, international large-scale assessments continue to provide the strongest basis for cross-national comparison, whereas enterprise-based initiatives and China's national assessment instruments demonstrate significant potential for international adaptation through their transferable methodological approaches.

Table 3.3 Comprehensive Comparison of the Ten Assessment Instruments

Assessment Instrument	Target Population	Core Assessment Content	Data Level
TALIS	Teachers, principals	Frequency of digital technology use, AI-supported teaching, professional development, working environment	Individual, school, national
DigCompEdu	Teachers across all education levels	Self-assessment of 22 digital competencies across six competency areas	Individual (aggregatable)
ICILS	Grade 8 students, teachers, principals	Computer and Information Literacy (CIL), Computational Thinking (CT), teachers' ICT use, school ICT resources	Student, teacher, school, national
UNESCO AI CFT	Teachers at all education levels (competency framework)	15 competencies across five domains; three proficiency levels (Acquire, Deepen, Create)	Depends on the assessment instrument developed from the framework
PISA 2022	15-year-old students	Student ICT use, teachers' ICT integration, TK/TPK/TPACK scales	Student, school, national
UNESCO UIS World Education Statistics	Countries, teachers, students, etc.	ICT competencies of adults with completed tertiary education across five domains	National (aggregatable to regional and

		(Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Safety, and Problem Solving)	global levels)
Assessment Evolved	K–12 and higher education teachers in the United States and the United Kingdom	Familiarity with GenAI, attitudes, perceived assessment vulnerability, institutional policy environment, teachers' own AI use, concerns about students' AI use	Individual teacher, institution/national
Asking to Learn	Higher education students	Bloom's cognitive process levels, knowledge dimensions, and AI prompt behaviour	Individual student (aggregatable to teacher/course level)
China's Teacher Digital Competence Assessment Instruments	Primary and secondary school teachers	Digital Awareness, Digital Knowledge and Skills, Digital Application, Digital Social Responsibility, Professional Development	Individual teacher (aggregatable to school, regional, and national levels)
Certiport AI Teacher Certification Survey	Certified teachers from universities and vocational colleges	Generative AI competencies, ITS-AI professional competencies, transfer of learning into practice, implementation barriers, and unexpected benefits	Individual teacher, programme/cohort

4. Discussion and Implications

4.1 Direct Assessments and Indirect Indicators Form a Complementary Multi-dimensional Evaluation System

Taken together, the ten assessment instruments demonstrate clear functional complementarity, collectively establishing a multidimensional evaluation system that spans individual teacher competence, system-level environments, general ICT competence, specialised AI competence, and both subjective self-report and objective certification evidence.

Among the direct assessment instruments, TALIS, DigCompEdu, China's Teacher Digital Competence Assessment Instruments, and Certiport AI Certification focus primarily on teachers' individual competencies. TALIS situates teachers' digital competence within broader contexts of instructional practice, professional development, and working conditions, thereby identifying systemic factors influencing teachers' competency development. DigCompEdu provides a detailed self-assessment framework consisting of 22 competencies organised within six competency areas, making it particularly suitable for teachers' self-diagnosis and professional learning planning. China's assessment instruments are aligned with the Teachers' Digital Competence national standard and cover five domains—Digital Awareness, Digital Knowledge and Skills, Digital Application, Digital Social Responsibility, and Professional Development. Supported by large-scale national validation, these instruments provide robust tools for context-specific assessment. Certiport combines internationally benchmarked certification examinations with post-certification surveys, creating a dual-track model that integrates objective competency certification with subjective perceptions of professional efficacy, thereby addressing the lack of external validation commonly associated with traditional self-report instruments.

The indirect indicators complement teacher assessment from the perspectives of student outcomes, macro-level statistics, and cognitive learning behaviours. ICILS and PISA 2022 indirectly reflect teachers' instructional effectiveness through students' digital competence and learning performance. UNESCO UIS World Education Statistics provides macro-level evidence by using ICT competencies among adults with completed tertiary education as a proxy for teachers' digital competence. Assessment Evolved examines teachers' attitudes towards GenAI and their competence in AI-supported assessment design, while Asking to Learn introduces an innovative "evaluating teaching through learning" paradigm by inferring teachers' instructional quality from the cognitive sophistication of students' AI prompts.

Together, these five categories of evidence—teacher self-report, student assessment, macro-level statistics, cognitive behavioural analysis, and external certification—form an integrated evaluation framework that combines self-reported competence, behavioural evidence, and contextual monitoring.

4.2 All Assessment Instruments Have Inherent Limitations and Should Be Used Complementarily

Each assessment instrument possesses inherent strengths as well as methodological limitations.

TALIS, conducted approximately every five years, cannot fully capture the rapidly evolving nature of teachers' digital competence. Moreover, digital competence represents only one component of a much broader survey, limiting the depth of AI-related assessment.

DigCompEdu relies primarily on teachers' self-reported perceptions and is therefore susceptible to social desirability bias and cultural differences in self-assessment, without directly verifying teachers' performance in authentic instructional settings.

ICILS focuses primarily on eighth-grade students. Information concerning teachers is collected mainly through contextual questionnaires, resulting in limited direct measurement of teachers' digital competence. Furthermore, teacher questionnaires are optional in some participating education systems.

As a competency framework, UNESCO AI CFT does not itself collect empirical data, and its practical effectiveness depends largely on the quality of national adaptation and implementation.

PISA 2022 relies principally on students' perceptions and principals' reports to characterise teachers' digital competence, making it an indirect rather than direct assessment of teachers' capabilities.

UNESCO UIS World Education Statistics aggregates data primarily at the national level and cannot distinguish teachers from other professional groups within broader ICT skill statistics. Furthermore, because ICT competency data originate largely from household surveys, they may not accurately represent the actual digital competence of the teaching workforce.

As enterprise-led research initiatives, Assessment Evolved and Asking to Learn currently cover only the United States, the United Kingdom, or English-speaking higher education contexts, limiting the breadth of international comparison.

China's teacher digital competence assessment instruments are based on nationally developed standards and have not yet been incorporated into international large-scale assessments such as TALIS, resulting in the absence of cross-cultural calibration.

Finally, the Certiport AI Teacher Certification Survey currently includes only 26 participants, limiting its statistical generalisability and capacity for large-scale comparative analysis.

Accordingly, no single assessment instrument provides a comprehensive representation of teachers' digital competence. A combination of complementary assessment approaches is therefore essential for obtaining a more comprehensive and valid understanding of teachers' digital and AI competencies.

4.3 Five Implications for Advancing Teacher Digital Competence Assessment in China

Drawing upon international experience, five strategic directions can be identified for strengthening teacher digital competence assessment in China.

First, a multi-source assessment framework integrating self-assessment, professional certification, and behavioural evidence should be established. Building upon the existing Teachers' Digital Competence standard, self-report instruments should be complemented by classroom observation, student feedback, and third-party certification examinations to create a comprehensive evaluation system combining subjective and objective evidence.

Second, specialised assessment of AI competence should be strengthened. Drawing on the five competency domains of UNESCO AI CFT—Human-Centred Mindset, AI Ethics, AI Foundations and Applications, AI Pedagogy, and AI for Professional Development—together with Certiport's objective certification model, future assessments should incorporate competencies such as AI ethics, prompt engineering, and bias detection as core evaluation indicators.

Third, indirect assessment mechanisms based on the principle of "evaluating teaching through learning" should be developed. Inspired by the Asking to Learn framework, educational big data—including students' learning behaviours and AI interaction records on digital platforms—can be analysed to infer teachers' instructional design quality and AI integration competence, thereby addressing the validity limitations of conventional self-report measures.

Fourth, China's assessment instruments should be aligned more closely with international competency frameworks, including UNESCO ICT CFT, UNESCO AI CFT, and DigCompEdu, while actively participating in international assessments such as TALIS and ICILS to obtain internationally comparable benchmarking data.

Fifth, China's national data infrastructure should be strengthened by adopting the statistical framework of UNESCO UIS to improve the collection of teachers' ICT competency data and provide robust evidence for national policymaking. At the same time, wider implementation of Certiport-style certification programmes could promote the large-scale development of teachers' AI competence through objective, internationally recognised assessments.

4.4 National Assessment Results Reveal Significant International Differences in Teachers' AI Use and Students' Digital Competence

Recent findings from TALIS 2024 and ICILS 2023 reveal substantial international variation in both teachers' use of AI and students' computational thinking performance. East Asian countries and several Middle Eastern education systems demonstrate particularly strong performance, while considerable disparities remain both across and within many European and East Asian countries.

According to TALIS 2024, the average proportion of lower secondary teachers who reported using AI during the previous year across OECD member countries was 36.0%.

Among the education systems exceeding this OECD average, the United Arab Emirates ranked first at 76%, followed closely by Singapore (75%). Other high-performing countries included New Zealand (69%), Australia (66%), Italy (64%), Uzbekistan (62%), Kazakhstan (61%), Luxembourg (59%), Azerbaijan (58%), and Mexico (56%).

Shanghai (China) reported a teacher AI usage rate of 54%, while China overall reached 53%, both substantially exceeding the OECD average. Additional countries performing above the average included Colombia (52%), Algeria (51%), Costa Rica (50%), Bahrain (49%), South Africa (48%), Romania (47%), Czechia (46%), Poland (45%), Israel (44%), Kosovo (43%), the United States (42%), and Saudi Arabia (41%).

Among the countries below the OECD average, teachers' AI adoption rates were relatively low in Denmark (35.5%), Spain (35.2%), Latvia (35.1%), Estonia (34.8%), Slovenia (34.6%), Belgium (33.3%), Croatia (32.8%), Sweden (31.4%), Portugal (30.5%), Serbia (29.8%), Slovakia (29.2%), Montenegro (27.5%), Finland (26.8%), Morocco (25.8%), Italy (24.5%), Iceland (23.8%), Türkiye (23.5%), Hungary (23.2%), the French Community of Belgium (22.8%), Bulgaria (17.5%), Japan (14.0%), and France (13.5%). Notably, both France and Japan reported AI usage rates below 20%, placing them among the lowest-performing countries and highlighting a striking contrast with leading performers such as the United Arab Emirates and Singapore.

Overall, substantial cross-national disparities exist in teachers' use of AI, reflecting significant differences in the promotion of AI in education, teacher professional development, and digital infrastructure. With an AI usage rate of 54%, Shanghai (China) substantially exceeds the OECD average, indicating that China has made encouraging progress in advancing teachers' AI literacy and the integration of AI into educational practice.

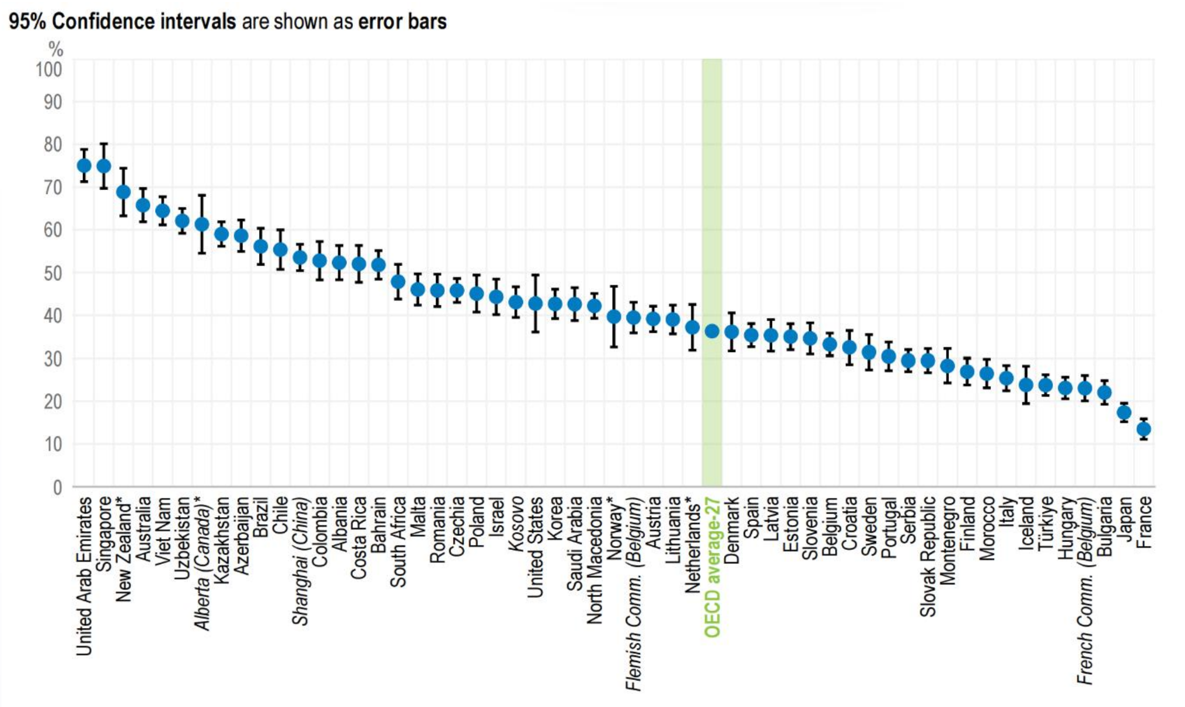
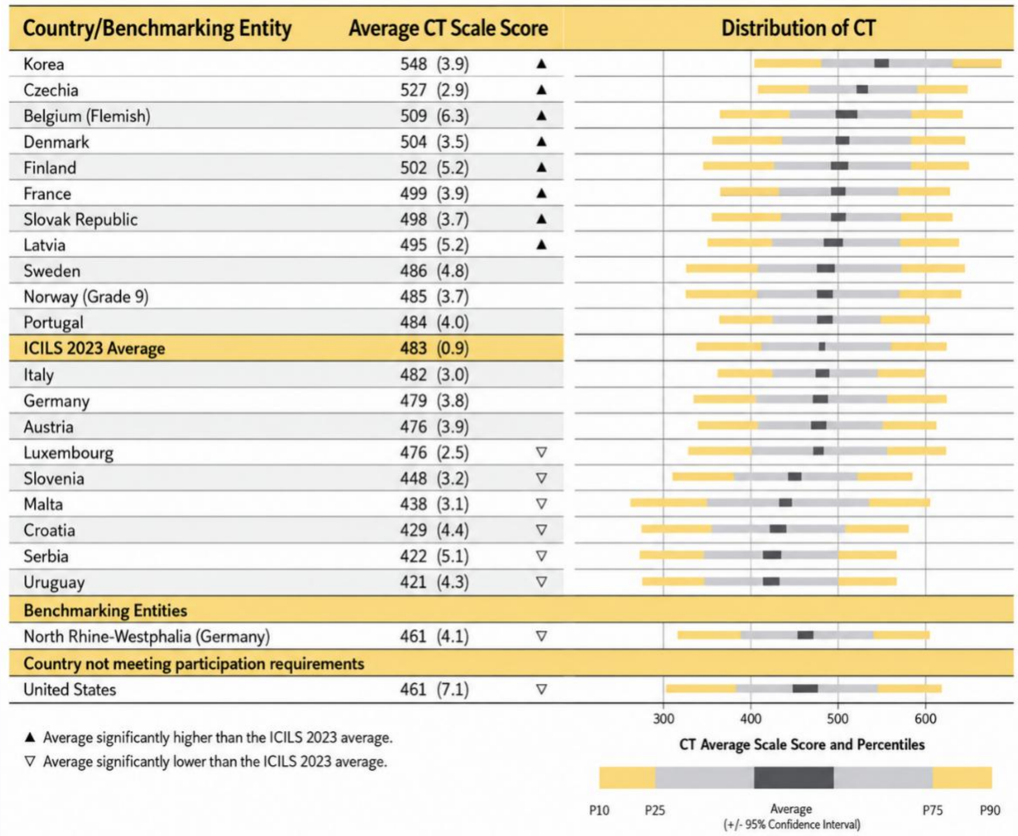


Figure 3.11 Teachers' Use of AI: Percentage of Lower Secondary Teachers Who Used AI in the Past Year by Country, 2024

(Source: Teaching and Learning International Survey (TALIS) 2024 Conceptual Framework (p. 23), by J. Ainley and W. Schulz, 2025, OECD Publishing (https://doi.org/10.1787/7b8f85d4-en))

According to the findings of ICILS 2023, the computational thinking (CT) performance of eighth-grade students across participating countries and benchmarking entities exhibits a clear hierarchical distribution, with substantial within-country variation. Korea, Czechia, Belgium (Flemish Community), and Denmark ranked among the highest-performing systems, demonstrating strong overall levels of students' computational thinking proficiency. Finland, France, Slovakia, Latvia, Sweden, and Norway (Grade 9) formed the middle-performing group. Portugal, Italy, Germany, Austria, Luxembourg, Slovenia, Malta, Croatia, Serbia, and Uruguay performed comparatively lower. The ICILS 2023 international average is located near the center of the distribution, while North Rhine-Westphalia (Germany) and the United States scored slightly below the international average.



Country/Benchmarking Entity	Average CT Scale Score	
Korea	548 (3.9)	▲
Czechia	527 (2.9)	▲
Belgium (Flemish)	509 (6.3)	▲
Denmark	504 (3.5)	▲
Finland	502 (5.2)	▲
France	499 (3.9)	▲
Slovak Republic	498 (3.7)	▲
Latvia	495 (5.2)	▲
Sweden	486 (4.8)	
Norway (Grade 9)	485 (3.7)	
Portugal	484 (4.0)	
ICILS 2023 Average	**483 (0.9)**	
Italy	482 (3.0)	
Germany	479 (3.8)	
Austria	476 (3.9)	
Luxembourg	476 (2.5)	▽
Slovenia	448 (3.2)	▽
Malta	438 (3.1)	▽
Croatia	429 (4.4)	▽
Serbia	422 (5.1)	▽
Uruguay	421 (4.3)	▽
Benchmarking Entities		
North Rhine-Westphalia (Germany)	461 (4.1)	▽
Country not meeting participation requirements		
United States	461 (7.1)	▽

▲ Average significantly higher than the ICILS 2023 average.
▽ Average significantly lower than the ICILS 2023 average.

Figure 3.12 National Scale Scores in Computational Thinking

（Source： IEA International Computer and Information Literacy Study 2023: Assessment framework, by J. Fraillon and M. Rožman (Eds.), 2025, Springer Nature (https://doi.org/10.1007/978-3-031-61194-0). Copyright 2025 by IEA.）

Particularly noteworthy is the substantial variation within individual countries and benchmarking entities. The range shown between the lowest-performing 10% and highest-performing 10% of students indicates that even in high-performing systems such as Korea, computational thinking achievement remains highly polarized. This finding corroborates the ICILS 2023 International Report, which concludes that the performance gap between the lowest and highest deciles of students within the same country generally exceeds 200 score points. Similar patterns of internal disparity are evident across several European education systems, with Slovenia and Croatia, for example, displaying particularly wide distributions in students' CT performance.

When considered alongside the Computer and Information Literacy (CIL) results from ICILS 2023, the international digital literacy gap becomes even more pronounced. Korea ranked first in CIL with a score of 540, followed by Czechia at 525 and Denmark at 518, whereas Azerbaijan scored only 319. These results highlight substantial disparities in students' digital literacy across countries and education systems.

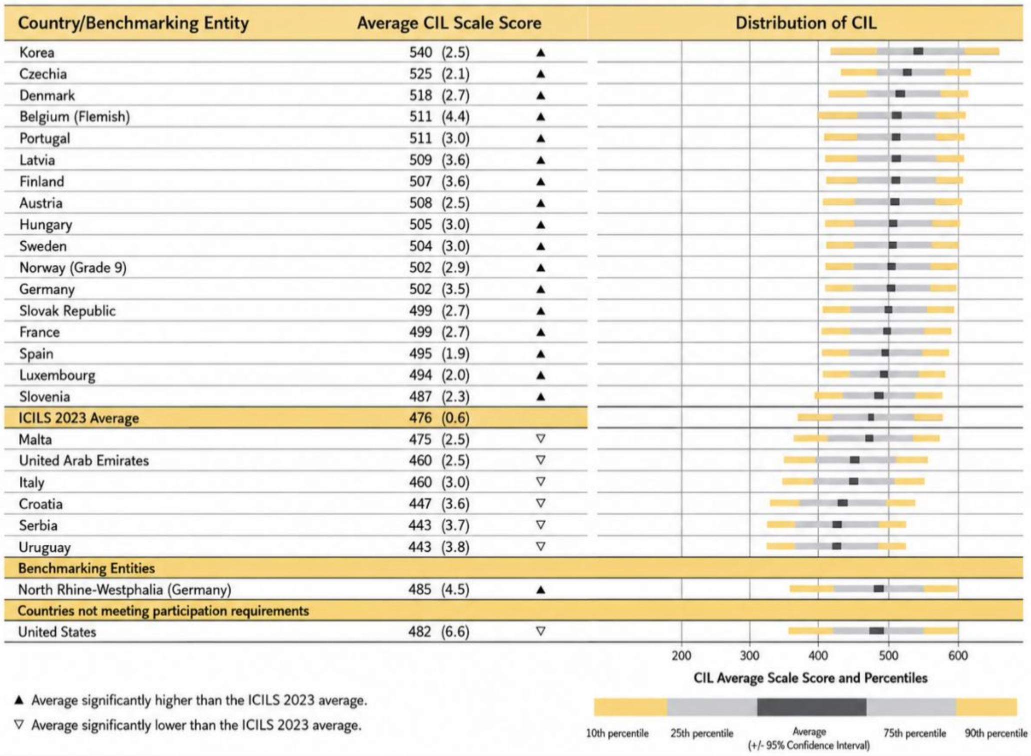


Figure 3.13 National Scale Scores in Computer and Information Literacy

（Source： IEA International Computer and Information Literacy Study 2023: Assessment framework, by J. Fraillon and M. Rožman (Eds.), 2025, Springer Nature (https://doi.org/10.1007/978-3-031-61194-0). Copyright 2025 by IEA.）

In terms of trends, CIL performance declined in most participating countries between 2018 and 2023, with only a small number of countries, such as Sweden, remaining stable or showing slight improvement. For Computational Thinking (CT), among the seven countries participating in trend comparisons between 2018 and 2023, only one showed a statistically significant improvement, five remained stable, and one declined.

These trends serve as an important warning for education systems worldwide: despite the rapid diffusion of digital technologies, students' computational thinking and digital literacy have not improved at the same pace. Systematic curriculum reform and sustained teacher professional development are therefore urgently needed.

04

PART FOUR

Development Pathways

International Policies and Approaches for Enhancing Teachers' Digital Literacy

Part IV

In recent years, international organizations and national policies have shown a marked shift in their understanding of teachers' digital literacy. Earlier policies placed greater emphasis on teachers' mastery of ICT tools and their ability to use digital resources. Current policies, by contrast, increasingly emphasize whether teachers can translate digital technologies into high-quality teaching, personalized learning support, improved assessment, and the promotion of educational equity.

UNESCO's ICT Competency Framework for Teachers explicitly situates teacher competencies within dimensions such as policy, curriculum and assessment, pedagogy, the application of digital skills, school organization, and teacher professional learning. This indicates that teachers' digital literacy is, in essence, part of the capacity of the education system, rather than an isolated skill possessed by individual teachers. The European Union's DigCompEdu reflects a similar shift. The framework divides educators' digital competence into six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. It emphasizes that teachers should not only be able to use digital resources, but should also be able to use technologies to support instructional interaction, formative assessment, personalized support, and learners' autonomous development. UNESCO's 2024 AI competency framework for teachers further extends teacher competencies into the age of AI. It proposes competence dimensions such as a human-centred approach, AI ethics, AI foundations and applications, AI pedagogy, and AI-supported professional learning. OECD's 2025 study on teachers' readiness for digital education further points out, from the perspective of policy practice, that continuous professional learning can help address gaps in initial teacher education. Relevant evidence shows that, in some countries, many in-service teachers did not receive sufficient preparation in the pedagogical use of ICT during their initial teacher education. This suggests that efforts to enhance teachers' digital literacy must be advanced into pre-service teacher preparation, while also being continuously updated through in-service training.

1. Embedding Digital Literacy in Pre-service Teacher Education and Teacher Qualification Processes

Pre-service teacher education is the starting point for developing teachers' digital literacy. If student teachers enter classrooms without having developed basic capacities in digital instructional design, resource evaluation, data ethics and technology integration, subsequent in-service training will have to play a long-term remedial role in addressing these gaps. OECD's 2025 study points out that many teachers did not receive sufficient preparation in the pedagogical use of ICT during initial teacher education, and that subsequent professional learning often has to compensate for this shortfall. This suggests that embedding digital literacy requirements into teacher education curricula, teaching practicums, teacher qualification certification and induction standards for new teachers is critical for improving the overall digital readiness of the teaching workforce. International experience shows that such embedding in pre-service education usually takes three forms.

First, digital literacy is incorporated into teacher professional standards and teacher qualification frameworks. For example, the Australian Professional Standards for Teachers describe what teachers should know and be able to do across four career stages, and integrate ICT use into the selection of teaching content and the design of learning. The standards for "Graduate Teachers" also serve as an important basis for the accreditation of initial teacher education programmes. Second, digital teaching competence is embedded in student teachers' coursework and teaching practicums. For example, Ireland's Digital Strategy for Schools to 2027 emphasizes support for teachers and school leaders through effective initial teacher education and continuing teacher professional learning. Third, digital literacy is linked with national curriculum reform and the development of students' digital competence. For example, Estonia identifies digital competence as a key competence in the national curriculum and provides schools and teachers with a shared reference through digital competence models for both teachers and students.

Embedding digital literacy in pre-service teacher education should not be reduced to simply adding a course on "educational technology tools". Rather, digital literacy should run throughout the entire process of teacher preparation. Student teachers should repeatedly experience the application and reflection of digital technologies in courses on subject pedagogy, curriculum design, classroom management, educational assessment, teaching practicum and educational ethics. In particular, as AI rapidly enters educational settings, student teachers should also learn how to evaluate AI outputs, design AI-supported learning activities, prevent risks related to data privacy and algorithmic bias, and safeguard student agency and academic integrity.

Table 4.1 National Policies and Pathways for Digital Literacy

Country / Region or Framework	Approach to Embedding in Pre-service Teacher Education	Transferable Practices

OECD, Digital Education Outlook 2025	Emphasizes that continuous professional learning can help address insufficient preparation in the pedagogical use of ICT during initial teacher education.	Move digital teaching competence upstream into student teacher preparation and teacher qualification processes.
Australia, AITSL Teacher Professional Standards	Describes teachers' professional competence across four career stages: Graduate, Proficient, Highly Accomplished and Lead; also supports the accreditation of initial teacher education.	Integrate the use of digital technologies into teacher professional standards and career progression pathways.
Ireland, Digital Strategy for Schools to 2027	Emphasizes support for teachers and school leaders through initial teacher education and continuing professional learning.	Establish a coherent teacher digital competence development system linking pre-service preparation, induction and in-service development.
Estonia, Digital Competence Models	Incorporates digital competence as a key competence in the national curriculum and provides a shared reference through digital competence frameworks for teachers and students.	Connect teachers' digital literacy with the development of students' digital competence and subject curriculum reform.
China, Education Sector Standard Teachers' Digital Literacy	Proposes dimensions such as digital awareness, digital technology knowledge and skills, digital application, digital social responsibility and professional development.	Use the standard as a foundational reference for student teacher preparation, teacher training and school-based diagnosis of teachers' competencies.

2. Establishing a Tiered and Progressive System of In-service Training and Continuous Professional Learning

Teachers' digital literacy is inherently dynamic. As technologies such as AI, learning analytics, digital textbooks, virtual simulation and intelligent assessment continue to develop, teachers' competencies cannot be fully developed through one-off training. Rather, they need to be continuously updated through ongoing professional learning.

Both UNESCO's ICT-CFT and DigCompEdu embody a level-based and progressive development logic. Teachers move gradually from understanding technologies, selecting resources and completing basic applications, towards pedagogical innovation, learner empowerment, organizational collaboration and professional leadership. The key to in-service training does not lie in the number of training sessions delivered, but in whether a sustainable pathway for competency progression can be established. More mature approaches usually include tiered courses tailored to teachers at different levels of competence; short-cycle workshops organized around specific teaching contexts; micro-credentials linked to teacher career development; school-based professional learning focused on school-level problems; online courses and open resource platforms; and peer support and practical guidance provided by expert teachers, teaching researchers or educational technology specialists. The European Union's Digital Education Action Plan 2021–2027 sets out a shared vision for high-quality, inclusive and accessible digital education, and supports European education systems in adapting to the digital age through a series of actions. The United States' 2024 National Educational Technology Plan emphasizes the need to address three digital divides: digital access, digital design and digital use. It also proposes providing professional learning for teachers and administrators so that they can develop digital literacy and model it for students. Singapore's EdTech Masterplan 2030 likewise clearly proposes providing professional development opportunities for teachers in order to enhance their capacity to use educational technology effectively for teaching and learning.

Taken together, these policies indicate that in-service training should not merely address the question of whether teachers can use a platform. Rather, it should help teachers develop the capacity to translate technology use into instructional improvement. The effectiveness of training should not be measured only by the number of participants, training hours or certificates issued. Greater attention should also be paid to whether teachers' classroom practices have changed, whether students' learning experiences have improved, whether teaching and assessment have become more effective, and whether schools have established mechanisms for continuous improvement.

Table 4.2 Types of International Digital Literacy Training

Training Type	Main Objectives	Target Participants	Key Quality Assurance Considerations
Foundational awareness training	Help teachers understand digital tools, data security, AI fundamentals and ethical risks	Teachers with weak digital foundations or newly recruited teachers	Use low-threshold cases and avoid excessive technical terminology
Scenario-based workshops	Focus on tasks such as lesson preparation, classroom interaction, assessment and feedback, and resource development	Teachers with basic tool experience but limited capacity to translate technology into teaching practice	Start from authentic classroom problems and generate reusable teaching solutions
Micro-credential	Provide short-cycle, recordable	Teachers who need	Certification should be

courses	and accumulative certification around specific competency units	evidence of professional development and continuous progression	based on artefacts, classroom evidence and reflection, rather than learning hours alone
School-based professional learning	Address school development issues, subject-based teaching research and instructional improvement	Subject groups, grade-level teams and school-based teacher teams	Align with school curriculum reform, teaching research systems and leadership support
Professional leadership and peer mentoring	Develop expert teachers, digital teaching mentors and regional expert networks	Expert teachers, teaching researchers and school leaders	Establish "training of trainers" and inter-school diffusion mechanisms

3. Providing School-based Support Centred on Teaching Application Scenarios

A substantial body of policy and practice experience indicates that effective enhancement of teachers' digital literacy is usually not achieved through abstract training, but through support organized around specific teaching scenarios. What teachers are most concerned about is not the framework itself, but how digital technologies can help them prepare lessons, organize classroom interaction, understand students' learning status, provide differentiated feedback, develop resources, improve homework assessment and reduce the burden of repetitive work.

This is highly consistent with the competence structure of DigCompEdu. By situating teachers' digital competence within six areas—professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learners' digital competence—DigCompEdu, in effect, indicates that teachers' digital literacy must be manifested throughout the entire teaching process. In other words, teachers' digital literacy is not a "tool-based competence detached from the classroom", but a professional competence that runs through instructional design, teaching implementation, assessment and feedback, and learner support.

Within the Pearson International Schools system, the Teacher Education and Leadership Academy (TELA) offers the On the Go series of teacher professional development programmes. Each unit in the programme includes video materials, guided texts, interactive activities, ready-to-use teaching tools, templates and strategies, and uses automatically scored quizzes to check understanding. At the same time, the "Try It Out" practice activities encourage teachers to apply what they have learned directly in the classroom and to reflect on the effects of their practice. Upon completion of the required tasks, teachers can receive digital badges, micro-credentials and Pearson certificates (Pearson, 2026).

School-based support centred on teaching application scenarios should include at least four types of scenarios. First, lesson preparation and resource development scenarios, which help teachers select, adapt and generate digital resources, and judge whether these resources are aligned with curriculum objectives and students' characteristics. Second, classroom teaching and interaction scenarios, which support teachers in using digital tools to promote participation, collaboration, inquiry and immediate feedback. Third, assessment and feedback scenarios, which help teachers conduct formative assessment, collect evidence of learning and provide personalized feedback. Fourth, student support and equity scenarios, which help teachers identify learning difficulties, provide differentiated support, and attend to data privacy, algorithmic bias and the digital divide.

Table 4.3 Digital Literacy Training Centred on Teaching Application Scenarios

Application Scenario	Key Teacher Competencies	Support Measures That Can Be Provided
Lesson preparation and resource development	Selecting, evaluating, adapting and generating digital resources; judging the alignment between resources and curriculum objectives	Resource repositories, AI lesson preparation assistants, exemplary lesson cases, resource evaluation rubrics
Classroom teaching and interaction	Organizing digital classroom activities and promoting participation, inquiry, collaboration and feedback	Classroom interaction platforms, digital instructional design templates, peer classroom observation and lesson refinement
Assessment and feedback	Collecting evidence of learning, conducting formative assessment and providing personalized feedback	Learning analytics tools, assessment rubrics, homework feedback assistants, cases of process-oriented assessment
Student support and equity	Identifying differentiated learning needs and ensuring privacy, safety and accessibility	Student profiles, adaptive learning resources, accessibility support, data ethics guidelines
Teacher professional reflection	Improving teaching based on data and classroom evidence, and engaging in collaborative teaching research	Teacher professional growth portfolios, school-based professional learning platforms, instructional improvement reports

4. Coordinated Support from Policies, Platforms and Resources for Enhancing Teachers' Digital Literacy

Teachers' digital literacy is not merely an individual teacher issue; it is also a matter of institutional support. UNESCO's ICT-CFT explicitly understands teacher competencies within systems of policy, curriculum, pedagogy, school organization and professional learning. This indicates that teacher capacity development needs to be aligned with national digital education strategies, school organizational change, resource platform development and professional development systems. Many countries have explored such systemic coordination from different perspectives. Ireland's Digital Strategy for Schools to 2027 links schools' digital development with teacher professional learning, school leadership, infrastructure and digital resources. Singapore's EdTech Masterplan 2030 emphasizes a student-centred and pedagogy-first approach, while providing professional development opportunities for teachers to use educational technology effectively. The United States' 2024 National Educational Technology Plan conceptualizes the challenges of digital education in terms of three divides—access, design and use—and emphasizes the need not only to address issues of devices and connectivity, but also to support teachers in designing high-quality digital learning experiences. Estonia connects students' digital competence, teacher support and school practice through digital competence models and the national curriculum. China, in turn, promotes the alignment of teachers' digital literacy with the national strategy for education digitalization through the education sector standard Teachers' Digital Literacy, the development of the National Smart Education Platform, and guidance documents on AI education in primary and secondary schools. Taken together, these cases show that enhancing teachers' digital literacy requires a coordinated chain linking policy goals, competency frameworks, platform tools, resource provision, training systems and assessment feedback. If there are only policy initiatives without tools and resources, teachers will find it difficult to put them into practice. If there are only platform products without pedagogical support, technology is likely to remain at the level of superficial application. If there is only training without competence diagnosis and evidence for improvement, professional development will also be difficult to sustain.

Pearson's AI Literacy Modules and its collaboration on AI learning tools offer useful insights. The AI Literacy Modules can be embedded into course platforms such as MyLab, Mastering and Revel, helping students develop basic norms for the responsible use of AI while reducing the burden on teachers to develop AI literacy materials independently.

Pearson's collaboration with Google Cloud further illustrates the integrated role of platforms, data and AI tools in supporting teaching. Its aim is to provide students with personalized learning tools and to help teachers track learning performance and adjust instructional arrangements. This suggests that enhancing teachers' digital literacy requires the systemic coordination of course platforms, learning resources, AI tools and data feedback mechanisms, rather than relying on isolated training activities (Pearson, 2025).

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Table 4.4 Strategies for Teachers' Digital Literacy in Different Countries

Country / Region	Policy or Framework Source	Implications for Enhancing Teachers' Digital Literacy
UNESCO	ICT Competency Framework for Teachers; AI Competency Framework for Teachers	Teachers' digital literacy should be advanced holistically within systems of policy, curriculum, pedagogy, school organization, ethics and professional learning.
European Union	Digital Education Action Plan 2021–2027; DigCompEdu	A shared framework can support the development of teachers' digital competence and the design of training tools at national, regional and school levels.
OECD	Preparing Teachers for Digital Education; Teacher Policies to Support the Use of Digital Resources in the Classroom	Attention should be given to gaps in initial teacher education, continuous professional learning, and policy support for integrating technology with pedagogy.
Ireland	Digital Strategy for Schools to 2027	Initial teacher education, continuing professional learning, school leadership and digital infrastructure should be advanced in a coordinated manner.
Singapore	EdTech Masterplan 2030	A pedagogy-first and student-centred approach should be maintained, while teachers' professional development should strengthen their capacity to integrate EdTech into teaching and learning.
Australia	Australian Professional Standards for Teachers	Career-stage standards can support teacher preparation, certification and continuous professional growth.

Estonia	National curriculum and digital competence models for teachers and students	Shared reference models can help schools and teachers clarify goals for digital competence development.
China	Education sector standard Teachers' Digital Literacy; guidance related to AI education in primary and secondary schools	Teachers' digital literacy development can be linked with the National Smart Education Platform and the advancement of AI education.
United States	2024 National Educational Technology Plan	The three divides of access, design and use should be addressed, with emphasis on teachers' professional learning and their capacity for digital learning design.

Drawing on international organization frameworks and policy practices across countries, the enhancement of teachers' digital literacy can be summarized as a four-layer mechanism. The first is an upstream embedding mechanism, through which digital literacy requirements are incorporated into pre-service teacher education and teacher qualification processes. The second is a progressive development mechanism, through which continuous professional learning, tiered training and micro-credentials support the updating of teachers' competencies. The third is a practice translation mechanism, through which digital technologies are transformed into instructional design, assessment and feedback, and student support around authentic teaching scenarios. The fourth is an enabling mechanism, through which policy, platforms, resources, data and school organization are coordinated to provide institutional support for teacher capacity development.

05

PART FIVE

Practical Implications

Building Teacher Digital Competence Systems for Future Education

Part V

Teachers' digital competence development requires coordinated action at two interconnected levels. On the one hand, governments, schools, and educational institutions need to establish localised, internationally comparable, and sustainable mechanisms for developing teachers' digital competence. On the other hand, enterprises and technology providers need to redefine their roles, shifting from product suppliers to providers of standards translation, competency services, data support, and ecosystem collaboration.

1. Establishing Localised yet Internationally Comparable Teacher Digital Competence Frameworks

Drawing upon existing international research and competency frameworks, countries should develop localised teacher digital competence frameworks that balance international comparability with national relevance. International frameworks provide a common language and competency structure, facilitating cross-national dialogue, knowledge exchange, and regional collaboration. Local frameworks, however, should reflect national curriculum goals, teacher professional standards, school governance cultures, digital infrastructure, and broader societal values.

At a minimum, national frameworks should encompass six competency domains:

- Digital awareness and educational value judgement;
- Digital resources and technology applications;
- Digital instructional design;
- Learning assessment and educational data use;
- Student support, equity, and inclusion;
- Ethical responsibility and continuous professional development.

Given the rapid advancement of AI, future frameworks should further incorporate competencies related to AI foundations, AI pedagogy, AI ethics, academic integrity, and human–AI collaborative teaching.

Within this process, enterprises should move beyond the role of technology vendors and become translators of international standards. Specifically, they can assist governments and schools in transforming international competency frameworks into practical instruments, including school diagnostic indicators, teacher self-assessment tools, classroom observation rubrics, professional learning maps, and competency development reports. However, enterprise participation in standards translation should remain subject to the principles of public educational values, data security, and transparent governance, ensuring that competency frameworks are not reduced to product marketing instruments.

2. Building a Closed-Loop Mechanism Integrating Frameworks, Assessment, Professional Learning, and Certification

Many education systems have already established teacher digital competence frameworks. However, unless these frameworks are systematically connected with assessment, professional learning, and certification, they are unlikely to translate into genuine improvements in teachers' competencies.

Teacher professional development should therefore avoid situations in which there is a framework without assessment or training without meaningful evaluation. Instead, education systems should progressively establish a closed-loop model integrating competency frameworks, assessment, professional learning, and certification.

This cycle begins with clearly defined competency standards. Teachers' competency profiles should then be developed through multiple evidence sources, including self-assessment, school-level diagnostic evaluation, classroom observation, professional portfolios, and learning analytics. Based on these profiles, differentiated, context-specific, and continuous professional learning programmes can be designed. Finally, learning achievements should be recognised through micro-credentials, school-based certification, professional development records, or teacher professional portfolios, thereby linking competency development with long-term career progression.

Within this closed-loop system, enterprises can serve as competency service providers by offering digital assessment platforms, personalised learning pathway recommendations, professional learning resource repositories, micro-credentialing systems, and continuous progress monitoring services. Nevertheless, assessment results should primarily support teacher professional growth and school improvement, rather than being used for simplistic ranking or accountability purposes. In particular, within international collaborative initiatives, assessment instruments should balance cross-national comparability, cultural appropriateness, and data protection requirements.

Table 5.1 A Closed-Loop Mechanism for Enhancing Teachers' Digital Competence

Closed-Loop Stage	Core Tasks	Responsibilities of Governments / Schools	Potential Roles of Enterprises
Framework	Define the competency structure and developmental levels of teachers' digital competence	Develop public standards and ensure educational values, equity, and fairness	Translate international frameworks into localised indicators and practical tools
Assessment	Develop teacher competency profiles and diagnose school development needs	Define the scope and purpose of assessment while safeguarding teachers' rights and data security	Provide self-assessment, diagnostic tools, classroom evidence collection, and visualised reporting systems
Professional Learning	Deliver differentiated, context-based, and continuous professional development	Organise school-based professional learning and ensure sufficient time and institutional support	Provide learning resources, case libraries, mentoring services, and practice-based learning platforms
Certification	Recognise teachers' competency development and support professional advancement	Establish credible certification mechanisms aligned with teacher professional development systems	Provide micro-credentials, digital learning portfolios, and competency tracking systems
Continuous Improvement	Continuously improve policies and practices based on data and evidence	Use assessment results to support school improvement rather than simple ranking	Provide trend analysis, evaluation of training effectiveness, and evidence-based recommendations for improvement

3. Shifting from Tool Training to Developing Pedagogical Transformation Competence

The ultimate goal of enhancing teachers' digital competence is not simply enabling teachers to operate digital platforms, but empowering them to transform digital technologies into higher-quality instructional design, learning assessment, and student support. Many professional development programmes fail to achieve lasting impact because they focus primarily on introducing technological functions rather than addressing authentic pedagogical challenges within subject teaching, classroom practice, and assessment.

Governments should therefore promote a transition from tool-oriented training to pedagogical transformation competence. Professional learning should be organised around teachers' authentic instructional workflows, including how to:

- Use digital tools to analyse curriculum standards and learning objectives;
- Design AI-supported inquiry-based learning activities;
- Employ learning analytics to conduct formative assessment;
- Utilise digital resources to support learners with diverse needs;
- Evaluate the reliability of generative AI outputs; and
- Guide students in using AI responsibly, critically, and creatively.

Within this process, enterprises can serve as data support providers, helping schools develop teacher digital competence profiles, professional learning profiles, and evidence-based improvement strategies. For example, platform data can assist schools in identifying teachers' professional learning needs in areas such as resource development, classroom interaction, assessment and feedback, and student support. Digital learning portfolios can document teachers' participation in professional learning and classroom implementation, while data dashboards can visualise trends in school-based professional development.

Such data, however, should be collected and used exclusively to support teachers' professional growth and should adhere to the principles of data minimisation, informed consent, transparency, and secure data governance.

4. Embedding Teacher Digital Competence Development within Whole-School Transformation

Teacher digital competence cannot be developed independently of the broader school system. Even when individual teachers participate in professional development, sustained classroom implementation is unlikely without adequate resources, dedicated time, collaborative professional learning structures, leadership support, and appropriate evaluation mechanisms.

Consequently, teacher digital competence development should be embedded within whole-school transformation, aligning it with curriculum reform, school-based professional learning, digital resource development, learning space redesign, assessment reform, and leadership development.

Key priorities at the school level include:

- Establishing a shared vision for digital teaching and learning;
- Developing school-based digital competence development plans;
- Organising interdisciplinary teacher learning communities;
- Building shared repositories of digital resources and instructional cases;
- Integrating digital teaching practices into regular professional learning activities;
- Providing teachers with sufficient time and workload recognition for formative assessment, digital resource development, and AI-enabled teaching innovation; and
- Establishing improvement-oriented evaluation systems.

At this level, enterprises should function as ecosystem collaborators rather than merely technology vendors. Instead of offering isolated products, they should integrate digital platforms, professional learning, assessment services, data analytics, and educational resources to help schools establish continuous improvement ecosystems.

For example, digital platforms should seamlessly connect teacher competency diagnostics, curriculum resource recommendations, classroom implementation records, student learning feedback, and professional development portfolios. Professional learning services should be aligned with school curriculum reform and collaborative professional learning plans, while assessment tools should help schools identify challenges and improve instructional practice without creating unnecessary administrative burdens.

5. Strengthening Digital Leadership to Sustain Teachers' Digital Competence Development

In the context of comprehensive digital transformation in education, digital leadership has become a critical driver of school improvement and teacher professional development. Current efforts to develop teachers' digital competence continue to face challenges, including fragmented training, short-term interventions, and insufficient systemic leadership. Strengthening digital leadership at both the school and system levels is therefore essential to position teachers' competency development within broader organisational transformation and digital education governance.

First, digital leadership requires the ability to establish a shared strategic vision. School leaders should integrate teacher digital competence development with curriculum reform, pedagogical innovation, assessment improvement, and students' competency development, rather than viewing it simply as technology training or platform adoption.

Second, digital leadership involves resource allocation and institutional support. Schools should provide teachers with adequate digital infrastructure, platforms, educational resources, dedicated professional learning time, and technical support. Continuous teacher development should be promoted through school-based professional learning, collaborative learning communities, co-creation of teaching cases, and reflective practice within authentic instructional contexts.

Third, digital leadership requires data-informed improvement. Schools should integrate teacher digital competence assessment results, classroom implementation evidence, student learning data, and professional learning feedback to develop comprehensive teacher competency profiles and professional development portfolios. These evidence bases can then support differentiated, personalised, and continuous professional learning.

Finally, digital leadership also encompasses value-based governance. As digital technologies become increasingly embedded in education, school leaders must ensure that issues such as data security, AI ethics, student privacy, educational equity, and digital well-being remain central considerations. In this way, the development of teachers' digital competence can consistently serve the broader goals of student learning, educational quality, and the public value of education.

06

PART SIX

Conclusion

Part VI

1. New Demands for Teachers' and Students' Digital Competence Brought About by Artificial Intelligence

(1) The impact of AI on teachers' work is mainly reflected in the reconstruction of teachers' roles and professional boundaries.

Generative artificial intelligence has already entered multiple aspects of teachers' work, including lesson preparation, resource generation, assignment grading, learning feedback, and assessment design. Its impact does not lie in simply replacing teachers, but in redistributing teachers' professional tasks, thereby concentrating the professional value of teachers more strongly on the setting of learning objectives, the design of learning activities, judgments about student development, process-oriented assessment, ethical oversight, and value guidance. Accordingly, the core of teachers' digital literacy is no longer merely the mastery of tool operation, but the ability to appropriately select, design, evaluate, and govern educational applications of artificial intelligence in alignment with educational goals.

(2) Students' use of AI is becoming increasingly differentiated, making high-quality use a key focus of digital literacy development.

Students have widely used artificial intelligence for writing, translation, literature reading, information retrieval, coding assistance, and learning-related question answering. However, their modes of use vary significantly. Some students are able to use artificial intelligence as a cognitive scaffold for comparing viewpoints, optimizing language, supplementing information, and supporting reflective revision. Others directly rely on artificial intelligence to generate answers, first drafts, or complete assignments. This indicates that the development of students' digital literacy should not remain at the level of "whether they can use tools," but should place greater emphasis on whether learners possess problem awareness, information judgment, critical thinking, original expression, and a sense of responsibility in using artificial intelligence.

2. Reconstructing the Meaning of Teachers' Digital Literacy in the Intelligent Era

(3) The meaning of teachers' digital literacy has expanded from instrumental skills to

comprehensive professional competence in the intelligent era.

Digital literacy is not a single form of computer operational competence. Rather, it is a comprehensive concept gradually formed through the integration of related concepts such as media literacy, computer literacy, information literacy, and network literacy. Its meaning has evolved from tool operation, information understanding, and information judgment to participation in digital society, ethical responsibility, and lifelong development. After entering the field of education, teachers' digital literacy has become further embedded in instructional design, classroom implementation, assessment and feedback, student support, and teachers' professional development. Particularly in the context of the rapid integration of artificial intelligence into education, teachers' digital literacy has further extended to include human-AI collaboration, algorithmic understanding, data security, academic integrity, and ethical reflection on technology.

3. Structured Representations of Teachers' Digital Literacy in International Frameworks

(4) The function of teachers' digital literacy frameworks is to translate complex competencies into structured references that are understandable, cultivable, and comparable.

Mainstream international frameworks no longer understand teachers' digital literacy as a list of technical skills. Instead, through dimensions, competency descriptors, and developmental levels, they translate teachers' digital literacy into structured references that can be used for policymaking, teacher education, competence diagnosis, and professional development. For example, UNESCO's development from the ICT Competency Framework for Teachers to the AI Competency Framework for Teachers reflects an expansion from technology integration toward the reconstruction of teacher competence in the intelligent era. China's Teachers' Digital Literacy standard establishes a national competency framework around digital awareness, digital technology knowledge and skills, digital application, digital social responsibility, and professional development.

(5) Frameworks developed by different countries and organizations follow diverse pathways, yet they jointly point to the reconstruction of teacher professional competence centred on learner development.

Teachers' digital literacy frameworks developed by international organizations and representative countries differ in their construction logic, institutional foundations, and practical emphases. UNESCO highlights education system transformation and the reconstruction of teacher competence in the age of artificial intelligence; UNICEF emphasizes contextual adaptation in low-resource settings; Austria focuses on the full professional lifecycle of teachers; Norway foregrounds the holistic structure of teacher professional competence; the United Kingdom emphasizes multi-stakeholder co-construction and practical support; and China highlights national standardization, digital social responsibility, and the strategic orientation of education digitalization. Despite these different pathways, these frameworks collectively show that the goal of teachers' digital literacy is not for teachers to master more tools, but to promote learner development, improve teaching quality, support educational equity, and advance the continuous transformation of education systems through teachers' digital professional action.

4. Shifts in the Evidence System for Assessing Teachers' Digital Literacy

(6) Direct assessment tools are mainly used to identify teachers' levels of digital literacy and professional development needs.

Assessment tools that directly target teachers or educators mainly focus on teachers' competence levels in areas such as the use of digital resources, instructional design, learning assessment, student support, professional development, and artificial intelligence applications. The value of such tools lies not only in judging the stage of competence at which teachers are located, but also in helping teachers identify their strengths, weaknesses, and subsequent directions for development. Accordingly, the assessment of teachers' digital literacy should not merely classify teachers into levels; rather, it should function as a diagnostic tool that supports teachers' professional development.

(7) Indirect assessment indicators can supplement the understanding of teachers' digital literacy development from the perspectives of schools, students, and systems.

Teachers' digital literacy cannot be accurately judged solely through teacher self-assessment. Indirect evidence such as student questionnaires, principal questionnaires, indicators of the school digital environment, national statistical data, and students' AI use behaviors can supplement understanding of teachers' digital literacy development from the perspectives of classroom experience, school support conditions, system-level resource allocation, and learning behaviour. Thus, the assessment of teachers' digital literacy needs to move from single-source self-reporting toward the mutual validation of multi-source evidence, thereby forming a more explanatory assessment system.

5. Development Pathways for Enhancing Teachers' Digital Literacy

(8) The cultivation of teachers' digital literacy needs to be moved forward into pre-service teacher education and the process of teacher qualification formation.

Many teachers did not receive sufficient preparation in the pedagogical application of digital technologies during initial teacher education. As a result, they are inadequately prepared when they enter the profession and face artificial intelligence and digital teaching transformation. The cultivation of teachers' digital literacy should not depend for a long time on compensatory training during in-service stages. Instead, it should be moved forward into teacher education programmes, teaching practicums, teacher certification, and induction support for new teachers, so that digital literacy becomes a foundational component in the formation of teachers' professional competence.

(9) In-service teacher professional development needs to shift from short-term tool training toward stratified, scenario-oriented, and sustained support.

Teacher training in the age of artificial intelligence should not remain at the level of "teaching teachers how to use a particular tool." Instead, it should be organized around authentic teaching scenarios and support teachers in understanding AI-generated outputs, designing learning tasks, conducting process-oriented assessment, governing academic integrity, protecting data privacy, and guiding students to improve their digital literacy. Because teachers' needs vary across disciplines, years of teaching experience, digital foundations, and school environments, training systems should place greater emphasis on stratification and differentiation, continuous iteration, and integration with school-based teaching research, classroom improvement, and school governance.

6. Building a Future-Oriented Training System for Teachers' Digital Literacy

(10) Future development of teachers' digital literacy needs to form a closed-loop system of framework–assessment–development–certification–improvement.

Future-oriented training for teachers' digital literacy should not consist of fragmented courses or one-off training sessions. Rather, it should establish a localized yet internationally comparable competency framework and, on this basis, form a complete system integrating competence assessment, stratified development, practice-based tasks, certification mechanisms, and continuous improvement. For educational institutions and education enterprises, products and services also need to move beyond single content provision or tool delivery toward comprehensive solutions that cover competence diagnosis, learning pathways, practical support, process feedback, and certification-oriented development.

List of Abbreviations

Abbreviation	Full Name in English
AI	Artificial Intelligence
GenAI	Generative Artificial Intelligence
ICT	Information and Communication Technology
EdTech	Educational Technology
STEM	Science, Technology, Engineering and Mathematics
K–12	Kindergarten to Grade 12
LLM	Large Language Model
LMS	Learning Management System
OER	Open Educational Resources
MOOC	Massive Open Online Course
API	Application Programming Interface
GDPR	General Data Protection Regulation
SDG	Sustainable Development Goal
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO IITE	UNESCO Institute for Information Technologies in Education
UNESCO MGIEP	UNESCO Mahatma Gandhi Institute of Education for Peace and Sustainable Development
UIS	UNESCO Institute for Statistics
OECD	Organisation for Economic Co-operation and Development
IEA	International Association for the Evaluation of Educational Achievement
ISTE	International Society for Technology in Education
ASCD	Association for Supervision and Curriculum Development
ISTE+ASCD	International Society for Technology in Education and Association for Supervision and Curriculum Development

SEAMEO	Southeast Asian Ministers of Education Organization
SEAMEO RECSAM	SEAMEO Regional Centre for Education in Science and Mathematics
GSENet	Global Smart Education Network
BNU	Beijing Normal University
SLI	Smart Learning Institute
JRC	Joint Research Centre
EC	European Commission
ETF	Education and Training Foundation
JISC	Joint Information Systems Committee
ALA	American Library Association
ACRL	Association of College and Research Libraries
IFLA	International Federation of Library Associations and Institutions
WEF	World Economic Forum
MGI	McKinsey Global Institute
HolonIQ	HolonIQ
Pearson	Pearson plc
TALIS	Teaching and Learning International Survey
PISA	Programme for International Student Assessment
ICILS	International Computer and Information Literacy Study
ILSA	International Large-Scale Assessment
DigComp	Digital Competence Framework for Citizens
DigCompEdu	European Framework for the Digital Competence of Educators
SELFIE	Self-reflection on Effective Learning by Fostering the use of Innovative Educational Technologies
SELFIE for TEACHERS	Self-reflection on Effective Learning by Fostering the use of Innovative Educational Technologies for Teachers
UNESCO AI CFT	UNESCO AI Competency Framework for Teachers

UNESCO AI CFS	UNESCO AI Competency Framework for Students
TET-SAT	Technology Enhanced Teaching Self-Assessment Tool
TPACK	Technological Pedagogical Content Knowledge
CIL	Computer and Information Literacy
CT	Computational Thinking
TK	Technological Knowledge
PK	Pedagogical Knowledge
CK	Content Knowledge
TPK	Technological Pedagogical Knowledge
TCK	Technological Content Knowledge
PCK	Pedagogical Content Knowledge
CPD	Continuing Professional Development
VET	Vocational Education and Training
DIKW	Data–Information–Knowledge–Wisdom
NRI	Network Readiness Index
CSEDU	International Conference on Computer Supported Education
ITU	International Telecommunication Union
ISCED	International Standard Classification of Education
TKS	Teacher Knowledge Survey
PIAAC	Programme for the International Assessment of Adult Competencies
EMIS	Education Management Information System
UN	United Nations
EU	European Union
ITS	Information Technology Specialist
CACIE	China Annual Conference for International Education

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