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AI adoption in the education system

International insights and policy considerations for Italy

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Abstract

This paper examines how artificial intelligence (AI) can be deliberately deployed to tackle persistent disparities in primary and secondary schools and to align curricula with changing skill demands. It focuses on three priorities for Italy's school system: preventing dropout and promoting learning, reducing the maths gender gap, supporting students with an immigrant background. Drawing on international evidence, the paper reviews how AI can support these objectives, the risks that may arise, and possible mitigation strategies. It also considers how countries are integrating AI literacy and reforming curricula in response to shifting skill needs. The paper proposes key principles and a policy roadmap to guide AI adoption in schools. Recent initiatives in OECD countries illustrate opportunities and risks associated with AI adoption in schools and potential policy options for Italy.

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1 Introduction

The paper explores how AI could be deployed in a deliberate, problem-focused manner to address long-standing disparities in educational outcomes. With a focus on school-related teaching and learning activities, it examines examples of how AI is being used or could be used to tackle challenges and support schools and school systems. Although the analysis encompasses a range of AI applications, particular attention is given to the emerging use and implications of generative AI (GenAI) tools, defined as "models that create new outputs (e.g. text, code, audio, images, or video) in response to prompts, based on their training data" (OECD, 2023[1]). Furthermore, the paper reviews emerging evidence on the impact of AI use in workplaces, and society more widely, on the demand for skills. It examines whether and how education systems are reconsidering curricular priorities, in relation to AI-related changes in labour markets as well as broader questions about the civic and cultural purposes of schooling that arise because of AI integration in society.

The aim of this paper is to identify emerging learning from the development and use of AI tools and applications internationally and how past reform initiatives in education may inform current efforts to reconsider the role of schooling in the AI era, with a focus on key challenges and opportunities in the context of Italy. The report first outlines the opportunities and risks associated with the use of AI in three key areas: reducing school (explicit and implicit) dropout rates, tackling gender disparities in mathematics achievement, supporting the learning trajectory of students with an immigrant background. It then reviews examples of efforts to integrate AI literacy and reform curricula to reflect changing skills needs in labour markets and societies. A key distinction is between AI as a ***tool for learning***, i.e. how AI tools and applications can be used to enhance teaching and learning processes, and AI as a ***subject of learning***, whereby students develop an understanding of how AI systems function and their ethical and societal implications. Finally, the paper outlines key principles and factors that policymakers should consider in decision-making related to AI in education and provides examples of pathways to the introduction of AI in school systems.

Throughout the paper, special attention is paid to the experience of Italy. Evidence of AI use cases, impact and policy options is presented and discussed in light of key characteristics of Italy's school system, and of Italy's policy initiatives on digital and AI technology and education, with the aim of supporting informed policy debate and learning on this topic in Italy.

The paper draws on a desk-based review of available documents and academic literature. A survey to members of the Trade Union Advisory Committee (TUAC) to the OECD was carried out in March 2025 to garner information on teacher union perceptions, country examples of AI use in schools and evidence of impact of AI tool use on student and teacher outcomes. The evidence summarised reflects the state of knowledge as of October 2025. Research on generative AI is rapidly evolving and small differences in tool design or implementation can significantly change effectiveness and adoption possibilities. This should be taken into account in approaching the evidence and policy considerations presented by this paper.

Technology adoption in schools

Already before ChatGPT was launched in 2022, prompting education systems to consider more urgently the impact of technological change on educational practices and the purpose of schooling, the COVID-19 pandemic had already accelerated ongoing trends in the adoption of digital technologies in classrooms and led to a marked shift in educational practices worldwide (Pozo et al., 2021[2]). Tools such as video conferencing software, learning management systems (LMS), and interactive digital resources became essential for facilitating teaching and learning during lockdowns. The rapid adoption of these technologies not only revealed existing digital divides but also underscored the potential for educational technology, or EdTech, to reshape the educational landscape (Means and Neisler, 2021[3]).

However, as pandemic restrictions eased, concerns about excessive digital exposure among children gained prominence, focusing on possible negative impacts on cognitive, emotional, and social development (Haidt, 2024[4]; OECD, 2025[5]). In addition to the risks inherent to AI, educators and policymakers are now evaluating the impact of openly available tools, such as ChatGPT, in light of concerns about academic integrity, ethical use, assessment practices, and learning (Kosmyna et al., 2025[6]; Rudolph, Tan and Tan, 2023[7]). In fact, the European Union's AI Act lists education and vocational training as one of the "high-risk" areas (European Commission, n.d.[8]).

Digital technology use in schools varies across countries. Discussions in Germany and Sweden reflect a cautious approach towards digital technologies, emphasising traditional learning methods and interpersonal skills (Helmke, 2009[9]; UNESCO, 2023[10]) and some countries including Italy, have introduced partial or full bans on mobile phones in schools, arguing that they distract from learning and limit opportunities for social interactions among students. With respect to AI specifically, in contrast, some education authorities have embraced and promoted AI-use within their jurisdictions. For example, countries such as Estonia and Finland have been proactive in integrating digital technologies into their curricula, promoting individualised learning experiences and preparing students for a digitalised society (Ministry of Education and Research of Estonia, 2019[11]; Finnish Ministry of Education and Culture, 2020[12]).

Beyond such differences, the European Commission's Digital Education Action Plan (2021–2027) underscores the importance of digital competence and the integration of AI and data-driven tools in education systems across EU member states (European Commission, 2023[13]). Recent reviews, including the one completed for this paper (see Section 6), find growing policy attention to the issue of AI in education, even though, across OECD countries, there is a large degree of variation in the adoption of AI tools in educational settings, how they are being used, and the level to which their use is approved or supported within the education system. The OECD Policy Survey on School Education in the Digital Age examined some elements of systemic AI adoption across 37 jurisdictions and revealed that guidelines and regulations related to AI were rarely addressed in detail, and binding regulations regarding their use are even more rare. AI was mentioned in the strategies of 26 of the 32 responding jurisdictions (81 per cent), only 8 strategies (25 per cent) contained specific initiatives and 6 strategies (19 per cent) include timebound goals on the topic (Boeskens and Meyer, 2025[14]).

School leaders and educators are testing generative AI where it promises workload relief, especially in planning and materials production (Fraillon, 2024[15]). At the same time, there are widespread concerns about academic honesty, data security and the reliability of AI-generated content, as well as practical obstacles such as blocked access and uneven infrastructure (Scottish Qualifications Authority, 2024[16]; Staff College, Association of Directors of Education, 2024[17]). Both school staff and parents trail significantly in first-hand experience compared to adolescents, which magnifies their concerns and underscores the importance of clear, accessible guidance from schools (Department for Science, Innovation & Technology; Department for Education, 2024[18]). When AI is positioned as augmenting rather than replacing teachers – and when strong privacy protections are explicit – both parents and students express conditional support.

Individual country experience reflects these trends. In Switzerland, the Monitoring the Digitalisation of Education from the Students' Perspective survey of 10 000 Swiss students aged 8-18 found that, for every phase of schooling, students were more likely to use GenAI at home than in class, and usage rose sharply with age (Oggenfuss and Wolter, 2024[19]). Regular classroom use was reported by 8 per cent of primary school students, 30 per cent of lower-secondary students, 50 per cent of those attending general upper-secondary schools and 42 per cent of learners in vocational programmes. The equivalent figures for home use for schoolwork were 9, 33, 54 and 41 per cent respectively.

In 2024, the OECD Teaching and Learning International Survey (TALIS) asked participating teachers to report whether they used AI in their teaching or to support student learning. In Italy, 25 per cent of lower-secondary school teachers reported having done so in the previous 12 months, compared with an OECD average of 37 per cent (OECD, 2025[20]). In Singapore, the figure was as high as 75 per cent. Among teachers who reported using AI, 68 per cent on average indicated using it to efficiently learn about and summarise a topic and 64 per cent indicated using it to generate lesson plans. In Italy these shares were 70 per cent and 64 per cent respectively. Italian teachers also reported relatively high use AI to review data on student participation or performance (31 per cent, compared with the OECD average of 25 per cent), and 27 per cent used it to assess or grade student work (OECD average 26 per cent). Moreover, 60 per cent of teachers in Italy "agreed" or "strongly agreed" that AI helps them support students with specific needs (OECD average 52 per cent). At the same time, many teachers expressed concerns: 67 per cent of Italian teachers said AI could enable students to present others' work as their own (OECD average 72 per cent), and 32 per cent said AI may amplify biases (OECD average 42 per cent).

TALIS also shows that between 2018 and 2024 participation in professional learning on digital resources and tools rose markedly in most systems, including Italy, where it increased from 68 per cent to 84 per cent. Given how recent the spread of AI has been, this suggests a relatively rapid response to emerging training needs: 38 per cent of teachers across participating OECD systems reported receiving training on AI in 2024. In Italy, 26 per cent of teachers had taken part in professional learning activities on AI, while participation exceeded 60 per cent in Kazakhstan, Korea, Singapore and the United Arab Emirates.

Small-scale surveys of AI use by students and teachers in Italy indicate that AI use is more prevalent among students than teachers, that students appear to use AI primarily at home, for homework, and that teachers' use of AI is for now primarily focused on lesson planning, education material preparation and in support of students with special educational needs. The 2024 ImparaDigitale survey of 50 Italian upper secondary schools (1 175 students; 136 teachers primarily) revealed that 87 per cent of students and 69 per cent of teachers reported using AI tools, mainly for personal purposes such as web search or media creation. A quarter of students reported using AI for learning with their teachers. AI was largely confined to homework support, as reported by 51 per cent of student users (ImparaDigitale, 2024[21]). In 2025 a survey of 3 564 primary and secondary school teachers indicated that 66 per cent were using AI at school (Tortuga, 2025[22]).

Beyond considerations of AI use in specific teaching and learning practices, proponents of AI and digital technologies in education also view them as potential tools for improving system-level productivity. This argument is often framed in relation to Baumol's cost disease. The cost disease highlights how costs in labour-intensive sectors such as education or the performing arts tend to rise without corresponding productivity gains (Archibald and Feldman, 2010[23]; Baumol and Bowen, 1966[24]). To attract and retain qualified staff, wages in these sectors must keep pace with economy-wide wages, even when the sectors' output per worker remains broadly unchanged. In schooling, the basic technology of teaching and learning (and student-to-teacher ratios) has remained largely stable over time. This has led to increasing expenditure on education without equivalent gains in measurable productivity, and in many countries, to declining relative teacher salaries and growing teacher shortages. Advocates argue that AI systems could help mitigate these pressures by improving productivity, for example reducing the amount of time teachers devote to routine administrative tasks, and by enabling larger or more diverse classes to be supported through adaptive tutoring systems and real-time analytics. Such developments could, in principle, contain spending growth while enhancing learning outcomes, raise teachers' real earnings, and alleviate the effects of teacher shortages.

Opportunities and risks associated with the adoption of AI in education

This paper considers AI's (potential) role and impact on education systems via two inter-related channels. AI adoption across school-related administration, teaching and learning activities have direct implications for the organisation and delivery of education. AI adoption in labour markets, and by societies more broadly, by altering labour market demand for skills and bringing a renewed focus on distinctly human capabilities, have implications for the objectives that societies pursue through schooling and, consequently, for curricular priorities (indirect effects).

Direct effects: School-related organisational and operational changes

AI-enabled tools are increasingly being employed to redesign many aspects of school life, raising questions and debate around associated potential benefits and risks. The reconfiguration of roles and tasks could play out in:

- **School administration.** Predictive analytics already support enrolment forecasting, timetable optimisation and resource allocation, while intelligent document-processing agents expedite reporting and compliance. AI-enabled efficiencies could not only reduce but redistribute administrative workload, and may reshape patterns of accountability across the school system, provided that governance frameworks are established and accountability mechanisms for AI-assisted decisions are specified.
- **Teachers' task mix and professional learning.** Automated marking of objective items, timetable generation and progress-report compilation reduce the time spent on routine administration, reallocating teachers' efforts towards coaching, dialogue and the design of learning activities. However, new demands emerge: educators must curate AI outputs, interpret dashboards and liaise with technical staff. Parallel developments in professional-development platforms – for example, systems that analyse classroom video and propose targeted resources – expand opportunities for continuous learning while requiring teachers to exercise informed judgement about automated recommendations (Pratschke, 2024[25]; Molina et al., 2024[26]).
- **Classroom instruction.** Adaptive learning environments increasingly sequence content and feedback on the basis of real-time data, while generative models provide explanations, worked examples and simulations. These tools allow several pedagogical "tracks" to coexist within the same classroom, thereby broadening the scope for personalised learning (Holmes, Bialik and Fadel, 2019[27]; Luckin et al., 2016[28]).
- **Assessment design.** Once information retrieval and routine composition tasks can be performed by AI tools and applications, traditional recall-focused examinations lose validity. In response, many systems are trialling performance tasks, digital portfolios and data-rich continuous assessments that capture the application of knowledge in authentic contexts.
- **Student support and communication with families.** Early-warning dashboards flag disengagement or well-being concerns, and multilingual chatbots offer round-the-clock academic or pastoral guidance, lowering language barriers for families with an immigrant background. Although such tools can improve information flow, they also increase the volume of personal data shared beyond school walls, demanding stringent governance to comply with instruments such as the GDPR.

AI use across these sets of school-related tasks presents potential benefits and risks which are examined by this paper. Table 1 provides a non-exhaustive summary of such potential opportunities and related risks.

Table 1. Key opportunities and risks arising from AI adoption in education settings

AI function	Potential benefit	Risk of adoption
Early-warning and drop-out prevention	Predictive analytics can flag disengagement or declining performance long before it becomes visible in grades, allowing teachers and counsellors to intervene promptly and reduce dropout, chronic absenteeism and silent under-achievement.	False positives can stigmatise students or divert resources away from those most in need. False negatives can lead to failure to provide resources to those who need them. Although individual teachers can make erroneous predictions, the adoption of AI systems changes the scale and the perceived confidence actors in the system have over outcomes. Concerns over data privacy can erode trust in education.
Personalised Learning	Adaptive algorithms can tailor content, pace and feedback to each learner's needs, supporting mastery for high-achievers and targeted remediation for struggling students. This individualisation is difficult to achieve at scale with traditional classroom methods.	Biased or opaque recommendation engines may narrow curricular breadth or perpetuate stereotypes. Students can lean on AI tools offloading knowledge acquisition and problem-solving leading to lower proficiency.
On-demand tutoring and translation	AI chat-tutors and conversational agents give disadvantaged learners round-the-clock academic support that would otherwise require expensive private tuition, helping to narrow socio-economic gaps in attainment.	Unequal access to devices/connectivity could widen the digital divide; privacy breaches could expose sensitive data.
Content accessibility	Speech-to-text, automated captioning, real-time translation and adaptive interfaces make content accessible for students with disabilities, language barriers or limited literacy, promoting full participation in mainstream classrooms.	Stigmatisation of students, stereotyping and low quality resources being made available. Although individual teachers can make erroneous predictions, the adoption of AI systems changes the scale and the perceived confidence actors in the system have over outcomes.
Student engagement	Simulations and AR/VR scenarios may raise motivation and deepen conceptual understanding.	Excessive screen-time and immersive contexts may affect attention, well-being and social interaction.
Teaching productivity	Automated marking, lesson-planning assistants and administrative bots may free teachers' time for high-value activities such as mentoring and formative feedback reducing work on administrative tasks, improving job satisfaction and potentially mitigating subject-specific teacher shortages.	Over-reliance may deskill the profession and reduce critical scrutiny of machine-generated outputs. Cost of adoption may crowd out investment in teacher professional development or determine which schools can access the technology. Generative AI systems may process sensitive personal data, raising significant privacy concerns. Ensuring compliance with GDPR and maintaining parents' meaningful right to opt out are therefore essential.
Rich data for instructional insight	Dashboards aggregating micro-level learning analytics enable evidence-informed teaching, curriculum refinement and system-level policy decisions, fostering continuous improvement.	Inadequate data protection measures or compliance, compromise data sovereignty and long-term costs.
Continuous professional development	Intelligent coaching platforms offer teachers personalised feedback on instructional practice, curated resources and peer networks, supporting lifelong upskilling and fostering a culture of reflective teaching.	Because vendors are rewarded for scale and quick, quantifiable wins, AI tools often optimise for what's easiest to measure rather than what matters most. This can misalign provider priorities with teachers' professional judgement, curriculum goals, and equity commitments.

Indirect effects: Evolving educational aims

The diffusion of AI in workplaces and societies raises questions about which human skills will be required going forward, to enable people to live full lives and active participation, including in the labour market, and how education systems respond (OECD, 2021[29]). As is explored further in section 5, with regards to the labour market dimension, generative-AI-driven automation is associated with declining demand for structured cognitive-task jobs, yet it amplifies the importance of occupations that combine technical proficiency with creativity, complex problem solving and socio-emotional competence (Loaiza and Rigobon, 2024[30]). In establishments where exposure to AI has risen, vacancies increasingly call for collaboration, originality and digital fluency, although effects vary with the mode of organisational adoption (Green, 2024[31]). As a result, AI adoption could reshape:

- **Curricular focus.** AI adoption in societies and labour markets may result in a rebalancing of curricula to incorporate AI and data literacy, algorithmic thinking and the responsible use of AI, while reaffirming the value of creativity, ethical reasoning and interpersonal skills.
- **School purpose and social role.** When individualised instruction becomes accessible outside institutional settings, arguments for schooling increasingly foreground its civic, relational and well-being functions – offering spaces where young people engage with diversity, deliberate ethically and develop resilience (Williamson and Eynon, 2020[32]).

Considerations related to the adoption AI in the Italian education system

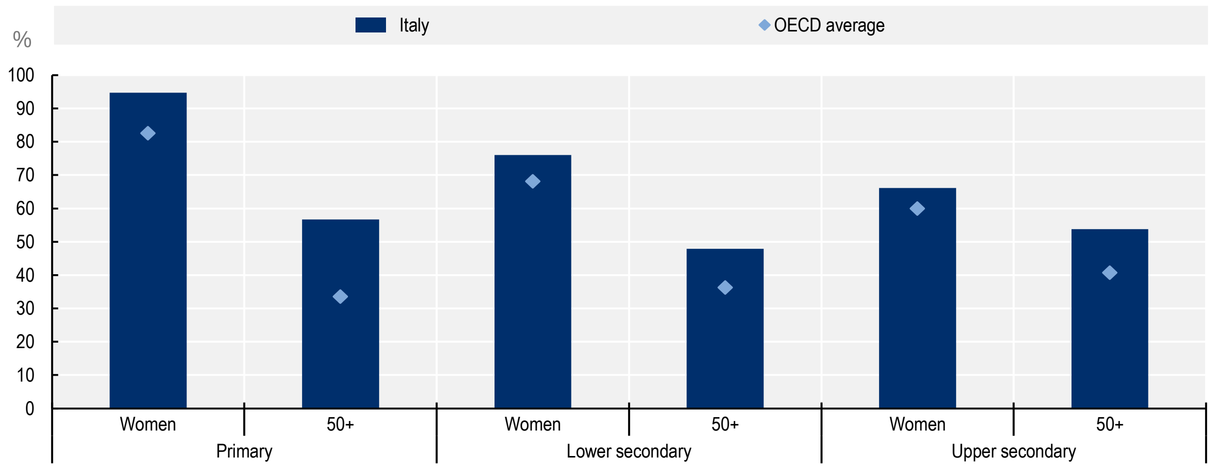
National school system features shape the conditions for AI adoption and define its opportunities and risks. In Italy, key characteristics include: a mature, strongly feminised workforce, early academic tracking and programme differentiation, and traditions of stable teacher–pupil relationships (looping) and oral assessment.

Teacher placement and demographics

Older educators and female educators, on average, report lower confidence in using new digital tools, reinforcing the importance of targeted professional development and support if AI were to be introduced at scale in Italian classrooms. The Italian teacher workforce is in fact mature and predominantly female. For example, nearly 60 per cent of lower- and upper-secondary teachers are over 50, and women account for roughly two-thirds of all teachers. While younger teachers who are more tech-savvy may compensate for some of the disadvantage driven by older teachers' unfamiliarity with digital technologies, they often face weaker job security (Bryson, Corsini and Martelli, 2022[33]; Magni, 2024[34]), limiting their impact on students' educational experience. As in other OECD countries, Italian teachers see administrative burden as a major source of stress, which AI tools such as automated marking, scheduling and document preparation could help reduce (OECD, 2020[35]). Time saved could be redirected to planning, providing feedback and professional learning.

Figure 1. Demographic characteristics of teachers

Percentage of women among teaching staff and teachers at least 50 years old in Italy and OECD average, by level of education, 2022



Source: OECD (2024[36]), *Education at a Glance 2024: OECD Indicators*, https://doi.org/10.1787/c00cad36-en.

Mode of instruction and student-teacher relationships

In Italy, classroom practice in secondary school remains predominantly lecture-based, with limited small-group work or digital experimentation: 88 per cent of lower-secondary teachers “frequently or always” lecture to the whole class, 10 percentage points above the OECD average, while only 46 per cent regularly use small-group work, 7 percentage points below the OECD average (OECD, 2020[35]; OECD, 2024[37]). This is in spite of the growing body of research suggesting that a balanced mix of direct instruction and interactive learning results in better student outcomes (Fisher, Perényi and Birdthistle, 2018[38]).

More interactive and dynamic teaching practices that involve students in the learning process and have them carry out meaningful learning activities and reflect on their work, are more compatible with AI-adoption given the user-centric nature of tools providing personalised feedback (Agostini, 2024[39]). Therefore, the adoption of AI-powered tools in the Italian education system may require – and promote – the adoption of different teaching strategies. The Lombardy Region Department of Education AI guidelines for secondary school teachers emphasise the potential for AI to facilitate classroom discussion, generate realistic scenarios for simulations and role play, develop activities based on real-life problems that encourage critical thinking and the application of learning and knowledge to new and complex contexts (Lombardy Region Department of Education, Training and Employment, n.d.[40]).

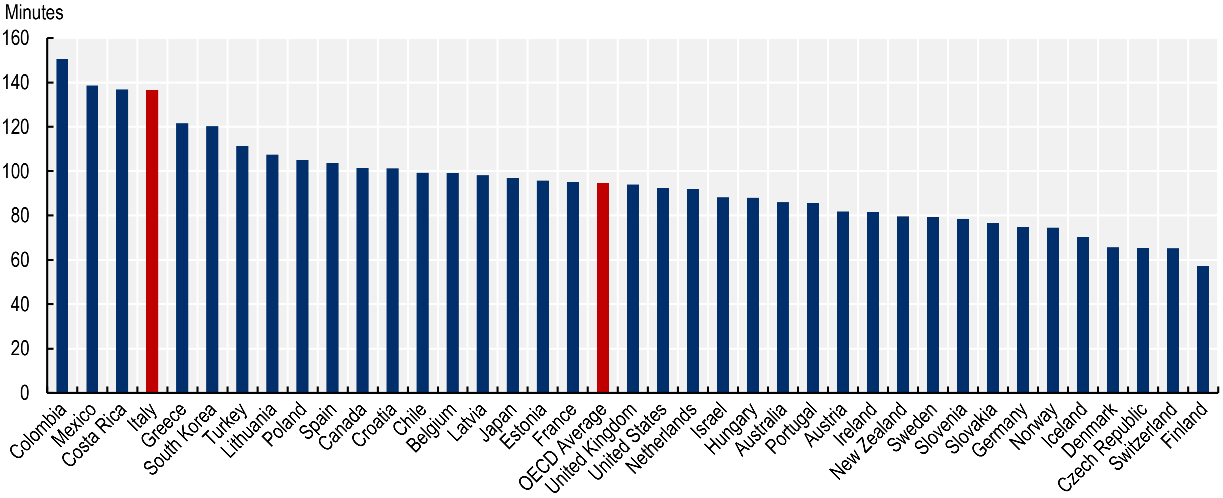
Italian students typically stay in the same class group throughout compulsory school, and often have the same teachers as they progress. Keeping the same class and teacher together (known as “looping”) can help build strong relationships, reduce the risk of pupils feeling isolated, and allow teachers to understand their pupils better and judge them more fairly. However, this process reinforces differences related to teacher quality, and could reduce the progress of students if certain teachers were to hold stereotypes or biases. Using predictive models alongside teachers’ own judgements can highlight when a teacher’s view of a pupil does not match the pupil’s actual performance, and can therefore lead to fairer, more accurate assessments, fostering deeper contextual awareness and fairer judgements.

Self-study and homework

Italy's education system is heavily reliant on self-study, a modality in which personalised feedback from AI tools could help narrow achievement gaps the most, but also one that is most vulnerable to the negative effects associated with unstructured and unsupervised AI use. Empirical evidence suggests that in Italy, students spend more time on independent study and homework than their peers in many other OECD countries. According to data from PISA 2022, see students in Italy spent almost 140 minutes per week on homework in 2022, far above the OECD average of around 100 minutes (Figure 2). This reliance on self-study is particularly pronounced at the lower- and upper-secondary school levels, where students are expected to manage a substantial amount of their learning independently.

Figure 2. Time spent studying outside of the classroom

Number of minutes spent in a week on homework, OECD countries, 2022



Source: OECD (2023[41]), *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*, https://doi.org/10.1787/53f23881-en.

While fostering autonomy, self-study can reinforce socio-economic disparities. Students from affluent families benefit from tutoring, parental support and technology, while disadvantaged students often lack such resources and face additional demands on their time. Reliance on independent learning can therefore widen gaps in outcomes, with motivated privileged students thriving and less advantaged peers struggling without support (OECD, 2021[42]). This unequal distribution of support can lead to widening gaps in academic performance and long-term educational attainment.

AI may mitigate these disparities by providing personalised pathways, feedback and real-time assistance, offering disadvantaged students support otherwise unavailable. Platforms can guide complex tasks, supply practice materials and monitor progress. Yet risks may arise if AI is used without guidance: students may engage in "cognitive offloading", becoming dependent on technology instead of developing critical skills. Those from disadvantaged backgrounds are particularly vulnerable, given limited exposure to structured strategies and greater external pressures (Di Pietro and Castaño Muñoz, 2025[43]). Unequal internet access further restricts opportunities, and while many AI tools are currently free, future pricing changes could deepen divides.

Oral examination and assessment practices

Another key feature of the Italian system is its strong reliance on oral examinations, both in low-stakes formative assessments and high-stakes examinations. Teachers routinely assign grades based on students' oral communication skills; for example, small groups of students are randomly selected for grading during classroom activities and assessed on their communication skills, as well as subject-matter knowledge, by the teacher. This differs from approaches such as classroom-wide written standardised assessments or project-based marking of individual or group work completed at home.

Oral assessment practices are relational in nature, promoting student engagement and teacher-student interactions and feedback (Selwyn, 2024[44]; Leaton Gray, Edsall and Parapadakis, 2025[45]). While oral assessment and examination practices may be more difficult to scale and standardise, they present a concrete approach to upholding academic integrity in the age of AI. In addition to helping safeguard the authenticity of assessment and examination processes, they encourage the development of fundamental competencies, such as the capacity for persuasion, critical reasoning, and adaptive responsiveness, which are set to become increasingly valuable in educational settings, as well as labour markets. Answering live, in-person questioning cannot be aided by AI tools, requiring students to develop and demonstrate communication skills (Komasawa and Yokohira, 2025[46]) While many assessment and examination practices are vulnerable to cheating or inappropriate AI use (EPFL Grader Consortium/EPFL Data Consortium, 2024[47]), oral assessments, especially when unscripted and dialogical, are resistant to aid from existing AI tools (Larsen, 2023[48]). The strengthening and continued practice of oral assessments and examinations may be an appropriate response to the growing concerns that other that traditional forms of written assessment are ill-equipped to withstand AI disruption.

Digital infrastructure and digital competence

An accessible and efficient digital infrastructure, and the appropriate skills to use it, are essential to the adoption of AI in education. Access to fast internet connectivity, appropriate technological tools and a well-structured system for exchanging information from different sources, enable AI tool integration into teaching and learning environments. At the same time, limited digital skills on the part of educators and students, would limit the usefulness of investments in digital infrastructure. Teachers need to be able to interpret the information generated by AI, making critical use of it to improve the learning of all their students through pedagogical adaptation and ethical and inclusive use. Students also need to develop critical and responsible digital skills to understand, interact with and question AI systems. Where digital infrastructure is weak or digital literacy is limited, the adoption of AI remains fragmented and experimental.

Digital infrastructure in the Italian education system lags behind other OECD countries, while students' digital competence varies across regions and students' socio-demographic characteristics. The device-to-student ratio, at approximately 1 device per 7.1 students (Ministero dell'Istruzione e del Merito, 2023[49]) indicates Italy significantly trails other OECD countries such as Denmark, Norway and Sweden, where it is 1:1 from primary school onwards, while the OECD average stands at 1 device per 3 students OECD data (OECD, 2023[50]; OECD, 2023[51]). In terms of connectivity, high-speed connectivity has until recently covered only a minority of school buildings, with pronounced regional disparities. Around 42 per cent of schools relied on slower connections and often unstable Wi-Fi networks (European Commission, 2012[52]). Recent national efforts have altered the connectivity landscape. As of mid-2025, data from the National Ultra-Broadband Plan show that approximately 26 600 out of the 27 800 schools targeted under the national *Connected Schools programme* have been successfully linked with faster and better connections; this represents around two-thirds of all school facilities in the country (Ministero delle imprese e del Made in Italy, 2025[53]).

The 2025 INVALSI standardised assessment of digital competencies showed that over 80 per cent of upper secondary students achieved at least an intermediate level in digital competencies: 89 per cent in information and data literacy, 91 per cent in communication and collaboration, 84 per cent in content creation, and 85 per cent in safety. These results are encouraging compared to subjects such as Italian and mathematics, where challenges are greater (INVALSI, 2025[54]). However, disparities remain: students in northern regions outperform those in the south and islands; those from advantaged socio-economic backgrounds are up to 15 percentage points more proficient than disadvantaged peers; and students in academic high schools show stronger competencies than those in vocational institutes (INVALSI, 2025[54]).

Among 16-24 year-olds, 87 per cent of Italians have at least basic digital competence, close to the EU average of 90 per cent (Eurostat, 2025[55]; Eurostat, 2024[56]). The IEA ICILS (International Computer and Information Literacy Study), which assesses computer and information literacy (CIL), indicates that Italian 8th-graders outperform the international average, with 54 per cent reaching at least basic CIL proficiency compared to 50 per cent on average across ICILS participating countries. Socio-economic background and regional disparities remain important, with stronger results in northern and central regions (Fraillon, 2025[57]). Since first joining in 2018, Italy has improved its CIL performance by 30 score points, while no overall progress occurred across other participating systems between 2018 and 2023 (Fraillon, 2025[57]). For teachers, however, digital pedagogy remains a challenge. Among teachers who report that they have not used AI in their teaching in the 12 months prior to the TALIS 2024 survey, 69% report that they do not have the knowledge and skills to teach using AI (OECD, 2025[20]).

2 Use of AI to reduce early school leaving and support learning

Early school leaving and learning fragility

Dropout, or early school leaving, refers to non-completion of upper secondary education (Lyche, 2010[58]); it is the result of progressive student disengagement and withdrawal from schooling and has significant negative effects on individuals and society. At the individual level, it is associated with reduced lifetime earnings, higher unemployment, and poorer health outcomes including increased vulnerability to mental health issues (Brunello and Rocco, 2024[59]; Davies et al., 2018[60]; Esch et al., 2014[61]). At the societal level, it imposes broader costs, such as lower tax revenues, greater dependence on welfare and healthcare systems, and higher crime rates (Brunello and Paola, 2014[62]; Ward, Williams and van Ours, 2020[63]).

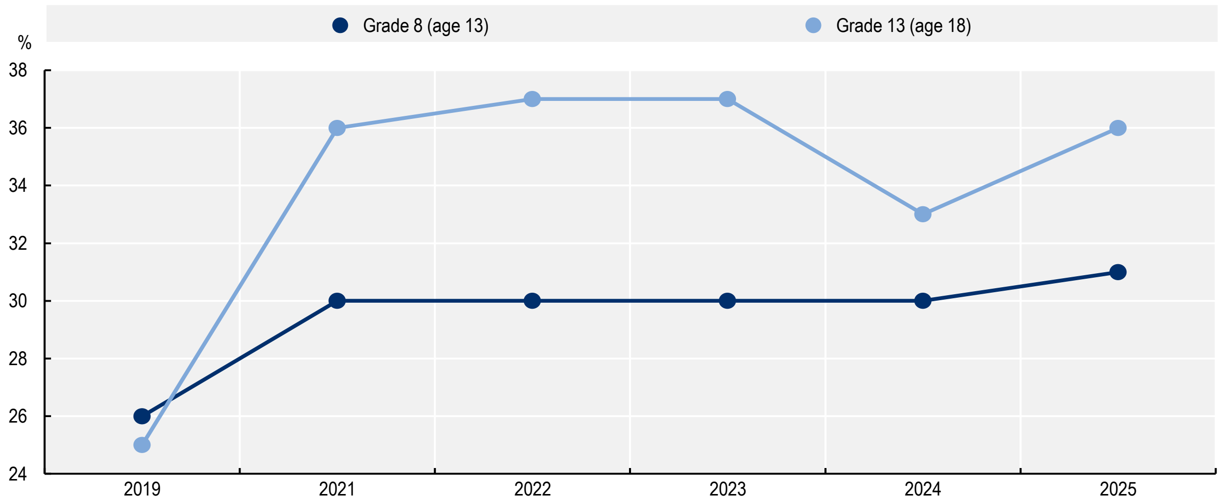
In Italy, efforts to reduce early school leaving are closely linked to tackling "learning fragility". On the one hand, targeted measures aim to strengthen students' skills in Italian and mathematics, as low achievement increases the likelihood of dropping out. On the other hand, learning fragility is treated as an important policy concern in its own right and is monitored separately. Under the INVALSI system, pupils who do not reach the baseline proficiency levels in Italian and mathematics are classified as academically fragile (INVALSI, 2025[64]).

The 2024 report on the Sustainable Development Goals (SDGs) by the Italian National Institute of Statistics (ISTAT) outlines Italy's commitment to reducing early school leaving, highlighting several government initiatives, including targeted investments through the EU Next Generation initiative – known in Italy as the *Piano Nazionale di Ripresa e Resilienza* (PNRR) – and regional interventions (Instituto Nazionale di Statistica, 2024[65]).[1] These efforts are aligned with the European Council Recommendations and the Strategic Framework for Education and Training 2021-2030, which aim to reduce the dropout rate to 9 per cent by 2030 (in 2024 the EU average was 9.3 per cent and 9.8 per cent in Italy) while fostering equitable access to quality education, particularly in underprivileged areas (Eurostat, 2025[66]). By 2022, early school leaving targets in Italy had been met for young women – the share of girls dropping out was 7.1 per cent, nearly 2 percentage points below the EU target of 9 per cent. In contrast, the dropout rate remained relatively high for young men, at 12.1 per cent in 2024. There is a consistent downward trend in the rate of early school leaving for both girls and boys, though it is more pronounced for girls.

In addition, regional disparities are pronounced. Early school leaving is highest in Sardinia and Sicily, at 17 per cent, and lowest in Umbria, Marche, and Lazio – which are among the few regions in which boys' early leaving rate is below the EU 2030 target. In Umbria, the dropout rate is 5.6 per cent for all students, and the gender gap 3.5 in favour of girls. While progress has been made to reduce early school leaving, learning fragility is on the rise. Between 2019 and 2025, the percentage of Italian students not reaching baseline proficiency levels in mathematics and Italian at the end of lower secondary education (i.e. Grade 8) increased from 26 to 30 (Figure 3). At the end of upper secondary education (i.e. Grade 13), this percentage increased from 25 to 36.

Figure 3. Trends in academically fragile students at the end of lower and upper secondary school in Italy

Percentage of students in grade 8 (age 13) and grade 13 (age 18) not reaching the baseline proficiency levels in mathematics and Italian required by their level of education, 2019-2025, Italy



Source: INVALSI (2025[64]), *Rapporto INVALSI 2025,* https://serviziostatistico.invalsi.it/wp-content/uploads/2025/07/Rapporto-prove-INVALSI-2025.pdf.

In Grade 13, socioeconomic inequalities in the risk of experiencing learning fragility are marked, with a higher risk for boys and first-generation immigrants (INVALSI, 2025[64]). These disparities were exacerbated by pandemic learning losses (Borgonovi and Ferrara, 2023[67]) and are especially pronounced in the Southern regions (Carlana, La Ferrara and Lopez, 2023[68]; Contini et al., 2023[69]). Results from PISA data confirm the high prevalence of students who have low levels of academic proficiency and the strong relationship between students' socio-economic background and their likelihood of experiencing learning fragility (OECD, 2023[41]). In 2025, in Grade 8, 13.4 per cent of socioeconomically disadvantaged students did not meet baseline proficiency levels compared with 6 per cent of socioeconomically advantaged students; in Grade 13 such figures are 9.8 per cent compared with 5.3 per cent respectively (INVALSI, 2025[70]). Socioeconomic differences in learning achievement are further accentuated by the stratified structure of the Italian secondary school system, where at the end of upper secondary education significant differences in mathematics and Italian results persist between school tracks: the highest results are observed in academic lyceums, lower in technical institutes, and the lowest in professional schools (INVALSI, 2025[70]).

Summary of evidence on key drivers of early school leaving

Early school leaving and learning fragility risks are influenced by a range of school-related factors, including teacher workload; teaching and didactic approaches; efforts on early detection of dropout risk; approaches to content and lesson planning; feedback timing and personalisation; school-family communication and parental engagement (see Table 2). Such factors impact student learning and risk of dropout through a number of channels, including by conditioning student engagement and participation.

Table 2. Summary of school related factors that influence students' likelihood of early school leaving and support learning

Factor	Key factors and dimensions of variation	Relating to early school leaving and low achievement	Effects on student outcomes
Teacher workload	Administrative burden, imbalance between tasks, burnout, career allocation	Excessive workload harms teacher wellbeing and effectiveness; younger teachers face more demanding conditions	Indirect negative impact on achievement, motivation, and student-teacher interactions; teacher burnout linked to lower learning outcomes (Zhou, Slemp and Vella-Brodrick, 2024[71]; Arens and Morin, 2016[72]; Wartenberg et al., 2023[73]; Bryson, Corsini and Martelli, 2022[74])
Teaching and didactic approaches	Active (e.g. flipped classroom, problem-solving) vs. passive instruction; peer interaction; engagement types	Dynamic methods increase engagement; effectiveness varies by student learning strategy and task type; Italian teaching emphasises order over activation	Increased engagement leads to better performance, retention, and motivation; surface learners benefit less from active methods (Alp Christ et al., 2022[75]; Zhang and Ma, 2023[76]; Strelan, Osborn and Palmer, 2020[77])
Capacity for early detection of dropout risk	Warning systems using indicators (attendance, behaviour, grades); targeted interventions	Multi-indicator systems improve specificity/sensitivity; early intervention lowers dropout, especially in low- and middle-income countries	Early detection coupled with engagement-focused intervention improves retention and academic success (Bowers, Sprott and Taff, 2013[78]; Chappell et al., 2016[79])
Content and lesson planning	Differentiated instruction and sequencing; curricular alignment; relevance to students' lives and contexts; integration of digital and culturally responsive materials	Structured, relevant, and culturally connected content improves motivation and retention	Planning enhances engagement, attention, and performance; culturally responsive content yields higher participation (Deunk et al., 2018[80]; Bonilla, Dee and Penner, 2021[81]; Johansen, Eliassen and Jeno, 2023[82])
Feedback and assessment	Timing, elaboration, peer vs. teacher feedback, classroom context	Timely, personalised, regular feedback, embedded in learning context, supports student engagement and participation	Boosts achievement and reduces dropout; peer feedback is valuable but underused (Double, McGrane and Hopfenbeck, 2019[83]; Hattie and Yates, 2014[84])
School-family communication and parental engagement	Proactive communication, trust-building, engagement programmes	Improves behaviour, attendance, and achievement; protects against dropout	Enhances engagement, success, and equity; especially effective in disadvantaged contexts (Kraft and Rogers, 2015[85]; Bergman, 2021[86]; Wilder, 2023[87])

Scope for AI to reduce early school leaving

The potential and risk of digital technology, including AI, use to address risk of school dropout and support learning, especially among children at risk of low attainment, is broadly discussed with respect to two sets of activities: efforts to i) improve the accuracy and timeliness of early detection of risk of student dropout and fragility and ii) to support learning and teaching through the personalisation of teaching material, training and assessment practices and reallocation of teacher workload away from administrative tasks.

Early warning systems

Early warning systems (EWS) use data to detect students who are at risk of dropping out of school, based on a series of "early warning" indicators that predict student performance. EWS can be valuable if they accurately flag students at risk of dropping out that teachers had not identified as such, if they do so with a high level of accuracy, and if timely detection triggers appropriate interventions in support of students identified as “at risk” (Bowers, 2021[88]). If designed to do so, EWS may also directly suggest relevant and feasible interventions in response to risk identification (Khosravi et al., 2022[89]).

Machine learning algorithms could make existing digital tools more effective and applicable in the education setting through increasingly advanced computing methods which include complex factors influencing student outcomes, such as motivation and mental health information, that may improve the effectiveness of predictive models (Mustofa et al., 2025[90]). However, the inclusion of such socio-emotional and psychological variables raises important methodological and ethical considerations. Measuring constructs like motivation, engagement or wellbeing reliably and consistently across schools is challenging, and proxy indicators may introduce bias or noise into predictive models. Moreover, the collection and processing of sensitive personal data (particularly concerning students’ mental health) pose significant privacy and data-protection concerns under frameworks such as the GDPR. Ensuring that data use is proportionate, transparent, and securely governed is therefore essential to maintain trust and safeguard students’ rights.

Available studies indicate how ML can be effective in improving the accuracy and timeliness in identifying students’ risk factors of dropping out. A study of upper secondary school dropout and non-dropout in Finland highlights how, with an expanded data set (including students’ academic and cognitive skills, motivation, behaviour and wellbeing) and modelling horizon (13-year longitudinal dataset), predictive tools can deliver accurate predictions as early as the end of primary school: key to effectively supporting students in time (Psyridou et al., 2024[91]). The comparison of the performance of ML classifiers in predicting school dropout when utilizing data up to the end of primary school (Grade 6; age 12-13) versus data up to the end of lower secondary school (Grade 9) finds that the model can accurately predict both dropout and non-dropout cases from upper secondary school from as early as Grade 6, with only a slight decrease in accuracy compared to predictions with data up to Grade 9. Other models tested in academic research have shown similarly promising results in terms of the performance of AI models relative to other models in predicting school dropout (Roda-Segarra, De-la-Peña and Mengual-Andrés, 2024[92]).

Risks and mitigation

A key concern is that the accuracy of prediction tools may vary by student group and be lower for students from disadvantaged backgrounds. A study on Germany finds ML algorithms underlying prediction systems in university were significantly less accurate for students who attended vocational schools compared with those with more “standard” academic trajectories prior to attending university, due to the fact that atypical and underrepresented educational paths in vocational schools have led algorithms, trained primarily on traditional academic profiles, to reproduce structural and data-based biases overestimating their risk of dropping out of school (Herrmann and Weigert, 2024[93]).

The poor transparency of AI-driven models and the opacity of its training data and processes confer risks of bias and stimulate debate over how risk prediction information is used by schools. The misuse of AI-driven prediction models could contribute to the profiling and discrimination of large student groups. An analysis of the Wisconsin’s Dropout Early Warning System, which uses race as a data point to predict the likelihood a student will graduate high school on time, generated false risk predictions for Black and Latino students at a significantly greater rate than it did for their White classmates. The false alarm rate, or the frequency with which the algorithm predicted that a student wouldn’t graduate on time when in fact the student did complete their studies according to schedule, was 42 per cent higher for Black students than White students. Such errors are of particular concern when risk scores have a negative influence on how teachers perceive students and on students’ own beliefs about their academic potential. In such cases, prediction results can lead to further discrimination (Pham et al., 2024[94]). To mitigate these risks, and help ensure AI delivers on its potential, the following strategies could be adopted:

- Regular audits of predictive algorithms for bias, transparency in predictive methods, and human oversight to validate predictions and interventions.
- Ensure training data is free of bias so that the models do not adopt and replicate it.
- Rigorous governance of AI tools, such as transparency in the design and implementation process, periodic bias audits and outcome monitoring are essential throughout the lifecycle of early detection systems and in how their recommendations are used.
- Ensure that EWS initiatives and risk identification are accompanied by active engagement strategies by and for teachers tailored to students' needs. Without consistent follow-up, teacher training and development, and personalised interventions, the potential impact of these EWS efforts remains limited.

Supporting learning outcomes and addressing learning fragility

Across education systems, AI tutors and teaching assistants are being deployed to provide step-by-step explanations, generate practice tasks, give immediate feedback and help students debug or revise work. These systems range from general-purpose, conversational tools (e.g. GPT-based chatbots used by students to ask for help) to purpose-built, curriculum-aligned platforms that guide learners through sequenced content and report progress to teachers. Their key promise is to democratise access to personalised support and reduce teacher workload by automating lower-value administrative and feedback tasks.

Use cases in mathematics illustrate the broader logic of AI-enabled personalisation: short instructional inputs, followed by practice, immediate feedback, and adaptive progression. Platforms such as Khan Academy (Oreopoulos, 2024[95]; Oreopoulos et al., 2024[96]), BrainPOP (BrainPOP LLC, 2018[97])., MATHia (CarnegieLearning, n.d.[98]; Fancsali et al., 2018[99]),, and low-cost WhatsApp-based tutors (e.g. Rori in Ghana and Sierra Leone) (Henkel et al., 2024[100]; Rising Academies, n.d.[101]). adjust the pace and level of difficulty to what the learner can do, monitor progress and surface information for teachers. Optical character recognition and step-by-step solvers, as in QANDA, further lower access barriers for students in need of support (Mathpresso Inc, n.d.[102]).

Use cases raise questions about the risk to student learning posed by the practice of students "offloading", overreliance on technology and quick fixes. Evidence on the effectiveness of AI tools and assistants remains mixed. Table 3 summarises selected studies that provide an indication of the impact on learning of AI tools and, where available, how these vary across student groups, for instance by skill level and socioeconomic background. Due to the speed with which generative AI systems are being updated, most of the evidence pertains to systems that have already been discontinued, such as OpenAI's ChatGPT 3.5 or ChatGPT 4.

Table 3. Selected examples and evidence on the effectiveness of AI tutors and TAs in supporting student learning

Country	Initiative	Description	Evaluation outcome
Chinese Taipei	ChatGPT as programming TA	Used ChatGPT to support high school students learning programming by assisting with syntax, debugging, and explanations.	In an RCT,153 high school students were randomly assigned to a control group where they were taught programming in a traditional lecture-based instruction modality or to an experimental group where they could use ChatGPT for programming support. Students from the experimental group showed lower self-efficacy and learning achievement outcomes after using ChatGPT, with small-to-moderate effect size scores, suggesting how the impact of ChatGPT in programming courses may have minimal or even negative effects on student outcomes (Yang, Hsu and Wu, 2025[103]).
Italy	GPT-4 as English homework tutor	AI-assisted homework in English as a secondary language class across two grades using interactive ChatGPT sessions.	This small RCT was carried out in four high school classes for a total of 76 students involved. Overall, although students responded positively to AI as a learning companion and reported short term positive feedback on their experience, learning gains did not vary significantly between study groups. However, weaker students in terms of initial skills benefited more from the tutoring compared to stronger ones (Vanzo, Chowdhury and Sachan, 2025[104]).
Nigeria	GPT-4 via Microsoft Copilot	Used ChatGPT to deliver after-school English tutoring sessions to high school students in Benin City.	For this RCT, 759 senior secondary school students were recruited on a voluntary basis among senior from nine schools in Benin City. After a six-week intervention three main outcomes were measured: English language proficiency, AI knowledge/skills, and digital skills. Significant improvements in the study group were observed for English ad AI skills. The intervention appeared to have had a larger positive effect on girls compared to boys. Also, students with higher SES background benefited more than their peers from poorer households (De Simone et al., 2025[105]).
Türkiye	GPT-4 in maths tutoring (RCT)	Tested standard ChatGPT versus a structured ChatGPT Tutor across high school maths classes.	This RCT involved 839 secondary school students and focused on normalized Maths grades as main outcome. Results indicated that access to standard ChatGPT improved students' performance by 48% on average relative to students in the control group. Moreover, access to a specialized version of ChatGPT instructed by best practices and teacher inputs (such as providing suggestions instead of giving the complete solution to questions), improved performance by 127%. However, while post-test performance (without any assistance) between students in the structured ChatGPT Tutor group and control students did not vary significantly, standard ChatGPT decreased average students' performance by 17%. These results indicate that AI tools such as ChatGPT can degrade student learning outcomes in absence of appropriate safeguards (Bastani et al., 2024[106]).
United States	Peer feedback with AI guidance (RiPPLE adaptive education system)	RCT with 1625 undergraduate students across 10 courses testing AI-assisted feedback prompts vs. human-led self-regulation strategies in writing tasks.	This RCT assessed different outcomes evaluating the quality of student-submitted feedback to learning resources created by other students. Feedback was evaluated according to its relevance, originality and constructiveness (qualities that reduce the likelihood of submitting repetitive comments). AI support was more effective than self-regulation alone but led to over-reliance. In addition, hybrid human-AI approaches did not yield significantly better results than AI alone (Darvishi et al., 2024[107]).
United States	Utah's Early Interactive Reading Software	Five different adaptive AI reading software implemented in 692 schools (kindergarten and primary schools) serving over 166 000 students, including English language learners and low-income learners.	This large RCT investigated how the adoption of reading software in primary and pre-primary school children – across an entire school year – improved their literacy scores. The study divided students from the treatment arm in two distinct groups: those who met the usage criteria for the adopted software as provided by the vendors, those who met at least 80% of such criteria (in terms of minutes per week and total

Country	Initiative	Description	Evaluation outcome
			number of weeks for students to use the software). The programme showed large positive effects among pre-primary school children on their reading scores, especially for those who met the vendors recommendations for use. Small-to-moderate effects were observed among primary school children. This was especially true when software was used as recommended. Across grades, students in disadvantaged subgroups (i.e., English language learners, low-income, and special education designation status), appeared to benefit the most from the programme (Wright et al., 2023[108]).

A 2024 meta-analysis of experimental and quasi-experimental studies reported overall positive effects of AI-based interventions in supporting young students (aged 5 to 16) with autism, learning disorders (e.g. dyslexia), and intellectual disabilities (Zhang et al., 2024[109]). The interventions used social robots, virtual reality systems, and intelligent tutoring software to promote engagement and emotional responsiveness, particularly in triadic interaction contexts involving peers or teachers, as well as supporting personalised and multimodal learning approaches (e.g. speech recognition programs). Similarly, recent OECD evidence details how AI can be used to support students with special education needs to achieve their learning goals, while underlining key risks and limitations (Linsenmayer, 2025[110]). In particular, AI tools that have shown promising results in supporting students with learning difficulties (dyslexia, dysgraphia and dyscalculia), sensory (visual and auditory) and language disorders, as well as autism and attention deficit hyperactivity disorder.

Risks and mitigation

Evidence shows that computer-assisted learning raises achievement only when used to empower, not bypass, teachers (Beg et al., 2022[111]). The effectiveness of different tools in randomised trials is in fact largely dependent on implementation protocols related to the introduction of such tools (Pane et al., 2014[112]). Successful integration often requires teachers to adapt methods, track progress and allow time for practice, yet many hesitate due to time pressures, limited familiarity or scepticism. Large language models can also inflate how much students believe their learnt rather than actual learning, leading to lower practice and cognitive offloading (Bastani et al., 2025[113]). Evidence on learning gains in middle schools related to AI tools indicates that human supervision was critical to realise the benefits of AI tools, especially for students with low pre-test scores (Thomas et al., 2024[114]) because educators provided essential motivational and cognitive support. In general, the effect of AI use on learning may vary depending on the domain, level of proficiency and the behaviour such use promotes. For example, students learning to code who used AI to generate solutions covered more topics but understood them less, while those using AI for explanations covered fewer topics but deepened understanding, with no net learning effects compared to students not using AI but markedly different depth and width of learning (Lehmann, Cornelius and Sting, 2025[115]).

AI tutors may give students a false sense of proficiency, as solving problems with assistance leads them to overestimate ability. Evidence from the learning effects of testing suggests that the mental effort students engage in when doing tests unaided is an integral part of the learning process, a learning that can be maximised with pacing and feedback (Adesope, Trevisan and Sundararajan, 2017[116]; Avvisati and Borgonovi, 2020[117]). At the same time, conversational AI tools have been shown to lead to higher engagement. Even in the absence of learning progress, students describe the learning process accompanied by AI tutors as more enjoyable. For students at high risk of disengagement from learning, positive affect may be viewed as a valuable outcome. Students who gain confidence in their learning and enjoy learning practice are more likely to continue their education. Moreover, evidence to date of AI tools supporting learning among students with low educational attainment in particular point to the role of clear guidelines, direct human support and human-centric values across AI-system design and implementation stages. The challenge is therefore to capitalise on motivational benefits while promoting actual learning.

Mitigation strategies include:

- Making scaffolding transparent and withdrawing it deliberately. AI platforms could be designed in ways that flag hints provided and impose students to solve practice tests unaided or require students to provide explanations or examples to ensure understanding before practice units can be marked as complete. Such strategy would require students to engage in AI use under supervision to support such use modalities and avoid the bypassing of in-built challenges.
- Pairing AI-driven supports with trained educators to curate and fact-check machine output and embed digital-inclusion safeguards so that the technology augments, rather than substitutes, the relational work that keeps vulnerable students connected to school.
- Regular "pen-and-paper" or unplugged assessments could be routinely organised to monitor progress without digital aids. This simple rule counteracts cognitive off-loading by keeping retrieval practice in play giving teachers a reliable external benchmark for AI-reported progress.
- As AI design increasingly integrates knowledge of diverse learner needs, researchers stress the importance of involving students, teachers, families and practitioners across design, selection, deployment and evaluation (Darvishi et al., 2024[107]; Yang, Hsu and Wu, 2025[103]) .
- Several providers added learning-oriented features in 2025. Anthropic introduced learning modes for Claude in April, OpenAI launched Study Mode in ChatGPT in July, and Google added Guided Learning in Gemini in August. Rather than giving direct solutions, these features are designed to guide students through problems step by step, scaffolding hints and reflection prompts. The goal is to reduce the risk of cognitive offloading by encouraging deeper comprehension. There are no independent evaluations at the time of writing, and the real-world impact of these features will depend on whether learners choose to use these modes during independent study.
- To counteract the tendency for learners to over-estimate their competence when working with an AI tutor, platforms could be designed to (i) make the level of assistance overt – flagging when a correct answer was achieved with hints or step-by-step guidance; (ii) require periodic, un-scaffolded "exit tickets" or low-stakes quizzes so that students are forced to demonstrate independent mastery before progressing; (iii) employ fading techniques that gradually withdraw support as proficiency improves; and (iv) feed the results of these independent checks into teacher dashboards so that teachers can use AI-reported progress alongside their own observations and intervene promptly where confidence outpaces actual understanding. Embedding short metacognitive prompts – such as asking pupils to explain why a solution works in their own words – could further help calibrate self-perception and maintain an appropriate level of desirable difficulties (Bjork and Bjork, 2020[118]).

Teacher task allocation and workload

High teacher workload, has been linked to lower student achievement (Arens and Morin, 2016[119]; Zhou, Slemp and Vella-Brodrick, 2024[71]). When a large share of teachers' time is taken up by administration, data entry and classroom management, less time is available for lesson planning, teaching and direct work with students. The potential for workload reduction was highlighted by the UK teachers consulted by the UK Department for Education (Box 3). The Korean's National Education Information System (NEIS) shows how digital infrastructure can support efficiency: NEIS automates administrative processes across about 12 000 schools and 17 regional offices, managing student enrolment, test scores, and academic records. It has generated an estimated cost savings exceeding USD 200 million annually, primarily by reducing time spent on data entry and verification (OECD, 2023[120]).

Table 4. Selected examples of AI tools in support of teacher task allocation and workload

Country	Initiative	Description	Evaluation outcome
Brazil	*Letrus AI writing platform*	AI platform offering instant feedback to public school students on writing tasks in preparation for university entrance exams.	A RCT involving 178 public schools in the Brazilian state of Espírito Santo showed an improvement in students' writing skills by about 0.09 standard deviations in the study group, also mitigating 9% of the public-private school gap in essay scores. Teachers reported to shift work hours from routing (e.g. essays correction and grading) to nonroutine tasks (e.g. providing individual support to students) (Ferman, Lima and Riva, n.d.[121]).
United Kingdom	ChatGPT for science teachers	RCT involving 259 lower-secondary science school teachers using ChatGPT and an online ChatGPT guide to support lesson planning and content creation over 10 weeks.	This study focused on measuring the amount of time teachers spent preparing lessons (total hours over a five-week period) and evaluating the quality of teaching materials (ranking order for lessons and resource material, evaluated by a teacher panel). Results showed that teachers in the ChatGPT group spent on average 31% less time than teachers in the control arm to prepare lesson and resources (56 vs. 81 minutes/week) with no reduced quality (Roy et al., 2024[122]).

Risks and mitigation

Experience to date points to several structural conditions that need to be met to help ensure that enhancements in efficiency using AI tools translate into educational gains for students. In particular, implementation support is crucial. When teachers are adequately trained and supported, experience suggests AI tools may make their jobs more manageable and rewarding, while also improving student learning outcomes. However, without proper integration and guidance, AI's potential remains limited and may even exacerbate teacher workload (Molina et al., 2024[26]). Box 3 details how teachers, when surveyed, report a strong need for receiving guidance on AI use and integration.

Realising efficiency gains from AI, such as reduced teacher workload, requires structural innovation. Pedagogical change and investment in training and experimentation, including time for teachers to learn and test applications, are essential to ensure that these gains feed back into learning outcomes (Pratschke, 2024[25]) . Similarly, interoperability and coordination across the digital education ecosystem are critical; without them, the current fragmentation of digital and AI tools risks increasing rather than reducing teacher workload (OECD, 2023[120]).

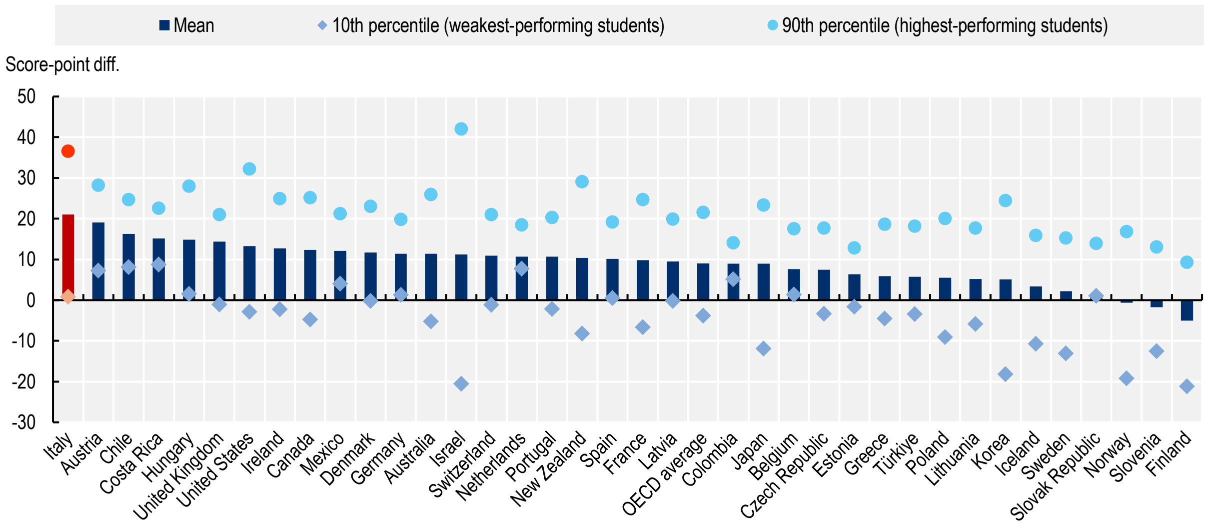
3 Use of AI to reduce the gender gap in mathematics

Gender disparities in mathematics performance

On average boys tend to outperform girls in mathematics, especially among the highest-achieving students, i.e. the group of learners most likely to enrol in mathematics-intensive Science, Technology, Engineering, and Mathematics (STEM) courses and careers. (Ellison and Swanson, 2010[123]; Hyde and Mertz, 2009[124]). A sustained imbalance at this level risks reinforcing gender segregation in advanced study and in the highly skilled segments of the labour market Evidence from PISA 2022 indicates that Italy was the country with the widest gender gap in mathematics (mean) and the second widest when considering differences between higher-achieving 15-year-old boys and girls (90th percentile of achievement) (Figure 4). Similarly, among 4th graders participating in the Trends in International Mathematics and Science Study (TIMSS) Italy recorded the third widest gender gap in mathematics. Among 8th graders, Italy had the seventh widest gender gap (von Davier, 2024[125]). National assessments indicate that in Italy girls underperform compared to boys already in grade two (Contini, Tommaso and Mendolia, 2017[126]).

Figure 4. Gender differences in mathematics performance in PISA

Score-point differences between boys and girls at the mean and at the 10th and 90th percentiles of the performance distribution, OECD countries 2022



Source: OECD (2023[41]), *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*, https://doi.org/10.1787/53f23881-en.

Italy has adopted initiatives such as Science, Technology, Engineering, and Mathematics (STEM) awareness weeks, Coding Girls (Digitale, n.d.[127]) and the PNRR's Piano Scuola 4.0 to promote achievement in STEM and technology-related fields overall and to reduce gender disparities (Ministers, 2025[128]). However, these initiatives have not yet had a large impact on measured achievement or course-taking. The Strategia Nazionale per le Competenze Digitali (Digitale, n.d.[129]) explicitly calls for reducing gender disparities and harnessing the potential of data-driven approaches and AI tools, creating a favourable policy window for AI adoption.

Summary of evidence on key drivers of girls' underperformance in mathematics

Several factors that contribute to girls' underachievement in mathematics are interrelated and span societal, psychological, educational, and cultural domains. They also interact in a cumulative fashion. For example, early anxiety and stereotype threat can suppress engagement; reduced engagement can limit course-taking; limited course-taking can lower competence and confidence. Table 5 summarises the set of factors that shape girls' underachievement in mathematics. The range of factors and levels and the different levels at which they exist remind that even if AI removed one barrier, others might still restrict girls' opportunities.

Table 5. Summary of factors that shape girls' underachievement in mathematics

Factor & brief description
Lower self-efficacy & higher anxiety. Girls report less confidence and greater mathematics anxiety even when their test scores match boys, which reduces persistence and course uptake (Foley et al., 2017[130]; OECD, 2015[131]) .
Lower perceived interest & utility value. Girls are less likely to see maths as enjoyable or useful for future goals, undermining motivation (Wigfield and Eccles, 2000[132]).
Stereotype threat and internalised bias. Awareness of the "boys are better at maths" stereotype can lower girls' performance in assessments relative to their true skills thus reducing their progression in maths-intensive courses (Steele and Aronson, 1995[133]; Spencer, Steele and Quinn, 1999[134]).
Parental expectations & gendered beliefs. Parents more readily attribute boys' success to talent and girls' success to effort, shaping self-concepts and aspirations (McCoy, Byrne and O'Connor, 2021[135]; Wang et al., 2024[136]; González de San Román and De la Rica, 2020[137]; Starr and Simpkins, 2021[138]).
Peer norms & socialisation. Friendship groups tend to be more important for girls than for boys and friendship norms can reinforce the notion that mathematics is a male domain; girls' course choices are highly responsive to close friends' attitudes and achievement (Brown and Leaper, 2010[139]; Eriksson, 2020[140]; Giordano, 2003[141]; Wu and Cai, 2023[142]; Crosnoe et al., 2008[143]).
Teacher expectations, feedback & interaction patterns. Unconscious bias leads some teachers to call on boys more often, grade girls more harshly in mathematics, or design examples that resonate less with girls' interests (Lavy and Sand, 2018[144]; Carlana, 2019[145]; Tiedemann, 2002[146]; Riegle-Crumb and Humphries, 2012[147]; Keller, 2001[148]).
Assessment format & curriculum alignment. Time-pressured, multiple-choice tests widen gender gaps; mathematics curricula and mathematics resources often embed male-oriented examples (Azmat, Calsamiglia and Iriberri, 2016[149]; Borgonovi and Biecek, 2016[150]; Gamer and Engelhard Jr., 1999[151]; Griselda, 2024[152]; Borgonovi, 2022[153]).
Stereotypes & educational resources. Textbooks often contain material that conveys gender stereotypes, suggesting that women are less capable in mathematics than men or not suitable for STEM occupations (Aband, 2017[154]; Guichot-Reina and De la Torre-Sierra, 2023[155]; Fruehwirth, Heilemann and Stoeger, 2024[156]; Sovič and Hus, 2015[157]).
Cultural stereotypes & media messages. Societies with stronger implicit "maths-male" stereotypes show larger gender gaps in mathematics achievement and course choices (Nosek et al., 2009[158]; Starr and Simpkins, 2021[138]).
Lack of visible female role models. Few female mathematics teachers or public figures that are lauded for their mathematics achievements limits girls' sense of belonging and aspiration (Carrell, Page and West, 2010[159]; Breda et al., 2023[160]; Lockwood and Kunda, 1999[161]).

Scope for AI to reduce the gender gap in mathematics

AI enhanced mentorship opportunities

AI tools could enhance mentorship opportunities for women in STEM by powering platforms that match mentees with suitable mentors. These relationships can provide guidance, support, and networking opportunities, which are crucial for career advancement and breaking the glass ceiling in traditionally male-dominated fields. AI-powered recommender systems can match girls with relatable female STEM mentors, with the aim of promoting aspirations and career intentions. AI-powered conversational "role-model agents" are also being rapidly adopted to simulate dialogue with eminent female mathematicians. Early classroom pilots in the United States indicate that such agents raise girls' perceived belonging in mathematics when they are framed explicitly as companions rather than evaluators (Walkington, 2025[162]). Table 6 showcases selected examples of personalised AI enhanced mentorship opportunities.

Table 6. Selected examples and evidence on the effectiveness of AI enhanced mentorship opportunities

Country	Initiative	Description	Evaluation outcome, scope of implementation
Germany	CyberMentor	CyberMentor connects secondary school girls with female STEM mentors via an algorithmic matching system (Cybermentor, n.d.[163])..	An evaluation showed that participation in CyberMentor significantly increased STEM activities, a higher degree of certainty in career choices and increasing intention to study a STEM subject.62 per cent of former female participants later chose STEM majors and careers. This means they were twice as likely to choose STEM as female students in their respective age cohorts (Cybermentor, n.d.[164]) (Stoeger et al., 2013[165]).
United States	MentorNet	MentorNet uses algorithms to match university-level women with STEM professionals for structured mentoring cycles.	MentorNet has facilitated over 32 000 mentor-mentee pairs, resulting in higher retention and confidence among mentees. Although detailed evaluations are limited, participants consistently report increased networking skills, career clarity, and STEM persistence, highlighting the programme's potential to bolster representation of women in STEM (greatmindsinstem, n.d.[166]) .
India	Olay STEM Mentorship Program	The programme pairs aspiring young women in secondary and tertiary education with mentors using AI-powered matching. It further supplements mentoring with "AI-Shu," a chatbot offering continuous guidance and motivational support.	Although the tool has not been formally evaluated, feedback on the system suggests that it could have positive effects on participants' career guidance and self-confidence, indicating potential for scale-up and broader impact across diverse regions (Little Black Book, 2023[167]).
United States	Your Personal Female STEM AI Coach	Your Personal Female STEM AI Coach by EQLab employs AI chatbots modelled after female STEM icons to provide personalised, on-demand mentorship at scale for girls in schools. The vision is that a girl can be "coached by the most trailblazing female figures in STEM on the eve of your STEM test," essentially chatting with an AI avatar of a famous scientist or engineer for advice and encouragement.	Currently piloting with 2 000 students, the initiative aims to reduce dropout rates in STEM subjects by 25 per cent, emphasising long-term engagement through interactive and empathetic AI interactions (Solve, 2023[168]).

Risks and mitigation

AI-based mentor-matching systems can perpetuate existing inequalities if their training data over-represent certain demographics or career paths, leading to homophily that sidelines girls from under-represented ethnic or socio-economic groups. Recommendation engines may also steer mentees towards stereotypically "feminine" STEM niches (such as biology), reinforcing, rather than expanding, their horizons. Conversational agents, meanwhile, may be vulnerable to "hallucinations": plausible-sounding but factually incorrect guidance on coursework, university applications or workplace culture can mislead learners who lack the background knowledge to identify mistakes. Privacy and safeguarding concerns are amplified when adolescents disclose personal difficulties to a non-human interlocutor that cannot reliably recognise distress or refer young people to specialised services. Finally, over-reliance on AI mentors may displace richer human relationships, leaving students without the nuanced emotional feedback and sustained encouragement that in-person mentors provide. This is particularly critical for girls navigating stereotype threat in male-dominated fields. Robust human oversight, transparent audit trails and integrated referral pathways to qualified counsellors are therefore essential to complement any technical safeguards.

To mitigate these risks, the following strategies could be adopted if AI tools were to be used:

- Incorporate rigorous human oversight, ensure diversity and inclusivity in mentor representation, use curated training datasets to eliminate biases, and integrate teacher monitoring and involvement to maintain the quality and appropriateness of mentorship interactions.
- Matching algorithms should be periodically stress-tested with synthetic profiles so that latent biases in career-recommendation pathways can be uncovered. Where conversational agents are used, a "dual-channel" design (text coupled with a vetted list of follow-up questions) can reduce the risk that students treat hallucinated content as authoritative.

AI enhanced teacher support

Teacher practices significantly influence students' mathematics achievement. A number of studies have assessed programmes aimed at improving children's mathematical skills, focusing on interventions that alter daily teaching practices through active and cooperative learning, classroom management, and motivation programmes (Slavin and Lake, 2008[169]). At the same time, other studies identify significant positive impacts from traditional teaching methods such as lecturing and rote memorisation on test scores (Berlinski and Busso, 2017[170]; Lavy, 2015[171]; Schwerdt and Wuppermann, 2011[172]). Different students respond to different pedagogical approaches, and while certain teaching methods promote factual knowledge and routine problem-solving skills, others foster reasoning skills to a greater extent (Bietenbeck, 2014[173]). AI tools could help teachers become proficient in the use of a range of approaches and identify which are best suited to particular students and content. Furthermore, some teachers hold unconscious beliefs that negatively affect girls' confidence and engagement with mathematics. AI-supported professional development (PD) programmes, bias detection tools, and lesson-planning aids could enhance girls' achievement in mathematics without compromising boys' achievement.

Teacher attention is key to student progress. AI tools can be used to identify whether - and to what extent - teachers fail to allocate sufficient time to the students who need it most. Teacher attention was evaluated as part of 2-on-1 virtual tutoring sessions on early literacy (focusing on phonics, phonological awareness, and fluency), in which tutors – including former classroom and part-time teachers - worked with two students for 20 minutes. The study included 757 students in kindergarten through second grade in the United States. Girls received less attention when paired with boys, even when they were the lower achieving student in the group. In particular, computational analyses of educators' attention patterns revealed that lower-achieving female students in mixed-gender pairs received significantly less attention than their higher-achieving male peers, while lower-achieving male students received significantly and substantially more attention than their higher-achieving female peers (Zhang et al., 2025[174]). Table 7 gives selected examples and evidence on the effectiveness of AI-enhanced teacher support in the teaching of mathematics, as well as other subjects.

Table 7. Selected examples and evidence on the effectiveness on AI-enhanced teacher support

Country	Initiative	Description	Evaluation outcome, scope of implementation
United States (Michigan State University)	AI-Powered Professional Development Initiative	The initiative provides elementary mathematics teachers with AI-driven, real-time feedback to identify and address unconscious biases. This NSF-funded project (USD 4.7 million) leverages virtual modules that integrate adaptive learning paths and gender-inclusive pedagogical techniques, significantly increasing teachers' awareness of gender biases and their ability to promote inclusive classrooms.	A formal evaluation has not been conducted. More information about the initiative can be found in Michigan State University (2024[175]).
United Kingdom	Eedi	Edi is an AI-powered predictive model that pinpoints gaps in students' understanding, allowing educators to provide targeted support (The Learning Agency, 2025[176]). Eedi's "human-in-the-loop" model maintains educators at the centre of the learning process, integrating AI-generated insights with expert human judgment to refine teaching strategies.	Edi is used by over 160 000 teachers across 19 000 schools globally, Eedi exemplifies how AI can support scalable, personalised learning while upholding principles of equity, transparency, and pedagogical soundness in education.
United States	AI-supported story creation platforms ("Reading–Solving–Creating" pedagogy)	Platform that allows students to read a maths stories set in real-life contexts, solve the embedded mathematical problem, and then create new maths stories facilitated by AI.	The platforms showed significant benefits for girls' mathematics skills through narrative-based learning (Zhu et al., 2025[177]).
United States	TeachFX	AI-driven app that analyses classroom dialogue in real-time, identifying and reporting patterns such as gender disparities in teacher-student interactions (TeachFX, n.d.[178]).	Pilot studies suggest it significantly increases equitable participation by alerting teachers to unconscious biases and encouraging balanced engagement.

Risks and mitigation

Teachers may feel threatened by or resistant to engaging in professional development activities with the aim of integrating AI in their work due to unfamiliarity or perceptions of increased workload. AI-generated materials might also inadvertently perpetuate stereotypes or biases without rigorous oversight. Teachers' overestimation of AI capabilities might lead to inadequate critical evaluation of AI outputs. Technological advancements mean that students today not only communicate through technology but also communicate with technology. AI systems can alter communication dynamics by enhancing the communication capabilities of pedagogical agents (Guzman, 2020[179]). At the same time, students tend to overestimate the communication capabilities of pedagogical agents (Sikström et al., 2022[180]).

Professional-development packages need to pair technical micro-credentials ("how to write a reflective prompt") with critical media-literacy modules ("how to spot sociocultural bias in AI-generated tasks"). International evidence shows that such dual emphasis increases female teachers' readiness to adopt AI and, indirectly, reduces classroom gender gaps.

To mitigate these risks, the following strategies could be adopted if AI tools were to be used:

- Providing comprehensive, teacher-centred professional development focusing explicitly on building AI literacy and integrating AI-supported tools into routine classroom practices can reduce teachers' resistance. Emphasising teacher autonomy and framing AI as supportive rather than a substitute technology can also promote teachers' engagement.
- Deploying AI-based bias detection tools accompanied by periodic human reviews to validate AI-generated recommendations is key to ensuring that instructional materials use equitable language and representation.

- Equipping teachers with explicit training on the strengths and limitations of AI systems, fostering critical assessment skills to ensure informed integration into teaching practices.
- Ongoing research emphasises the importance of clear, credible, and motivational communication between students and AI-powered pedagogical agents (Edwards and Edwards, 2017[181]). Enhancing the effectiveness of pedagogical agents requires supporting the relational and communication practices of students, both as they interact with humans and digital agents.

De-biasing educational materials

Gender stereotypes in educational materials can implicitly discourage girls from engaging fully with mathematics, reducing their achievement and aspirations in STEM fields. Textbooks often perpetuate these biases, portraying women in passive or non-STEM roles and underrepresenting female success in mathematics and related fields (Aband, 2017[154]; Buckley, Farrell and Tyndall, 2021[182]; Fruehwirth, Heilemann and Stoeger, 2024[156]; Guichot-Reina and De la Torre-Sierra, 2023[155]; UNESCO, 2016[183]; UNESCO, 2020[184]). This pertains not only to textbooks used at the primary and secondary levels but also to the images contained in material used at the pre-school level (Sovič and Hus, 2015[157]). Such biases can subtly shape students' perceptions about gender roles and their own abilities (González-Pérez, Mateos de Cabo and Sáinz, 2020[185]). Among younger children, books often do not contain much text but instead convey meaning through visual representations. Pictures and illustrations in textbooks can convey biased gender representations, and AI could be deployed to flag potentially unbalanced representations of men and women engaged in different activities within images used in educational settings. Although image recognition systems offer the promise of learning from images at scale without requiring expert knowledge, research suggests that machine learning systems often produce biased output. Recent research has shown that algorithmic classification systems are reproducing - if not actively amplifying - general social biases (Schwemmer et al., 2020[186]; Noble, 2020[187]).

While AI systems have been shown to amplify existing social biases due to algorithmic design and biased training data (Baker and Hawn, 2021[188]; Li et al., 2023[189]; Obermeyer et al., 2019[190]; O'Connor and Liu, 2023[191]), they also hold the potential to detect and actively mitigate these stereotypes. AI tools can be used to systematically scan the content of textbooks and educational resources, searching for biased representations, supporting experts in identifying areas that need revision and ensuring more balanced representations. Analysing textbooks is, in fact, a time-consuming activity, and pattern recognition is one of the key capabilities of AI systems. For example, Natural Language Processing methods are being used to identify gender representation in literary texts published in English from the beginning of the nineteenth through the early twentieth century (Kejriwal and Nagaraj, 2023[192]). Similarly, the *Gender Novel Project*, developed by the MIT Digital Humanities Lab, analysed the description of gender roles across a large repertoire of English novels period using data sourced from the Gutenberg project (Project, n.d.[193]).

Another example is the *GenderAlign* project, a collaboration between researchers at South China University of Technology and the University of Maryland, uses reinforcement learning with human feedback (RLHF) to reduce gender biases in AI-generated content. GenderAlign developed a structured alignment dataset of 8 000 dialogues categorising biases into stereotypes, discriminatory language, occupational/educational biases, and biases against marginalised genders. AI models trained on *GenderAlign* demonstrated significant reductions in biased responses, with human validation confirming that 99.7 per cent of selected AI-generated outputs were bias-free compared to just 50.4 per cent in baseline models (Tao Zhang and Ziqian Zeng and Xiao et al., 2024[194])

Risks and mitigation

Despite its potential, AI-generated content introduces specific risks, such as inadvertently reinforcing existing stereotypes, particularly when adapting materials across languages. For instance, automated translation systems often default to masculine pronouns when translating from gender-neutral languages into gendered ones, leading to biases such as consistently associating STEM roles with males (Prates, Avelar and Lamb, 2019[195]). Furthermore, a reliance on AI-generated educational hints and content in adaptive tutoring platforms can lead to lower learning gains if the content quality is not carefully monitored. For example, algebra hints created by human tutors have demonstrated significantly higher effectiveness than those generated by ChatGPT (Prates, Avelar and Lamb, 2019[195]).

To mitigate these risks, the following strategies could be adopted if AI tools were to be used:

- Human Validation: Implement mandatory human review loops to verify AI-generated content, ensuring accuracy, appropriateness, and unbiased materials.
- Regular Audits: Conduct periodic audits of AI outputs to systematically evaluate and recalibrate algorithms, maintaining alignment with unbiased educational standards.
- Bias-aware AI Training: Incorporate structured datasets, such as those used by GenderAlign, to proactively train AI models on unbiased responses and inclusive representations.
- Transparent Reporting: Require AI system developers to provide "model cards" detailing performance metrics across gender and other demographic subgroups, enhancing transparency and accountability.

As of 2024, reinforcement learning with human feedback (RLHF) is the framework currently used to ensure that AI systems are aligned with human goals and objectives (Russell, 2021[196]). RLHF could be used to promote debiasing interventions in educational settings to help reduce the gender gap in mathematics as a result. RLHF uses feedback from human reinforcers to fine-tune outputs and all widely deployed large language models (LLMs) as of 2025 use RLHF to align their outputs with the way in which their modellers interpret “human values”. Adding to the existing safeguards, (Walkington, 2025[162]) recommends “counter-prompting” during content generation – e.g. explicitly instructing the model to depict female scientists in mathematically authoritative roles – which experimental evidence shows can reduce gender-biased portrayals by half without degrading narrative coherence. Furthermore, Italian data-protection rules should clarify that training snippets drawn from students’ work belong to the students, thereby limiting the recycling of potentially biased student-generated text into public models.

4 Use of AI to support the integration of students with an immigrant background

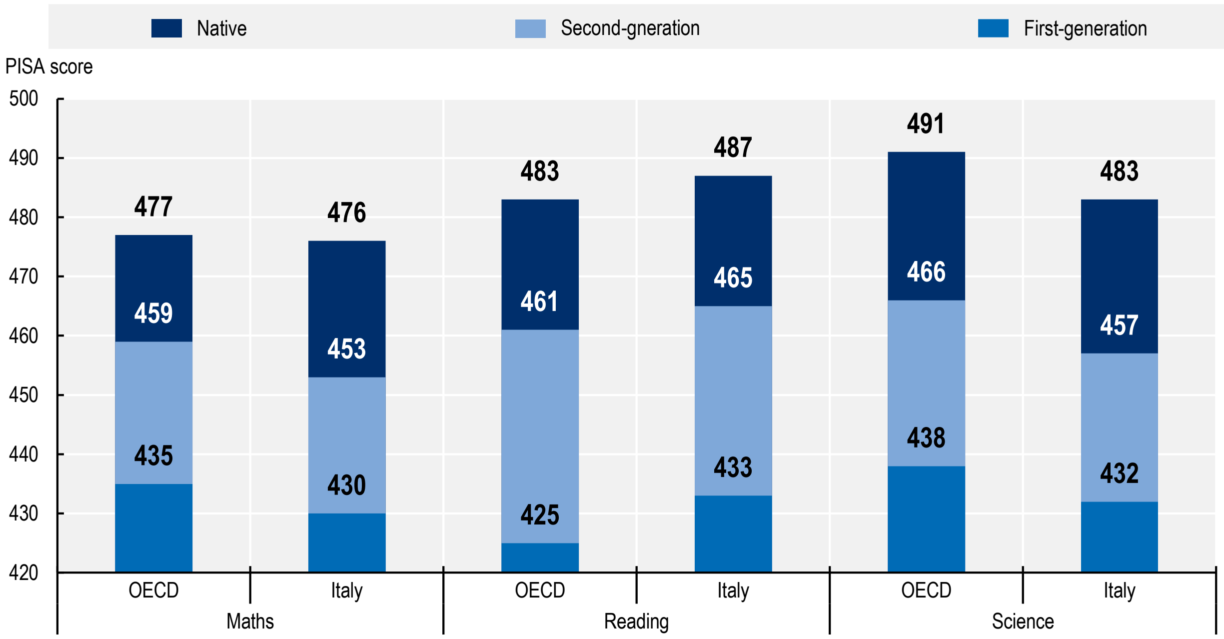
Immigrant children's educational outcomes

Italy's classrooms are becoming increasingly diverse. Children with an immigrant background now account for roughly one in eight learners in primary education, one in nine in lower-secondary schools and almost one in twelve in upper-secondary institutions. Italian is often a second (and sometimes third) language for many, and prior schooling ranges from uninterrupted progression in well-resourced systems to long periods of educational disruption (Pavesi, 2020[197]). Such heterogeneity in language proficiency, curricular familiarity and socio-emotional needs means that uniform support measures are unlikely to be effective in supporting their integration journey. Because starting points differ markedly, schools must calibrate both the level and the type of assistance they provide to address the linguistic diversity and uneven academic foundations of this heterogeneous group (Pavesi, 2020[197]). Early tracking into upper secondary school around age 14 is a critical juncture. Late-arriving students in particular may lack both the language skills and the time in the system to exercise genuine agency over their track selection. Without robust guidance and language support, they risk being funnelled into courses that are misaligned with their interests and/or potential.

Data from PISA in Figure 5 reveal persistent performance gaps across domains. Students without an immigrant background outperform their second-generation peers, who in turn outperform first-generation immigrants. The widest gap is in reading. In Italy, the mean reading-score differential between native and first-generation students is 54 points, while the gap between second- and first-generation migrants stands at 32 points. Although these disparities are slightly narrower than the OECD average, they remain very large.

Figure 5. Average PISA scores in core domains, by migration background

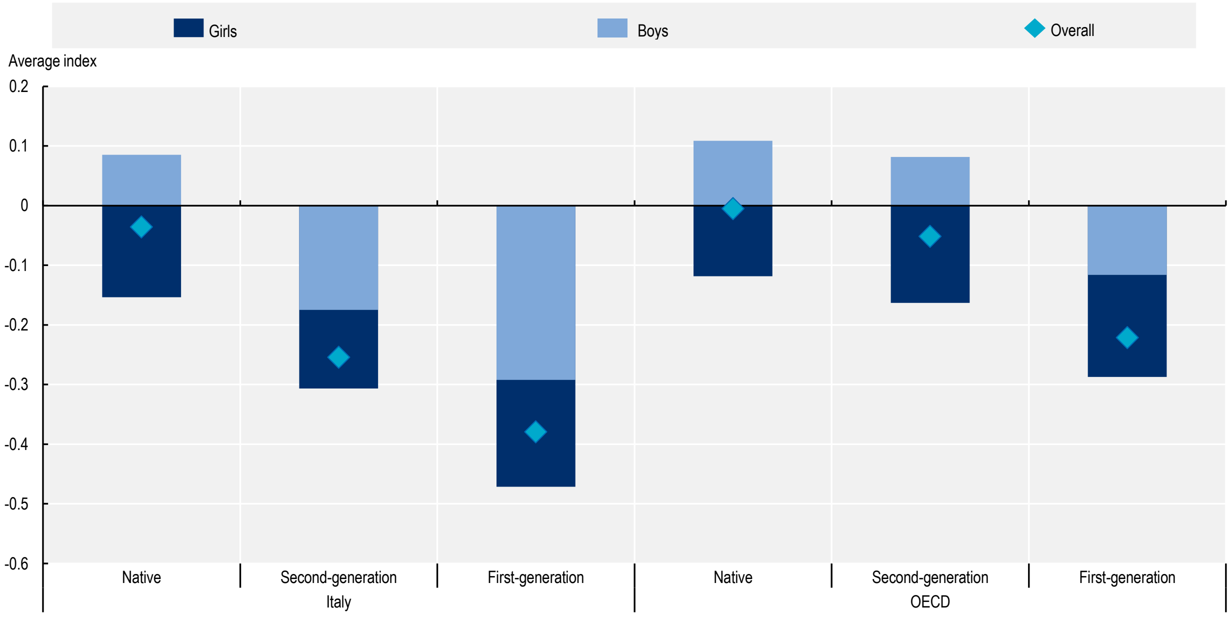
Average scores of 15-year-olds in PISA 2022 core domains (mathematics, reading, and science across native, second generation and first-generation migrant student in the OECD and Italy



Source: OECD (2023[41]), *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*, https://doi.org/10.1787/53f23881-en.

Academic outcomes are mirrored by affective ones. Figure 6 indicates that students with an immigrant background report a markedly weaker sense of belonging at school than their classmates without an immigrant background. Girls across all backgrounds feel less connected to school than boys, and first-generation girls register the lowest scores of all. The pattern is evident across the OECD but is especially pronounced in Italy.

Figure 6. Mean self-reported sense of belonging in school in Italy and OECD



Note: In order to measure students' sense of belonging at school, PISA asked students to report whether they "strongly agree", "agree", "disagree" or "strongly disagree" with six statements. These answers were used to construct an index standardised to have a mean of 0 and a SD of 1 across countries. Positive values indicate a stronger sense of belonging compared to the OECD average student and negative values indicate a weaker sense of belonging compared to the OECD average student.
Source: OECD (2023[41]), *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*, https://doi.org/10.1787/53f23881-en; OECD (2019[198]), *PISA in Focus #100: Have students' feelings of belonging at school waned over time?*, www.oecd.org/content/dam/oecd/en/publications/reports/2019/09/have-students-feelings-of-belonging-at-school-waned-over-time_1d5a20c8/bdde89fb-en.pdf.

The combined weight of demographic growth, early selection pressures, achievement gaps and low sense of belonging underscores the necessity for a multi-layered and resource-intensive support. Given budgetary pressures, AI may offer the possibility of developing and offering tailored language acquisition programmes at low cost.

Summary of evidence on key drivers of underperformance among immigrant communities

Immigrant-background students underperform their native peers in many countries, a gap that is driven by multiple factors (Porcu et al., 2023[199]). Key contributors include limited proficiency in the host-country language, socioeconomic disadvantage, and cultural or institutional biases. Table 8 provides an overview of the barriers that immigrant students' may encounter in integrating into their host education systems and societies more broadly:

Table 8. Summary of barriers to integration that immigrant students' may encounter

Barriers	Factor & brief description
Limited host-language proficiency	Proficiency in the language of instruction is critical to learning. Lack of language proficiency may hinder immigrant students' progress with learning. Language barriers correlate with lower achievement and greater social isolation in school (Borgonovi and Ferrara, 2020[200]; OECD, 2018[201]).
Socioeconomic disadvantage	Families with an immigrant background often have poorer socioeconomic and cultural resources than families without an immigrant background which can exacerbate learning differentials (OECD, 2018[201]).
Teacher expectations and attitudes	Some teachers may unconsciously grade immigrant students lower than their non-immigrant peers on coursework and not recommend them for academically enriching activities because they hold lower expectations of their learning potential. (Sahlström and Silliman, 2024[202])
Stereotype threat	Immigrants often face stereotypes about academic ability which may create anxiety and lower their achievement. (Appel, Weber and Kronberger, 2015[203])
Cultural mismatch / isolation	Lack of culturally responsive pedagogies or educational materials may leave immigrant students feeling alienated, which harms motivation and, ultimately, achievement (Lockwood and Kunda, 1999[161]).
Educational sorting and tracking	Immigrant students may be disproportionately placed in tracks with lower academic expectations or low ability groups within schools. The spatial division between newcomer and other students may, as a result, widens achievement gaps and lower social integration opportunities (OECD, 2018[201]).

Scope for AI to promote the integration of students with an immigrant background

Assisting in language teaching

Non-native speakers, particularly those who enter education systems in the target language after the age of 12, often require extensive support in learning the language of instruction, especially this differs greatly from the language/s they are proficient in (Borgonovi and Ferrara, 2020[204]). Across the OECD, there is much variation in the approaches that countries take to integrate students with no or limited proficiency in the language instruction. Some prominent types of support include: conducting early assessment and designing individualised study plans, introductory/welcome classes before transitioning to mainstream classes, and mother tongue tuition, amongst others (Cerna, 2019[205]).

Guidelines developed with the support of the Italian Ministry of Education, University and Research offer a broad view of how teachers may integrate multicultural and multilingual learning in the classroom, including promoting language and subject-matter knowledge learning through teaching in different languages. The recommendations include fostering the cognitive, identity and linguistic development of multilingual students in the classroom and promoting the development of critical and divergent thinking, the value of linguistic diversity and the value of multidisciplinary teaching for the benefit of all students. The guidelines identify translanguaging - the process of meaning-making and using vocabulary from multiple languages or dialects to communicate - as one that is desirable to implement in the language education curriculum (Zanzottera, Cuciniello and D'Annunzio, 2021[206])

AI could help teachers in carrying out a range of tasks that support language learning among students whose first language is different than that of instruction. Responsibility for the delivery of additional language instruction will vary across systems and schools, though often, teachers are expected to deliver additional instruction time and provide learning materials and resources tailored to the individual needs of language learners. Additionally, teachers are expected to engage in careful planning, tracking and assessment of student progress, adjusting goals and learning pathways in accordance with students' progress (Zanzottera, Cuciniello and D'Annunzio, 2021[206]). Teachers lacking specialist training, or who are already working within large classrooms in under-resourced environments, can find this challenging. Delivering on goals related to inclusion and plurilingual education in an education system-level requires investment and support of tools that can support such practices at scale. Table 9 provides examples of government funded – or otherwise supported – AI-powered tools rolled out on a systemic basis in OECD and partner countries.

Table 9. AI-powered tools assisting in language teaching

Government funded - or otherwise supported - AI-powered tools rolled out on a systemic basis in OECD and partner countries

Country	Function	Description
Canada	Digital language learning platform	The government has invested in the development and integration of AI into existing digital language learning platform, Voilà Learning. The use of AI is intended to enable the platform to gather information about each student's unique learning profile and provide them with personalised educational content that enhances student learning of French as a second language. The project is being conducted under the mandate and in partnership with 35 school boards across the country, where the tool is expected to be rolled out (Government of Canada, 2023[207]). Delegating or enabling AI to make recommendations or initial decisions on the content and the difficulty level of materials that students are given could greatly reduce the time and resources spent by teachers on creating and continuously updating personalised learning pathways.
Germany	Language assessment through Natural Language Processing	Federal Ministry of Education and Research is funding projects to develop Natural Language Processing (NLP) models to assess students' knowledge in the target language, and then to design a natural language generation technology capable of automatically adjusting the complexity of material and exercises to match the learning needs of the student (Hector Institute for Empirical Educational Research, 2024[208]; Tübingen Center for Digital Education, 2024[209]). The same developers at the Centre for Digital Education at Eberhard-Karls-Universität Tübingen are working on developing a digital learning platform that will generate grammar exercises based on users' indicated topics of interest to stimulate motivation and emotional wellbeing amongst learners (Tübingen Center for Digital Education, 2024[210]).
Iceland	Speech-recognition and feedback	The government supported the creation of a computer-assisted pronunciation training tool for students to give corrective feedback on speech, which has since been implemented in the Icelandic as a second language programme at the University of Iceland (Richter et al., 2022[211]). Further developments in Icelandic MT, ASR, and text-to-speech technology will enable ongoing integration of AI into existing EdTech tools (Language and Voice Laboratory, n.d.[212]).
Netherlands	Precise and personalised language feedback	The government is investing in technologies that could provide teachers with greater insights about the precise difficulties that students are facing. For example, exploring the use of ASR to identify students' progress and types of mistakes they are making; ASR can measure reading levels during regular classroom activities, allowing for more frequent technical reading skills progress check-ins, while reducing the time teachers spend on testing, marking and analysing student performance. The application has an accompanying dashboard that gives teachers insight into the development of technical reading skills at sound and word level. The tool is currently in the development/ testing stage and is part of the National Education Lab AI (NOLAI), an initiative financed by the Dutch government bringing together school staff with academics and AI developers to create and improve the quality of education technology (Radboud Universiteit, 2025[213]). Regardless of the degree of teacher involvement in the initial creation of personalised recommendations to students, NOLAI's ASR tools and other similar initiatives should include a teacher-centric dashboard or other space for teachers to be able to review the results of AI-led testing and evaluation exercises. Teacher input on the accuracy and relevance of scores and recommendations put forward to students will remain paramount.
Singapore	Marking system for language assessment	Singapore's National AI Strategy outlines work being done to develop an AI-enabled marking system for English-language instruction – the system is planned to be able to assess open-ended student responses such as short-answer response questions and essays, and provide quick feedback to students' work (Smart Nation Singapore, 2019[214]). Such tools could be used by teachers to cut down on the time spent marking and identifying students' specific areas of weakness.
Thailand	Language learning platform	Winner English is used for English-language instruction in some public schools in Thailand. For students, the platform comes in the form of a role-playing game through which they complete language learning exercises in and outside of the classroom. Winner English also features a Teacher Assistant System, which enables educators to see how students are interacting with the platform in real time and assign tasks. Moreover, generative AI functionalities can be used to suggest individual assignments to students based on their performance, taking into account areas of strength and weakness. The programme is a collaboration between domestic and international development organisations and is rolled out in affiliated schools which receive other forms of development assistance, though the content and lessons are aligned with the Thai Office of the Basic Education Commission, a governmental agency for education promotion (Vathanalaoha, 2022[215]; Khonthai Foundation, 2021[216]).

Risks and mitigation

The key challenge to the design and implementation of AI-powered tools for language instruction, and the integration of students with an immigrant background more broadly, lies in the metrics used to define and measure student outcomes. Just as standardised test scores or levels of reading literacy proficiency among non-native speaker students may not be indicative of their language proficiency or overall academic ability (De Angelis, 2014[217]), the measures imbedded in AI-powered teaching tools may carry similar limitations. Language learning is a complex process. While some studies provide evidence of a positive impact of AI on EdTech assisted language learning outcomes, specifically, on test scores, learning motivation and self-regulated learning (Wei, 2023[218]), there remains significant uncertainty regarding the effectiveness appropriateness in the given context. Tools may require learners to have some foundational literacy skills or assume the linguistic proximity of learners' first languages to the language of instruction.

Another risk inherent to language teaching in the context of learners with an immigrant background - whether enabled by technology or not -– is the marginalisation of learners' first languages and cultural identities. Multilingualism, also referred to as plurilingualism[2], involves the use of multiple languages in a setting and the promotion of positive attitudes towards linguistic diversity (European Union, 2019[219]). In practice, functional multilingual instruction may take the form of students from a similar linguistic background explaining concepts to each other in their native language, paraphrasing the learning content and seeking the teacher's input when needed. Such practices enabled students to reinforce the subject-matter learning while reinforcing their skills in both native and language of instruction (Sierens and Avermaet, 2013[220]).

Multilingual instruction

AI tools could help facilitate translanguaging practices in classrooms with students with limited language of instruction proficiency levels. Generative AI tools - such as chatbots, automatic speech recognition (ASR) or machine translation (MT) tools could enable students and teachers to communicate effectively in different languages and facilitate multilingual learning. However, the availability of such tools, particularly for public use and tailored to educational settings, remains limited. Table 10 provides examples of government initiatives supporting the development of such tools across several OECD countries, with a particular focus on low-resource languages, i.e. languages are those that have relatively less data available for training conversational AI systems and are typically excluded from mainstream commercial products.

Table 10. AI infrastructures for low-resource language

Government funded – or otherwise supported – infrastructures for the development of AI tools for public use across low-resource languages

Country; body	Language(s)	Investment amount	Description
European Union; several member states	24 official languages of the European Union	EUR 37.4 million	Co-founded by the European Union and several member states, the OpenEUroLLM project brings together leading universities, research organisations and industry partners (including developers and high-performance computing centres) from across Europe to develop an open-source multilingual and multimodal LLM for all 24 official European languages. The first model was released in September 2024, though work on updates and new models is ongoing. In May 2025, the project secured highly sought after computing resources on the LUMI supercomputer through the Finnish LUMI Extreme Scale Access 2025 call. The computing resources will be available for one year, providing time for essential experimentation. The project aims to democratise access to high-quality AI technologies, including for public institutions to use in the delivery of high-quality, multilingual public services. The models will be developed within the EU's robust regulatory framework, ensuring alignment and usability while maintaining technological excellence (European Commission, 2025[221]; Hajič, 2025[222])
Lithuania; Ministry of the Economy and Innovation	Lithuanian and English, French, German, Russian, Polish, Spanish, Ukrainian, Norwegian, Swedish and Danish	EUR 12 million	Since May 2024, investment has been made across six projects related to Lithuanian-language AI development. The tools under development will have a range of potential applications, including in educational settings and to support the development of Lithuanian language education technology. The largest project includes the development of a common Lithuanian language text database and vectorised Lithuanian language models, which will in turn enable the design and development of AI-based solutions and innovations in areas related to human language. Two other projects focus on the development or updating of monolingual and multilingual text databases in Lithuanian as well as English, French, German, Russian, Polish, Spanish, Ukrainian, Norwegian, Swedish and Danish. These will be made publicly available and can be used to develop new MT systems or other services based on MT and AI (Ministry of the Economy and Innovation of Lithuania, 2024[223]).

Country; body	Language(s)	Investment amount	Description
Sweden; AI Sweden	Swedish, Danish, Norwegian, Iceland; all 45 languages of the European Union	N/A	AI Sweden is a collaborative initiative of over 140 public, private and academic partners developing AI tools intended for public use in Sweden, it is partially funded by the Swedish government. AI Sweden focuses on the development of large language models in Scandinavian languages and is working on the development of language models for all 45 EU languages (AI Sweden, 2024[224]). Some of the models that they have released so far include GPT-SW3, the first large-scale generative language model for the Swedish language, which can be used by developers to construct tools such as chatbots in Swedish. They have also developed a MT tool for Swedish and English, using GPT-SW3, as well as handbooks and guidance on how their models and tools can be used (AI Sweden, n.d.[225]).
Denmark; Danish Ministry of Digital Affairs	Danish	DKK 30.7 million (~EUR 4.1 million)	Since December 2024, the government has supported a consortium of higher education and research bodies to develop an R&D platform for training, fine-tuning, evaluating and maintaining LLMs for Danish-language contexts; the platform builds on existing work done by the consortium in developing models and tools in Danish. The project represents a unified national effort to develop Danish-language AI infrastructures; all models and other project outputs will all be open-source and are tested across in public administration, education and health contexts, as well as with small and medium-sized enterprises. Use cases include assisting in the delivery of healthcare services or facilitating citizen-state interactions have a high priority in testing and development. One of the project outputs is a “sandpit,” in which sectoral experts across national projects collaborate to design and improve specific use cases in a flexible and secure environment. These programme features are intended to address biases, assumptions and other context-specific limitations of LLMs developed in English using industry-recognised performance benchmarks for Scandinavian LLMs to ensure model representativeness and suitability for the intended context (Enevoldsen, 2025[226]; University of Copenhagen, 2024[227]; Ministry of Digital Affairs, 2024[228]).
Iceland	Icelandic	ISK 2.2 billion (~EUR 13.6 million)	Between 2018 and 2022, the Icelandic government funded the “Language Technology for Icelandic” initiative, which included a range of projects for general public and education-specific application of Icelandic language accessibility through AI tools. The projects were a collaboration between nine different companies and organisations, including a consortium of universities and media firms. Almannarómur, a private non-profit institution was tasked with overseeing the projects; it acted on behalf of the Ministry of Education, Science and Culture in the project management, procurement, research and development, implementation, and evaluation. In terms of facilitating multilingualism, some of the projects included developing ASR technology for Icelandic to enable people who design and develop voice-based user interfaces to add Icelandic to tools such as voice-enabled MT, as well as a MT system between Icelandic and English, which will enable AI integration with pre-existing EdTech solutions for Icelandic language instruction (Language and Voice Laboratory, n.d.[212]; Nikulásdóttir, Guðnason and Steingrímsson, n.d.[229]; Ministry of Culture and Business Affairs, 2024[230]).

Parental involvement in the school community is another facet of integration and is associated with better academic and well-being outcomes for students. Evidence suggests that on average across OECD countries, the children of parents involved in the community are six percentage points more likely to report that they feel as though they belong at school and that they are satisfied with their life. At the same time, parents of students with a migrant background are less likely to be involved in the school community than parents of children without an immigrant background by as much as 17.4 percentage points across the OECD (OECD, 2018[201]). AI can promote the integration of non-native-speaking students in the broader education system and host society more broadly by facilitating parental involvement in the school community and integration into the broader host society; Box 1 provides examples of multilingual messenger apps and AI-powered chatbots developed by the private sector for use in educational settings and in the provision of public services.

Box 1. Multilingual messenger apps and AI-powered chatbots in the educational setting

Non-native speaking students and their parents have diverse backgrounds and needs. Multilingual messenger apps can improve communication between parents, teachers and school staff, supporting parental engagement in schools. With automatic machine translation increasingly built into many messenger apps; adapting these functions into EdTech solutions can enable families with little or no target-language proficiency to communicate independently, without interpreters or mediators.

TalkingPoints, a U.S. non-profit organisation, has developed a multilingual family engagement platform that combines AI-enabled machine translation with human translators. Used systematically across school districts in the United States, it allows teachers to share announcements, communicate in real time with parents in 150 languages, and track engagement through analytics. In-house research has shown that the platform has positive effects on reducing absenteeism and improving learning outcomes for marginalised students and English language learners (TalkingPoints, n.d.[231]; University of Chicago Harris School of Public Policy, 2019[232]).

Other commercial platforms also integrate automatic machine translation. *Remind*, for example, supports messaging in more than 90 languages and can be integrated with schools' learning management systems and allows verified community members such as extracurricular staff to participate (Remind, n.d.[233]; Remind, n.d.[234]). *PowerSchool*, *SchoolStatus* or *ParentSquare* are other examples of learning management systems or collections of EdTech solutions that incorporate automatic machine translation into their services.

AI-powered tools and services that connect individuals with a migrant background with services are not constrained to the education setting. Access to public services is becoming increasingly digital across the OECD; many governments have developed applications, tools or platforms to access information, determine eligibility, or even access or apply for different public services. Fifty-five per cent of OECD countries enable access to 75 per cent or more public services through a digital identity solution (OECD, 2024[235]). Apps developed by governments integrate services such as providing citizens with information, facilitating identification, registrations, applications for public services, or gathering citizen feedback (The World Bank, 2023[236]).

Risks and mitigation

The key risk associated with the use of AI-powered tools to foster immigrants' engagement in schools and communities and to empower their access to public services is their alienation from societies in which they live, as interpersonal, human-to-human interaction plays a crucial role in fostering integration (International Organisation for Migration, 2021[237]; Zhang et al., 2023[238]). In the pursuit of personalised information delivery and connecting people with tailored services through AI-powered solutions, individuals with an immigrant background may be deprived of channels of interacting with the communities in which they live, such as community-based organisations or local agencies. Moreover, the evidence supporting AI's ability to deliver on the personalised experience that it promises remains mixed, while it is not anticipated that these tools will have the capacity to acknowledge and respond to immigrants' complex socioemotional needs. Inaccurate translation of emotionally nuanced or culturally specific communication may exacerbate the challenges faced by immigrants.

Another challenge to harness investments for the development of AI-powered EdTech tools that can assist in language teaching will be sustaining long-term commitment. The pipeline of research and development of the infrastructures and models underlying multilingual EdTech is both lengthy and costly. Maintaining a focus on developing tools for public use with the needs of non-native speakers in mind requires careful consideration at every stage from decisions about which languages to prioritise in text database development, to the design of exercises and assessments that account for learner's diverse learning styles, literacy skills and educational backgrounds. Additionally, tools which rely solely on standard learning outcomes ignore risk overlooking broader indicators of language proficiency, such as functional and sociolinguistic knowledge about the language and environment in which one operates (Hulstijn, 2011[239]). Likewise, indicators and enablers of integration, such as students' relationships, identities and sense of belonging or their families' engagement in the school community will require complementary tools that go beyond language teaching along. Promoting well-being of immigrant students and their families. Learning the language of instruction is just one step in a student's educational journey. The integration of children into education systems is important for their academic outcomes, social and emotional well-being, as well as future labour market outcomes and social integration more broadly (Cerna, 2019[205]).

In order to minimise such risks, schools and public service delivery organisations could supplement AI translation with bilingual staff or community liaisons. Additional human oversight would not only reduce risks of mistakes or biases but also support community engagement. Training volunteers or utilising community organisation for interpretation can ensure accurate communication. Providing tutorials or in-person help to immigrant parents on using AI tools could equally promote engagement and reduce barriers to use. Furthermore, offering low-tech alternatives (such as printed multilingual notices) for families without connectivity could increase reach. Engaging immigrant community representatives in testing usability of AI tools could help identify cultural insensitivity, mistakes and facilitate understanding so that immigrant communities feel respected and included.

5 Rethinking education for an age of AI

AI is rapidly transforming economies and societies, reshaping skills needs as a result. Education systems are under growing pressure to reconsider curricular priorities, and more broadly, the objectives that societies pursue through schooling. A key question concerns whether and how schools and school systems are reviewing and revising curricular arrangements to help ensure that students will be adequately prepared for a society in which AI tools and agents are widely available and a labour market in which jobs, and the skills they require, are evolving. As AI alters how humans live and work, how are education systems changing, and how do they need to change, to prepare students for this new context? A renewed focus on distinctly human capabilities that complement AI and that underscores the irreplaceability of human skills is required. Another key implication of the rise of AI is the need to build AI literacy for all students. Ensuring every student attains a baseline of AI literacy – understanding AI's capabilities and limitations and being able to interact with AI tools effectively – is increasingly seen as essential (European Commission, OECD, 2025[240]). Without AI literacy, students risk being passive consumers of AI technologies rather than informed, critical users or co-creators.

The labour market effects of AI adoption

Empirical estimates of the impact of digital technologies on employment in the 20th-century and early part of the 21st-century are mixed: whereas some empirical studies reveal that technological developments have led to a growth in employment opportunities (Dixon, Hong and Wu, 2021[241]; Koch, Manuylov and Smolka, 2021[242]) others suggest that technological developments have reduced employment possibilities for workers (Acemoglu and Restrepo, 2020[243]). Overall, to date, empirical evidence suggests that past waves of technological developments did not lead to overall lower employment opportunities and net job destruction in the long run (OECD, 2019[244]). In fact, throughout the 20th century the employment-to-population ratio rose and the unemployment rate did not change over the long run (Autor, 2015[245]).

Nonetheless, in the past, computer automation did result in job losses, particularly in low-wage occupations in the manufacturing sector (Mann and Püttmann, 2023[246]), and generally among workers conducting routine work (Gaggl and Wright, 2017[247]). As a result of past waves of technological progress, today's workplaces demand people who can solve non-routine problems. As technologies capable of performing rule-based tasks were introduced, the importance of people's ability to solve complex problems that could not simply be solved by applying pre-specified rules grew (Autor, Levy and Murnane, 2003[248]). As opposed to only being able to follow narrowly specified rules, machine learning algorithms allow automata to perform a considerably broader set of tasks that lack rule-based solutions. It is possible that the advent of AI systems will radically change the demand for skills in the future as non-routine tasks fall within the scope of what automata can perform reliably; some tasks may disappear, while some workers will be required to learn with work effectively with new technologies.

Estimates suggest that as many as 80 per cent of the U.S. workforce could have at least one in ten tasks affected by the use of LLMs and around two in five employees might experience an impact on at least half of their tasks (Eloundou et al., 2023[249]). Recent analyses of online job advertisements in the United Kingdom and the United States indicate that, between 2021 and 2024, skill requirements for the average job changed by approximately one-third, with one in four jobs experiencing shifts in up to three-quarters of required skills (Lightcast, 2025[250]; Lightcast, 2025[251]). Moreover, in the United States, the pace of change between 2021 and 2024 (a three-year period) matched that observed between 2016 and 2021 (five years) (Lightcast, 2025[251]). The most disrupted occupations generally require extensive training or tertiary qualifications. For example, LLMs can substitute human labour in tasks such as writing and translation (Demirci, Hannane and Zhu, 2025[252]; Qiao, Rui and Xiong, 2023[253]).

In Italy, studies suggest that 15 of 22 million workers are exposed to AI, with 9 million workers employed in roles where AI is expected to complement tasks and 6 million in jobs at risk of substitution (Dagnino, 2024[254]; Zuanna et al., 2024[255]). Unlike earlier waves of automation that mostly affected low-skilled workers, AI threatens higher-educated groups by substituting specialised but standardised procedures while complementing complex decision-making. These pressures risk deepening existing regional and social disparities, particularly in southern Italy, where weaker digital infrastructure, lower educational attainment and uneven access to vocational training limit reskilling opportunities (EY/ Manpower Group, 2023[256]; Prometeia, 2024[257]).

Predictive studies point to increased occupational mobility and demand for EPOCH skills (i.e. skills such as Empathy, Presence, Opinion, Creativity, Hope) (Loaiza and Rigobon, 2024[30]) while also warning that low-skilled workers could face significant challenges. Structural weaknesses in the Italian labour market, such as existing skill mismatches and demographic decline, may inhibit resilience to the adoption of AI or the implementation of policies to mitigate the risks for workers. Fragmented training ecosystems and regional disparities point towards a need for more coordinated national strategies. Section 6 explores key elements of national strategies to help realise the potential and mitigate risks associated with AI diffusion.

Whether LLMs ultimately displace existing work or foster new forms of employment likely depends on how the technologies evolve, as well as organisational adoption practices, regulatory frameworks and institutional incentives (Autor, 2024[258]). Evidence on the impact of LLMs on labour markets is mixed, with early research indicating both substitution and complementarity effects. One way in which existing findings can be reconciled is to distinguish task complexity and, by proxy, required experience: in online consultancy marketplaces, decreases in demand are especially pronounced for short-term jobs and for jobs requiring novice workers to perform tasks that are complementary to the capabilities of existing LLMs. These results imply that the increased productivity of novice workers within firms (Brynjolfsson, Li and Raymond, 2025[259]) may reduce the need for novice freelancers. At the same time, the developing capabilities of LLMs appear to increase the need for workers with experience working on complex tasks.

Because the capabilities of AI tools continue to expand in unpredictable ways, today’s in-demand skills – such as prompt engineering – may become irrelevant if the outputs of AI systems were to become less responsive to prompt quality. As the capabilities of AI tools and applications evolve, their performance remains uneven: tasks that lie within today’s frontier can be completed rapidly and at low cost, yet performance deteriorates sharply for tasks that fall outside this frontier (Dell’Acqua et al., 2023[260]). Knowing where that boundary sits is a critical metacognitive skill. It is, in effect, a form of digital risk management: learners must weigh the reliability, transparency, and downstream consequences of delegating a task to AI against the comparative advantages of human cognition. This evaluative competence is going to be more valuable than routine coding skills (OECD, 2025[261]), - demand for which is already flattening as AI systems rapidly improve at solving coding problems, displacing early-career workers in the tech and other industries (Brynjolfsson, Chandar and Chen, 2025[262]).

As a consequence, education systems are required to balance responsiveness to labour-market signals with a commitment to deeper learning that equips young people to adapt to unanticipated change and to participate fully in civic and democratic life. This entails equipping young people with the ability to make the most of AI tools but also cultivating the skills that lie beyond AI’s capabilities. Supporting the integration of AI literacy

AI literacy is emerging as a critical component of general education – often defined as the knowledge, skills and attitudes needed to understand AI and use it effectively and ethically. In 2024, UNESCO published an AI competency frameworks for students (UNESCO, 2024[263]) and teachers (UNESCO, 2024[264]). The frameworks serve as a guide for education systems to build the competencies required of all students and citizens for the effective implementation of national AI strategies and the creation of inclusive, just and sustainable futures in the era of AI. In 2025, the OECD, in partnership with the European Commission, published a preliminary AI literacy framework for primary and secondary education: *“Empowering Learners for the Age of AI”.* The framework outlines the essential competencies students need to navigate, collaborate with, and shape AI technologies. AI literacy encompasses not just technical know-how, but also an understanding of AI’s societal impacts and ethical implications. In essence, a student who is “AI literate” should grasp *what AI is, how it works, where it is applied, and what its limitations and risks are*, and be able to engage with AI tools responsibly (OECD, 2025[265]).

The OECD’s draft AI Literacy Framework organises AI literacy into four key domains of competence: engaging with AI, creating with AI, managing AI, and designing AI. Supporting these four domains are 22 specific competencies, ranging from technical skills (e.g. understanding data and algorithms) to socio-emotional skills (e.g. assessing AI’s impact on society). Importantly, the framework emphasises that AI literacy is not purely a technical domain. For instance, the framework highlights ethical thinking, critical mindset, and awareness of bias as core parts of AI literacy. Another characteristic of the OECD/EC AI literacy framework is that it recognises the importance of integrating AI topics across the curriculum. Rather than treating AI as an isolated subject, it encourages embedding AI literacy within mathematics, science, social studies, arts and more. Because AI systems are probabilistic and often opaque, assessing their fitness for purpose cannot rely solely on narrow technical expertise; it also calls for habits of critical inquiry long nurtured in the humanities and social sciences. Whereas only few students will need to become machine-learning specialists, most will have to be able to decide not only how to use AI, but also whether to use it at all in specific contexts and circumstances.

International frameworks recognise the need of teachers foster digital futures of their students, who in turn need to build core AI competencies for lifelong learning required of students across all subjects. If AI tools can map entire national literature curricula, students must learn to frame corpus-level questions, interpret statistical visualisations and recognise how training data shape what is (and is not) considered in large models. In practice, this means blending close reading with data literacy: young people still need to be able to dissect metaphor and argument, but they also need to learn to query dashboards, assess sampling bias and weigh quantitative evidence against qualitative insight. Such hybrid competence is needed to engage critically with AI-augmented knowledge platforms and to act, whether as citizens or workers, with an informed understanding of how large-scale textual evidence.

Similarly, AI is giving rise to “distant writing” (Floridi, 2025[266]), recasting text production, with authors becoming designers whose role is to specify aims, constraints, and ethical guard-rails while large language model draft written text. The use of AI as literary mediators requires a shift in the pedagogy of writing instruction which incorporates the teaching of prompt engineering, iterative refinement and curation. Teaching composition in a “distant writing” framework involves creative-writing workshops, with learners critiquing alternative machine outputs, being asked to justify editorial decisions and discussing attribution and bias. Although skills such as clarity of exposition, the selection of register, and argumentation capacity, remain indispensable, but they are accompanied by the capacity to decide what should be delegated to AI, how to verify its reliability and when to reclaim full human control. Embedding this meta-writing literacy across the curriculum ensures that young people remain authoritative authors even when “writing” increasingly involves a conversation with machines.

None of these curricular shifts will gain traction unless schools receive orientation, or up-to-date information on how skill requirements are evolving and guidance on which new literacies warrant classroom time. Effective orientation draws on labour-market analytics, horizon-scanning research and employer partnerships to translate emerging demands into concrete learning objectives before skills gaps widen. Establishing such feedback loops means equipping national and local authorities to curate timely intelligence, supporting teacher professional development so that staff can interpret - and teach - the findings, and embedding flexible curriculum governance that permits rapid adjustment without sacrificing depth. In short, orientation functions as the antennae of the education system, allowing schools to recalibrate in real time and ensure that every learner acquires the competences most likely to remain valuable as AI redraws the contours of work and citizenship. The design of orientation is closely aligned with national strategies to the use of AI in the education system and the provision of other public services – investments by governments in this area can reflect the complexity of this task (Presidencia, 2025[267]).

Cultivating uniquely human capabilities

Education systems have a role in preserving their key goals and standards, while also reorienting curricula to cultivate human strengths that add value alongside AI. In practice, the expansion of AI is placing renewed demands on education systems to empower students to think critically and creatively, solve complex problems, communicate and collaborate, and develop ethical perspectives – competencies which not only complement AI, but also enable students to guide the use of AI responsibly. By prioritising what is "uniquely human" in students' development, schools can future-proof learners for roles where they work with AI in meaningful ways, rather than competing with it.

A number of frameworks have been proposed to define these distinctly human skills that machines cannot easily replicate, providing guidance for curriculum priorities in the AI era. One such model is the EPOCH framework (Loaiza and Rigobon, 2024[30]), which identifies five core human capability domains:

- **Empathy and emotional intelligence**: Essential for understanding, teamwork, collaboration, and building relationships. This includes capacities like compassion, altruism, communication, and genuineness. AI-driven agents aiming to perceive and respond to emotional cues remain highly limited, facing fundamental technical and ethical challenges. Empathy involves genuinely understanding and sharing another's experience, creating meaningful connection.
- **Presence, networking, and connectedness**: Pertains to the value of physical presence for face-to-face interaction, spontaneous collaboration, and building trust. It also includes abilities related to physical tasks such as dexterity, touch, and lived experience. Being physically "on the ground" is seen as important in some fields, like journalism.
- **Opinion, judgment, and ethics**: Encompasses critical thinking, synthesizing information, considering diverse perspectives, integrating rational analysis with intuition, and making moral considerations for decision-making. Key attributes include causality understanding, agency, accountability, responsibility, and self-determination. AI faces challenges in areas requiring accountability, navigating open-ended systems, and respecting human self-determination, as it often struggles with complexity, contextual nuances, moral reasoning, and delivering ethically unquestionable judgments in dilemmas.
- **Creativity and imagination**: Important for generating novel ideas and visualising possibilities beyond reality. This group includes curiosity, improvisation, humour, challenging conventions, originality, flexibility, risk-taking, and conceptualisations. AI-creativity is often tied to existing data, potentially lacking diversity and originality, and machines struggle with genuine curiosity.
- **Hope, vision, and leadership**: Includes capabilities like optimism, initiative, grit, perseverance, and the ability to develop a goal and inspire others towards it. Humans have a sense of purpose and objectives, while AI, so far, lacks the ability to create such a vision.

The EPOCH framework effectively urges educators to focus curriculum and pedagogy on elevating students' empathy, interpersonal skills, ethical reasoning, creativity and hopeful vision. For instance, an EPOCH-aligned curriculum might include socio-emotional learning for empathy and presence, debate clubs and ethics courses for opinion/judgment, makerspaces and arts for creativity, and student leadership projects for hope. At the same time, even when tasks relying on capabilities which are presently uniquely human will be automated in the future, individuals should retain the relevant skills so as to be able to understand and work alongside technologies and work independently of technology.

Beyond EPOCH, the *OECD's Learning Compass* defines three transformative competencies that students need in order to shape a better future: creating new value, reconciling tensions and dilemmas, and taking responsibility (OECD, 2025[268]). These map closely to distinct human abilities. Creating new value parallels creativity and innovation; reconciling tensions requires empathy, perspective-taking and ethical judgment (understanding diverse viewpoints and finding common ground); taking responsibility entails acting with agency and integrity for the good of society – akin to leadership and hope. Notably, these competencies are uniquely human and not within the capability of existing AI systems (OECD, 2025[261]).

Similarly, the World Economic Forum and other organisations highlighting "21st Century Skills" point to a mix of cognitive, interpersonal, and intrapersonal skills that are becoming more valuable. The 2025 WEF's future of jobs report (World Economic Forum, 2025[269]) lists skills like creative thinking, analytical thinking, curiosity, social influence, flexibility, and as among those increasing the in demand – essentially the human skills that complement technology. These overlap significantly with EPOCH and the OECD competencies. Education systems are responding by incorporating human-centric, 21st-century skills into their curricula (OECD, 2020[270]).

One practical model for implementing these 21st century skills is through project-based and inquiry-based learning. Because human skills such as empathy, teamwork and creativity are best learned by doing, pedagogies that allow students to work on meaningful projects, solve open problems, or engage with their community tend to cultivate these competencies. This aligns with guidance from OECD and UNESCO that education should emphasise "learning to learn," collaboration, and student agency as core outcomes for 21st century education systems (OECD, 2020[270]).

The importance of investing in skills that are broadly aligned with 21st century skills frameworks such as EPOCH has been recognised in Italy in new legislation which aims to integrate non-cognitive and transversal skills in the Italian education system. The recently promulgated Law No. 22 of 19 February 2025 embeds the systematic development of "non-cognitive and transversal competences", such as critical thinking, emotional intelligence and collaborative problem-solving, in all programmes in the Italian school system, provincial adult-education centres and regional vocational programmes (Gazzetta Ufficiale della Repubblica Italiana, 2025[271]). The law charges the Ministry of Education and Merit with introducing the promotion of these competences from the 2025/26 academic year, beginning with a nationwide audit of existing initiatives against early school-leaving and educational poverty. The Ministry also has the responsibility of developing and publishing a three-year national training plan for teachers and set, in consultation with the Higher Council for Public Instruction (CSPI), the criteria for a controlled national pilot open to state and independent schools.

The reform's underlying aim is to equip young people and adult learners alike with the personal and social skills that employers and communities increasingly prize. By strengthening non-cognitive and tranversal competences and helping young people's capacity to manage emotions, communicate effectively and work in diverse teams, the reform aspires to promote students' well-being, foster inclusion and reduce disengagement. In policy terms it represents a shift from an exclusively academic paradigm towards a more holistic view of learning that values attitudes and behaviours alongside knowledge.

No additional funds have been allocated in support of the reform. As a result, implementation rests largely on existing resources. Schools that volunteer for the pilot will design projects aligned with the national criteria and obtain ministerial approval, but they must rely on the staffing already available with no extra funding for overtime. The goal is for participating teachers to receive targeted professional-development courses, and be encouraged to adopt experiential, collaborative and work-linked learning methods, often in partnership with external experts and local employers. The law also invites schools to personalise pathways so that each student can practise and evidence these competences, gradually embedding them across curricula and classroom practice as the pilot expands to full national roll-out.

Adapting curricula to technological change

Aligning education with technological advances is complex and often slow (OECD, 2020[270]). Rapid developments of AI tools and applications make it particularly challenging to reform curricula. Changes in AI capabilities are shifting skills demands in unpredictable ways, but are also creating competing views over the risks and opportunities associated with technological developments. This can create resistance to reform, complicating decision-making over the direction of reform, the adoption of specific reform initiatives and how such initiatives are implemented in schools.

In the past quarter of a century, many OECD countries have launched curriculum reforms to equip students with digital competencies, computational thinking, as well as the broader skillset needed to adapt in increasingly digital societies and labour markets. Their experience in developing curriculum reforms, promoting stakeholder engagement, facilitating decision making and reducing the time lag between the recognition of the need for action and the time when reforms impact learners in classrooms can provide valuable insights into reform options and key issues for consideration in curriculum reform planning. The following points emerge from a review of the experience of different countries, with a focus on the cases of England (United Kingdom), Finland, Japan, New Zealand and Korea (for additional details on school curriculum reform processes in these countries, see 6Annex A):

- **Foresight and early recognition:** Successful curricula reforms often stem from proactively forecasting future skill needs. Countries that identified the digital transformation early (for example, England leveraging the Royal Society report on computing, or Finland using futures thinking to draft transversal competences), reduced recognition lag and built a compelling case for change. Some countries use formal foresight tools, for example Japan's Education Council and Korea's national plans explicitly linked curriculum goals to anticipated AI-era competencies. Incorporating frameworks like the OECD Learning Compass 2030 helps keep a future-oriented view, closing the recognition gap (OECD, 2020[270]).
- **Clear vision and strategic framing:** Developing a clear narrative linking curriculum change to national goals such as in the case of New Zealand framing its digital curriculum as key to "future-proofing" the economy and Japan tying its curriculum to "society 5.0" ambitions helps mobilise stakeholders, maintain momentum, ensuring a coherent reform design, and building consensus, making it easier to sustain support throughout the reform process.
- **Stakeholder engagement and consensus-building:** Successful reforms engage educators and experts in design, although the form such consultation takes can differ greatly. Broad consultation (such as in Finland and New Zealand) often lengthen the decision-making phase but can effectively reduce potential resistance later in the process, ensuring smoother implementation. By contrast, consultation with primarily selected experts and key stakeholders such as tech industry experts can lead to swift decision making but potentially encounter resistance during adoption and implementation. Ensuring that decision making processes are transparent, such as publishing drafts for comment, responding to feedback, can build trust and support system coherence by aligning the curriculum's goals with teachers' beliefs and public expectations. Notably, including student voice is an emerging strategy (Australia, Canada, and some OECD systems) to ensure relevance, although it remains underused in practice (OECD, 2020[270]).

- **Phased implementation with support:** A clear pattern of reform initiatives is the adoption of phased roll-out strategies accompanied by significant support measures. When reforms were imposed suddenly without support, they risk opposition in classrooms. Countries like New Zealand and England provided lead time and resources (curriculum guides, training funds, "master teacher" mentorship schemes), which helped shorten the implementation lag. Phasing can mean starting with pilot schools or specific grades (as Japan and Korea did) to learn and adjust before adoption is scaled. Continuous professional development for teachers is essential: reform leaders caution not to underestimate "teachers' fear of the unknown" (OECD, 2020[270]). Empowering teachers through training and involving them in material development fosters buy-in and competence, speeding up effective implementation.
- **Governance and continuity:** Systems that combined strong policy direction with continuity navigated reforms more effectively. In centralised systems, such as Japan, Korea, a clear mandate from the top ensured decisions were made, but the creation of structures such as expert committees was key to sustain reform efforts beyond electoral cycles. By contrast, decentralised systems, such as Finland and New Zealand for example, tended to rely more on leveraging local autonomy for innovation while maintaining national guidelines to align efforts. Frequent curriculum tweaks can cause reform fatigue, so many OECD countries space major overhauls (aound 10-year cycles) but allow incremental updates in between for agility. Striking this balance is critical yet difficult given rapid change in AI capabilities.
- **Alignment with assessment and other reforms:** Curriculum reform in initial education system should be aligned with broader education, economic, and social goals and strategies. For example, Japan updated its university entrance exam to emphasise competencies like problem-solving in tandem with the curriculum changes. Wales (United Kingdom) and Finland linked curriculum reform to new assessment practices focusing on formative assessment and competencies, ensuring signals to teachers and students are consistent. Moreover, integrating curriculum reform with digital infrastructure initiatives (Japan's device rollout, Italy's digital classroom investments) and with labour market policies (Korea's talent development plans) yields synergies and underscores the reform's importance. This avoids isolated curriculum changes that teachers might otherwise dismiss amidst conflicting priorities.
- **Iterative evaluation and flexibility:** Agile reforms treat implementation not as the end, but as an ongoing learning phase. New Zealand's commitment to gather feedback during rollout and adjust content or support accordingly is a good example. Similarly, countries that monitor early indicators (teacher preparedness, student engagement) can make mid-course corrections – e.g. Korea expanding teacher training when initial surveys showed low teacher confidence. This responsiveness to data shortens the impact lag, as issues are addressed before an entire student cohort is lost. It also prevents "lock-in" of flawed approaches – curriculum policies are refined in real time for better effect.

Box 2. Gauging AI adoption in the Italian education system

As of September 2025, there are no national surveys on whether and how Italian schools are taking AI into account in their educational offer, with only a few non-representative exceptions such as exploratory reports focusing on teachers (and no analysis based on administrative data). The *Piani Triennali dell'Offerta Formativa* (PTOF), strategic and pedagogical documents that every Italian school must draw up and submit every three years to the Ministry of Education, provide an indication of whether schools consider and include AI in their educational priorities, curricular and extracurricular offerings, organisational structure and innovation strategies.

We examined the PTOF documents for primary to upper secondary schools for the period 2022-25. Among the retrieved plans (out of 11 808 public and private schools, the PTOFs of 8 958 schools were retrieved), 3 695 schools mentioned artificial intelligence, accounting for almost one in two schools. AI mentions were more frequent in schools in the South than in the North. Upper secondary schools, particularly those offering academic programmes, showed the highest mention rates, followed by vocational schools.

Through a comparison of ministerial documents listing PNRR funding allocated to each school during the same period with PTOF AI mentions, we find that 92 per cent of the schools mentioning AI in their 2022-25 plans received funding through at least one of the *PNRR's Piano Scuola 4.0 (Missione 4, Componente 1)* investment lines with specific reference to AI or digitalisation, compared to 73 per cent of schools not mentioning AI. Although purely descriptive in nature, this suggests that, in the context of accessing PNRR funding, Italian schools have begun to pay greater attention to AI-related issues, both in terms of teacher training and the adaptation of teaching tools and pedagogical approaches.

Going forward, cross-searching results of documents relating to the 2025-28 three-year period, when fully available, together with an in-depth examination of projects funded in each school, will provide more accurate information on the most recent or ongoing adoption of AI tools in Italian schools and the relationship between this and government funding initiatives.

Note: Pre-schools were not included. Data for autonomous provinces of Bolzano and Trento were not available.
Source: Ministry of Education and Merit (2025[272]), *Scuola in Chiaro*, https://unica.istruzione.gov.it/portale/it/scuola-in-chiaro; INDIRE (2025[273]), *L'intelligenza artificiale entra in classe: cosa ne pensano i docenti? Risultati indagine INDIRE e Tecnica della Scuola*, www.indire.it/2025/03/13/lintelligenza-artificiale-entra-in-classe-cosa-ne-pensano-i-docenti-risultati-indagine-indire-e-tecnica-della-scuola/.

6 A national strategy for AI adoption in education

Key principles and factors for policymakers' consideration

Even within the same country, views on the adoption of digital technologies in schools remain polarised. Therefore, decisions about AI adoption could start not with the tools themselves, but with the problems their adoption is meant to solve. Anchoring adoption to well-defined policy objectives gives policymakers a clear yardstick for weighing benefits against risks and for choosing safeguards to mitigate risks and vulnerabilities. Robust data-protection frameworks, algorithmic-bias audits, sustained teacher professional development and transparent procurement processes then become integral parts of a strategy that keeps AI accountable to the educational outcomes societies care about most. In previous waves of digitalisation that have affected education systems, the "human factor" has been considered just as important, if not more, than computer security and data protection systems to securing students' data and safety online (Richardson et al., 2020[274]).

National bodies such as INDIRE have launched open questionnaires and repositories of case-studies to map practice and inform professional development ahead of new guidance expected in 2025 (Bertazzi, 2025[275]). Taken together, the Italian evidence mirrors wider international patterns: high informal experimentation, limited curricular integration and a pressing need for structured professional learning, clear governance and equity safeguards.

Principles of AI implementation

As illustrated by the use cases of AI highlighted in this report, there are several general principles that should be carefully considered by educators and policymakers when implementing AI within educational systems, irrespective of its features and systemic challenges:

- **Intentionality and pedagogical alignment:** AI is a means, not an end, and its deployment must be explicitly linked to clearly articulated pedagogic goals. Tools should be selected (or rejected) after policy makers and educators specify the knowledge, skills or dispositions they are attempting to cultivate, the metrics by which success will be judged, and the complementary human inputs required. The efficacy of AI use hinges on purpose, context and design. Research needs to be conducted in schools to pilot new applications in controlled settings, compare outcomes against non-AI alternatives, and iterate rapidly in response to emerging AI capabilities. Teachers are and remain central. They are the ones who can interpret analytics, curate prompts, integrate tools into daily activities and model behaviour so that students learn with the technology rather than merely from it. Teachers should therefore be involved in decisions related to AI adoption and budgets for professional development should rise in tandem with AI expenditure rather than be sacrificed as a result of it, ensuring that staff possess the evaluative capacity to match tools to tasks. In this light it is worrying that in many countries teachers report not being adequately involved in decisions over AI use.

- **Precaution:** Where a simpler technology with lower safety risks can achieve a comparable learning objective to AI tools, it should be preferred. This is especially the case because minors, who cannot give fully informed consent, are the users of AI tools in education. At its core, AI involves the deployment of algorithms and computational models that process large amounts of personal data. Precaution aligns experimentation with the duty of care owed to compulsory-age learners. A practical expression of precaution is a staged roll-out, which could help identify the effectiveness of different AI tools and adoption strategies through experimental protocols and evaluation strategies. AI tutoring could be reserved for optional enrichment sessions before being integrated into core subjects; daily usage time in school settings could be capped; or independent effectiveness reviews could be mandated before the renewal of licenses. Integrating these mechanisms could create opportunities to detect harms early on. They could also mean that biases could be rectified, and cost-effectiveness demonstrated, before entire cohorts of students are exposed to new tools and methods.
- **Educators' supervision:** Personalisation is not an unqualified good. Humans are "cognitive misers": their tendency is to default to processing mechanisms of low computational expense, willingly outsourcing effort whenever a shortcut presents itself (Bastani et al., 2025[113]). As a result, many may develop a false sense of mastery, being confident about being able to solve tasks the programme has already simplified. Unless policy makers build robust supervision over deployment, such complacency will be identified only when students confront situations that lie outside the parameters of their training. Educators, with training, should therefore be empowered with adequate resources to monitor not only immediate attainment but also learners' capacity to apply knowledge in novel settings.

Setting the goalpost of AI integration: Key factors for consideration

The decision to integrate AI into education systems extends beyond questions of technological feasibility or cost-effectiveness. It requires weighing how personalisation affects not only individual learning outcomes but also the social, civic, and democratic functions that schools have traditionally served. The following considerations highlight core tensions that education systems navigate as they define the goals and boundaries of AI use in schooling.

Education systems have long had to navigate whether schooling should be organised around classes and school programmes grouped by students' common interest and ability, or reflect the full spectrum of learners' abilities and personalities, and at what age differentiation should occur. Countries that do not separate students with different learning styles and preferences typically do so because exposure to diversity is seen as beneficial for learning and children's development. By contrast, systems that group students into distinct tracks and programmes do so to promote efficiency, for teachers who can tailor instruction more easily, and for learners who can progress at a more standard pace. Because of its personalisation potential, AI adoption may enable education systems to combine the benefits of differentiation and integration, allowing greater flexibility in educational provision without the stigma or rigidity of early selection. AI-driven personalisation can enhance engagement and responsiveness, but evidence also indicates that unequal access to digital tools and paid features may deepen existing socio-economic divides. Human mediation remains essential to interpret AI outputs, contextualise learning, and ensure that technology serves inclusive rather than stratifying purposes. Equity considerations must therefore be embedded from the design stage of any AI-based learning intervention.

However, the potential social implications of AI adoption go beyond how schooling is organised. Mastering content in an individually optimised learning journey may also not necessarily prepare young people to apply knowledge in new settings. Educational psychologists have long documented the value of "desirable difficulties": tasks that are effortful in the moment but foster durable, transferable competence (Bjork and Bjork, 2020[276]). If hyper-personalised AI tools were to remove too much productive struggle, they could offer short-term performance gains at the expense of long-term learning capacity (Kosmyna et al., 2025[6]). Education systems may therefore need to balance the measurable short-term learning improvements – often prioritised in international benchmarking exercises – against longer-term developmental outcomes that are harder to trace but ultimately more consequential.

There is also a cultural price to be weighed. Schooling is first and foremost a civic institution. In school children learn to negotiate a common good and encounter perspectives different from their own and those of their family members. A generation habituated to bespoke optimisation afforded by AI systems, whereby input received perfectly aligns with their interests and needs, may struggle to honour the principles and requirements of social cohesion. In an era where algorithms already shape much of everyday experience, the degree of personalisation introduced into schooling could alter how learners perceive themselves and others, shifting focus from collective engagement to individual well-being as the primary metric for judging the world. A quantitative difference in the degree of personalisation might bring about a qualitative difference in perceptions of the self with increased emphasis on the individual considering his or her well-being as the key metric by which to judge the outside world. Hyper-personalisation may therefore nurture a generation in which learners' own well-being is the sole metric by which they may come to judge the world. The implications stretch beyond academic attainment. Democracies depend on citizens capable of negotiating between personal preferences and collective goods.

Finally, socialisation is not value-neutral. Every curriculum transmits norms about history, identity and civic responsibility, but in the analogue era these were interpreted by thousands of teachers whose diversity "pluralised" the hidden curriculum. The introduction of AI tutors and automated learning systems consolidates that interpretive authority into a small number of proprietary models, shifting who controls the transmission of cultural values and social norms in education. While policymakers are already familiar with disputes over textbook content, AI is bound to amplify these dilemmas: code must make value priorities explicit, and the same underlying models or prompt libraries may reach millions of learners across contexts with very different moral and civic expectations. Current governance and technical mechanisms, such as transparency requirements, model documentation or content filters, offer only partial solutions, as trade secrecy, rapid model iteration and the opacity of machine learning processes limit effective oversight.

Control is further complicated by ownership. Most systems remain black boxes protected by trade secrecy. Education ministries lack visibility into the training data, optimisation targets or update cycles that shape the daily dialogue between learner and machine. Caution should be taken in the roll-out of commercial tools in formal education systems, particularly when equity is a goal; output is only as equitable as the corpora on which they have been trained, for example, mathematics textbooks dominating English-language training data have been found to embed narratives that marginalise or disengage minority students (Walkington, 2025[162]).

The European Union's AI Act classifies education as a "high-risk" domain, imposing stringent transparency, traceability and human-oversight duties on vendors and schools alike. Yet compliance costs are steep, and many lack the auditing capacity the regulation prescribes. Where oversight is weak, systems may perpetuate bias and stereotypes at scale before errors are detected. Sustainable and equitable AI integration requires participatory governance involving educators, students, families, and social partners in decision-making. Collective dialogue and negotiated implementation at the national, regional, and school levels, can strengthen transparency, trust, and alignment with educational values. Such engagement ensures that AI adoption in education reflects shared priorities.

Emerging fields like Machine Behaviour (Rahwan et al., 2019[277]) consider how AI systems can be led to reflect and align their outputs with human norms, yet there is no consensus on how this can be best achieved. It has been proposed that AI systems' outputs should approximate societal consensus and shifts in such consensus should be reflected in AI generated content (Awad et al., 2018[278]; Dwork et al., 2025[279]) Reinforced learning with human feedback (RLHF) is one of the means through which such consensus can be achieved, aligning AI tools with "human values". However, key challenges to date related to RLHF’s use include, for example, difficulties associated with selecting human trainers that are representative, and in determining what representation entails (Casper and et al., n.d.[280]). For instance, OpenAI’s training of GPT-4 relied on human reinforcers who aligned with expert researchers’ preferences (Long Ouyang, 2022[281]), potentially introducing biases due to systemic issues in training and hiring. Furthermore, the demographics of human reinforcers may not reflect those of the general user base. More fundamentally, building AI systems that achieve alignment through a democratic process may be impossible in practice, even when reinforcers are representative of underlying user populations (Mishra, 2023[282]). Implications for education systems are especially profound given the key role played by schools in socialising children into norms and mores that guide behaviours. Rather than pursuing a "one-size-fits-all" approach, focusing on narrow, user-specific AI alignment may be more practical and effective for application to satisfy the needs of smaller and communities that are relatively homogeneous in terms of preferences and goals (Mishra, 2023[282]).

Data protection adds another layer of fragility. AI tutors function best when they capture moment-to-moment signals of engagement, emotion and performance – data that, by definition, are both personal and sensitive. For minors, consent must be meaningful as well as comply formally with regulatory frameworks. Families who distrust the technology – or who simply wish to keep their children’s digital footprint minimal – need a practicable right to opt out without suffering from academic penalties or access to learning options. The UNESCO global guidance on generative AI in education underscores this principle of human-centred design, urging governments to legislate “privacy by default” architectures alongside strong data-minimisation and deletion protocols UNESCO (Miao and Holmes, 2023[283]).

A final concern is equity. In disadvantaged communities, the gap between the promise and the reality of personalisation may widen existing gaps. Allocation of public funds to subscription licences can also crowd out investments in libraries, laboratories and extracurricular programmes whose benefits remain essential to education. Moreover, tailored support to enable educators and school leaders in schools with a concentration of students from disadvantaged backgrounds will be necessary to ensure equal uptake; yet, a 2024 RAND study found that in the United States, teachers in schools in disadvantaged areas were half as likely as principals in more advantaged areas to report that guidance to educators was provided (13 per cent and 25 per cent, respectively (Kaufman et al., 2025[284]).

Towards a national strategy for AI adoption in education

Against the backdrop of emerging guiding principles and ongoing foundational debates on the integration of AI in schools, countries are taking steps towards the adoption of AI in school systems in practice, whether through the elaboration of national strategies and/or the establishment of essential “building blocks” of AI for school systems. These developments are increasingly guided by international standards, such as the European AI Act, the European Commission’s Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators, and the OECD AI Principles, which provide a blueprint for trustworthy, human-centred AI. The experience of different countries highlights the range of approaches taken and alternative policy options, with implications for the opportunities and risks AI presents and discussed in this paper, both as concerns school organisation, teaching and learning practices, and what schools teach. Among these, the case of Italy, in comparative perspective, presents particular features and policy priorities going forward.

Guiding frameworks and policy documents

Country experience varies depending on whether guiding frameworks and other policy tools in support of AI adoption in schools are in place, their content and elaboration and review process. Table 11 provides an overview of such documents in a select number of countries. These include:

- National or regional/local-level framework and guidance documents that outline key policy principles, goals and processes to be followed in AI for education development, adoption and governance (addressing stakeholders ranging from policymakers and public sector officials to educators, students and families, to private sector and commercial AI tool developers).
- Guidance, roadmaps and toolkits specifically designed for teachers and schools in support of AI adoption and use in school-related activities, including platforms providing school staff training tools.
- Repositories and information sources for documentation, monitoring and evaluation of digital/AI competences, AI tool use and effectiveness and teacher and student outcomes, in support of AI for education foresight and planning initiatives and evidence-based learning and policy.

Table 11. Guiding documents on the integration of AI in education

Education system; author	Date*	Title	Note
Australia; National AI in Schools Taskforce	2025 review ongoing	Australian Framework for Generative Artificial Intelligence in Schools	The framework is reviewed every 12 months, with updates reflected in the design of nationally-funded programs and initiatives. The Agency also maintains an up-to-date "Gen AI Knowledge Hub" with relevant resources for educators.
Australia; Tertiary Education Quality and Standards Agency	November 2024	Gen AI strategies for Australian higher education: Emerging practice	Building on the Generative Artificial Intelligence Guidelines, this toolkit is designed to help education providers craft strategies and integrate generative AI into their institutions
Austria; Ministry of Education, Science and Research	November 2023	The use of AI -based tools in the preparation of final papers – potential, risks, and assessment-relevant aspects	The Ministry convenes experts from universities and teacher training colleges to propose, reflect on and support AI measures in schools.
Belgium (Flanders); Digisprong Knowledge Centre and the Data and Society Knowledge Centre	*April 2024*	*Responsible AI in Flemish education: A collaborative process from development to use*	*The government of Flanders maintains an up-to-date resource bank of the publicly funded projects and organisations working on AI-development for the public sector.*
Belgium (French Community; General Administration of Education	*February 2024*	*Focus: AI*	*Guidance document for teachers, covering topics from regulatory and legal frameworks to making decisions about the scope of AI use in the classroom. More resources are publiced regularly on the regional "e-classe" platform for education providers.*
Canada (Querbec); Ministry of Education, Department of Digital Culture and Development	November 2024	The education, ethical and legal use of generative aritificial intelligence	Guide for teachers, published in conjunction with additional guidance on AI use in the public sector and good practices. .
Chile; Ministry of Education, Centre for Innovation	June 2025	Digital Competency Framework for Teachers	Roadmap for educators to integrate digital technologies into their teaching practices; reference point for both initial teacher training and ongoing professional development.
Czechia; National Pedagogical Institute of the Czech Republic	August 2024	Recommendations for schools for the use of artificial intelligence in primary and secondary schools & Artificial intelligence and the law in schools FAQs	The Institute creates additional resources for teachers, publishes information and organises events on the use of artificial intelligence in education settings.
Denmark; Ministry of Children and Education	*April 2024*	*Expert group on chat GPT and other digital tools*	*In 2023, the Ministry convened an expert group to put forward a set of recommendations on the use of AI in education. The document focuses on the management and incorporation of AI into testing environments. Recommendations pertain to teachers who administer tests, and policymakers shaping the design of national assessments.*

Education system; author	Date*	Title	Note
European Union; European Digital Education Hub's Squad on artificial intelligence in education	2023	AI Report	Building on the Commission's guidelines on the use of AI and data in teaching and learning for educators, the report provides use-cases of AI use and education and puts forward recommendations for teachers and other stakeholders.
Finland; National Board of Education	2025	Artificial intelligence in early childhood education and training – legislation and recommendations	The recommendations are published in a website format and are update as needed.
France; Ministry of National Education, Higher Education, and Research	2026	Charter to govern the use of AI in education, both in the pedagogical and administrative fields	In 2025, the Ministry launched a national and academic consultation with the educational community on the rules for using AI in education which will lead to the publication of the charter.
Germany; Standing Conference of the Ministers of Education and Culture of the Länder	*October 2024*	*Recommendations for dealing with artificial intelligence*	The recommendations are based on research by the Standing Scientific Commission outlined in the paper "Large language models and their potential in the education system."
Ireland; Quality and Qualifications (QQI), National Academic Integrity Network Working Group	July 2023	Generative Artificial Intelligence: Guidelines for Educators	In February 2025, Ireland's Artificial Intelligence Advisory Council published a brief update to the general guidelines s for the responsible use of AI across the Irish Public Sector and indicated that there are ongoing efforts at developing guidelines at sectoral level by the QQI, the Department of Education and at the levels of individual institutions and schools.
Israel; Ministry of Education & the Institute for Artificial Intelligence Research	January 2025	Draft national plan for artificial intelligence in education	Not publicly available.
Italy; Ministry of Education and Merit	August 2025	National Guidelines for the Introduction of AI in Schools	Provides a framework for AI adoption in schools, including guiding principles, minimum standards and criteria for AI adoption, procedural requirements across planning, monitoring and evaluation stages.
Italy (Region of Lombardy)	November 2024	The Art of Learning – guidelines for the use of GenAI for secondary school teachers	Provides guidance and practical examples of AI use across secondary-school teacher-led teaching and assessment tasks and activities
Italy (Region of Friuli Venezia Giulia)	May 2024	Guidelines for the use of AI in schools	A network of 55 Friuli Venezia Giulia schools collated guidance on issues of AI and teaching personalisation, student assessment, privacy and ethics, as well as of examples of AI use in teaching and guidance on prompts.
Japan; Ministry of Education, Culture, Sports, Science and Technology, Review Committee	December 2024	Guidelines for the Use of Generative AI in Primary and Secondary Education (Version 2)	Revised guidelines. The guidelines includes "checklists" for staff and students to guide responsible AI use. The guidelines are created and updated by a Review Committee which includes educators and experts. In order to iterate and deliver on recommendations, the Ministry designate pilot schools in which AI use is rolled out on a systemic basis and monitored.
Korea; Korea Education and Research Information Service; Ministry of Education, Science and Technology	November 2023	AI Digital Textbook Development Guidelines	In preparation for the creation of AI-powered textbooks, the Ministry published guidelines for textbook producers, AI developers and other stakeholders on the design and approval process of the textbooks. The convened stakeholders for the launch, giving them the opportunity to ask questions and engage with each other.
New Zealand; Ministry of Education	November 2024	Generative AI	The Ministry maintains an up-to-date repository of public initiatives and resources that pertain to the design and integration of AI into the education sector, including training resources for school staff.
Norway; Education directorate	November 2024	Artificial intelligence in schools	Regularly updated guidelines and recommendations for school staff and teachers.
Poland; Ministry of Education and Science	*November 2023*	*What AI is not for. A guide for teachers*	*Developed by an expert group within the Ministry.*

Education system; author	Date*	Title	Note
Poland; Ministry of Education and Science	*April 2023*	*Chat GPT – materials for teachers*	*Developed by an expert group within the Ministry. In conjunction with this guide, the Educational Research Institute was commissioned to conduct pilot projects and research into the needs of teachers and the suitability of AI to solve challenges in schools.*
Spain; Ministry of Education, VET and Sports	*July 2024*	*Guide on the use of artificial intelligence in education*	*At the end of 2024, the Ministry and the European Commission conducted a survey of the opinions of the educational community on these and prior guidelines related to digital literacy and the ethical use of AI.*
Sweden; Skolvert (Swedish National Agency for Education)	June 2025	On the topic of artificial intelligence	The Agency published high-level guidance for teachers who will begin teaching AI as subject in the school term beginning Autumn 2025. AI may be taught as an individual subject or included in existing high school programme specialisations. The Agency recently also published the results of the survey of high school teachers which have implemented the AI curriculum into existing programs during the Spring 2024 school term, which provides some best practices for educators to the teaching and management of AI in the classroom.
Türkiye; Ministry of National Education	*May 2024*	*Policy Brief for Artificial Intelligence in Education: Lessons from International Forum of Artificial Intelligence in Education*	*High-level policy brief discussing key issues related to AI integration in the education system and classroom.*
United States; Department of Education, Office of Educational Technology	October 2024	Empowering Education Leaders: A Toolkit for Safe, Ethical, and Equitable AI Integration	Building on guidance released in "Artificial Intelligence and the Future of Teaching and Learning Insights and Recommendations" in May 2023, the present toolkit targets school leaders and educators, providing guidance on mitigating risks related to AI implementation in the classroom, building a strategy for AI integration at the school-level.
United States (California); Department of Education	September 2023	Artificial Intelligence: Learning with AI Learning about AI	In September 2024, the California Legislature passed a bill (SB1288) establishing the working group on artificial intelligence in public schools. The purpose of the working group is to develop guidance for school districts, county offices of education, and charter schools on the safe use of artificial intelligence in education. The group will also develop model policies regarding the safe and effective use of artificial intelligence in ways that benefit, and do not negatively impact, pupils and educators, with the deadline of January 2026.
United States (Georgia); Professional Standards Commission	June 2025	Ethical Considerations in the Appropriate Use of AI for Educators	To compliment the guidance document published by the Georgia Department of Education in January 2025, the document intends to serve as voluntary statewide guidance for educators, administrators, and staff regarding the use of AI in schools and classrooms. The goal is to empower educators and students to use AI as a supplement to, not a substitute for, core human-cantered teaching and learning. The document is intended to be iterative and includes a feedback survey intended for its users.
United States (New Mexico); Public Education Department	May 2025	AI guidance for K-12 education 1.0	The guidance includes a breakdown essential components of AI literacy by the different levels of education, from early childhood education and care to upper secondary. Moreover, the guidance includes imperatives for AI developers and those implementing tools at the school level, stressing the importance of human-centric AI design and human-in-the-loop systems. The document provides examples of schools districts and schools in New Mexico which have successfully implemented AI in accordance with the principle outlined in the document.
United States (Oregon)	March 2025	Generative Artificial Intelligence (AI) in K-12 Classrooms	Initially published in August 2023. Updated version accompanied by a worksheet designed to help districts determine both their process for policy development as well as the specifics of that policy.

Education system; author	Date*	Title	Note
United States (Washington); Superintendent of public education	July 2024	Human-Centered AI Guidance for K–12 Public Schools	In February 2025, the Superintendent hosted the AI Innovation Summit, which convened school board members, administrators, educators, and IT professionals to co-create actionable AI implementation plans, share experiences and expertise.
United States	Misc. (July 2025)	State AI Guidance for K12 Schools	Across the United States, 26 states and Puerto Rico have authored or implemented official guidance or policy on the use of AI in the formal education system.
United Kingdom (England); Department for Education	June 2025	Using AI in education settings: support materials	The Department published free support materials for staff and school leaders on integrating AI into their practices and institutions.
United Kingdom (England); Department for Education	2025	Generative artificial intelligence (AI) in education	The policy paper is regularly updated on the Department's website.

Note: The review of policies constitutes an update and adaptation of the review reported in *OECD Education Policy Outlook 2024* (OECD, 2024[37]). Italics denotes policies that have not changed since the publication of the *OECD Education Policy Outlook 2024*. Column "Date" refers to the date that the document was published, or the most recent date on which it has been reviewed or updated by the authors.

In Italy, the national *Guidelines for the introduction of AI in schools*, published by Italy's Ministry of Education and Merit in 2025, outline guiding principles, minimum standards and criteria specific to AI adoption in schools, alongside procedural requirements across planning, monitoring and evaluation stages. These are preceded and accompanied by national legislation and policy initiatives, for instance on school digitalisation and teacher training, that shape AI adoption and use in schools (see Annex A). At the regional level, policy documents providing guidance and examples of AI use in education have been elaborated through participatory approaches in support of schools, teachers and families, for example in Lombardy and Friuli Venezia Giulia (see Table 11).

Foresight and early recognition for strategy and policy design

Given the rapidly evolving nature of AI technology and its proliferation in society, understanding the present and evolving state of AI adoption in the education sector, and options for integrating AI into an education system is key. Policymakers may commission research with this objective for example, the Northern Ireland (UK) Assembly's paper on gen-AI in education systems provides a detailed review of research, legislation and factors relevant to AI-adoption in the context of the local education system (Holmes, 2025[285]). Research and evidence which brings to attention the specific needs at the sub-national or sub-system level can ensure the relevance, effectiveness and sustainability of any national strategy.

Repositories of evidence on AI uptake and outcomes in schools can provide useful. The Generative AI for Education Hub at Stanford University features a comprehensive collection of academic research on the adoption and introduction of generative AI in schools that enables evidence sharing and use by families, schools and teachers, and policymakers. Similarly, the OECD.AI Policy Navigator provides access to policy initiatives, including on education.

Beyond system-wide stocktakes and research repositories, OECD countries have set up pilots to inform strategy and policy (see Table 11). In the 2024-25 school year, Italy's Ministry of Education and Merit launched a two-year pilot programme in 15 secondary schools across four regions (Calabria, Lazio, Tuscany, and Lombardy) introducing AI-powered tools. The initiative's goal is to leverage intelligent tutoring systems and virtual assistants to tailor assignments to each student's needs, identify learning gaps or strengths, and support teachers (Ministero dell'Istruzione e del Merito, 2024[286]).

Skills Assessment and Anticipation (SAA) systems are used across OECD countries to identify evolving skill needs and inform education policy. The main models include quantitative forecasting, employer skill surveys, expert-based foresight panels, and big-data analytics dashboards (OECD, 2023[287]). International experience suggests that SAA systems are effective in guiding curriculum reform, especially to integrate digital competences and respond to AI-driven change. In most OECD countries, Ministries of Education report using SAA findings to design new qualifications or revise curricula in line with anticipated needs (International Labour Organization, 2017[288]). Italy already collects rich SAA data – including the INAPP occupational skill surveys and Unioncamere's Excelsior forecasts. This intelligence could be used more systematically to ensure curricula respond to SAA evidence (CEDEFOP, 2023[289]).

Technical schools often update specialisations slowly, even as industry skill needs change. Strengthening feedback loops between SAA and curriculum development could address this gap. For instance, Excelsior data identifying growth in AI, automation, and IT technician roles in the Italian economy could inform the Ministry of Education's periodic curriculum revisions for technical institutes. Likewise, regional skills forecasts and employer input could guide professional school to introduce emerging subjects (such as industrial robotics or digital marketing) tailored to local industry demands.

Chambers of Commerce in Italy can help schools identify skill needs and strengthen school-work linkages (OECD, 2017[290]) but support has been uneven. A more systematic use of SAA could involve, for example, an annual process where Italy's national and regional authorities translate SAA findings into curriculum updates or training standards for each vocational course. This is especially important with the expansion of the ITS Academies, which provide advanced post-secondary technical programmes. To ensure smooth transitions from technical institutes into ITS or skilled employment, upper-secondary education should deliver the foundational skills identified in SAA analyses. A key strength of the ITS Academy model is its flexibility to adjust programmes in line with employers' input "so that students acquire skills truly required in the labour market" (OECD, 2017[290]). The *Italian Strategy for Artificial Intelligence 2024–2026* also identifies ITS as a critical hub for training highly skilled technical professionals to support industrial, technological and ecological transition policies, and calls for these institutions to integrate AI into their curricula in collaboration with universities and ICT companies (Agenzia per l'italia Digitale, 2024[291]).

Engaging and bringing together educators and industry partners

Throughout both the policymaking and AI tool development and implementation processes, the participation of educators and industry partners, alongside government, can help ensure the effectiveness and equity of AI tools and systems, mitigating the risks and helping realise the opportunities outlined in earlier sections of this paper. Educators can help ensure that tools are practical and responsive to actual needs and provide valuable insights on their capacity and system-readiness of integrating AI in schools. Policymakers can pull a range of policy levers to bring educators and industry partners together across these processes. Box 3 provides examples of how OECD countries engaged educators in the initial stages of designing and implementing their AI strategy for the education system.

Box 3. Engaging educators in policy design

Surveying educators

Before introducing AI in the curriculum, the Swedish National Agency for Education surveyed teachers on their classroom use of AI. Results informed guidance provided to teachers for managing AI both as a subject and as a teaching tool. Teachers reported a strong need for support and professional development, especially in managing students' use of AI. In response, the Agency published and regularly updates detailed online guidelines (Skolverket, 2025[292]; Skolverket, 2024[293]).

The UK Department for Education also consulted teachers to capture their perspectives on AI. Many highlighted time saving and standardisation as benefits, particularly for marking and feedback. The most desired applications were marking and assessment, followed by data entry and analysis of pupil progress, lesson planning, differentiation, and report writing. Concerns remained over AI reliability, especially in grading (Department for Education, 2024[294]).

Establishing working groups

In 2023, the Danish Ministry of Children and Education convened an expert group to recommend how AI could be used in education, while preserving exam integrity and assessment standards. Composed mainly of post-secondary educators, with one secondary teacher, the group's recommendations were published in May 2024. Similarly, the Austrian Ministry of Education, Science and Research convenes experts from universities and teacher training colleges to propose, reflect on and support AI measures in schools (Ministry of Children and Education, 2023[295]). In November 2023, it issued guidelines to help students prepare young people for lives shaped by AI adoption by equipping them with the skills needed to seize opportunities and assess risks (Federal Ministry of Education, Science and Research of Austria, 2025[296]).

In Italy, ensuring the participation of educators and schools in AI for education policy and practice is referred to as a priority in policy documents, including the 2025 national guidelines for AI introduction in schools. The national guidelines specify schools should adopt the HUDERIA Council of Europe approach across all phases and elements of developing their AI systems, involving, among other things, the establishment of networks and agreements with "startups" (Council of Europe, 2024[297]). The emphasis of the guidelines remains on the role and responsibilities of individual schools and their promotion of participatory approaches to AI adoption planning and implementation, with limited reference to the private sector, if not as an AI tool provider (Ministero dell'istruzione e del merito, 2025[298]).

Box 4. Italy: educator engagement in "AI for schools" strategy and tool development

Although the Italian Ministry's of Education and Merit 2025 "AI for schools" guidelines emphasise educator consultation and the establishment of working groups with pedagogists and school representatives for implementation, teachers do not appear to have been directly involved in drafting the national guidelines. Moreover, the expert committee that drafted Italy's 2024-2026 National AI Strategy for the public administration did not include a representative from the Ministry of Education.

At the regional level, however, more participatory approaches have been used. In the 2023-24 school year, the Friuli Venezia Giulia school network, comprising 55 institutions from primary to secondary levels, adopted a participatory action research model involving school leaders, teachers, students, and a scientific committee. This led to the co-development of *Costruire il futuro*, an e book and regional guidelines on generative AI in education (Fondazione Friuli, 2024[299]). The initiative also produced in-service seminars, ready-to-use teacher resources such as curated AI prompts, and a tailored support tool, "Mind in Class" a ChatGPT-based agent designed to help educators plan lessons, design learning activities, and address both pedagogical and ethical aspects of AI use.

Educator engagement is also central to the *AI4T (Artificial Intelligence for and by Teachers)* project (AI4T, 2024[300]). In Italy, hundreds of teachers have participated in the programme as trainees and contributors, helping to evaluate and refine training modules. Their feedback has helped adapt resources like MOOCs and open textbooks to classroom realities. As part of the project's evaluation, interviews with teachers and school leaders provided valuable qualitative insights to inform the design of teacher-centred strategies for AI integration in education.

By working closely with educators and industry partners, policymakers can stimulate research and development of AI-powered solutions for the education sector, ensuring that it is not overlooked by the industry. Despite this, few AI-related high-level documents reference the need for collaboration between educators and developers (OECD, 2024[37]).

Bringing together educators and industry partners may take the form of a national advisory council, which could be established to guide ethical and pedagogical aspects of AI adoption. Examples of such for a include the National AI Coalition in the Netherlands; taking a bottom-up route to AI in education, emphasising experimentation within an ethical framework. The Coalition brings together education institutions, government, and tech companies to explore AI's potential in schools (AI Coalition for the Netherlands, 2024[301]). On the development side, higher education institutions can create opportunities for policymakers to connect different stakeholders. The Dutch government also finances NOLAI, a lab at Radboud Universiteit funded to create and evaluate AI-powered EdTech solutions, bringing together researchers, industry partners, and educators to develop AI tools for the classroom (Radboud Universiteit, 2025[213]). Another example is the German government's partnerships with the Eberhard-Karls-Universität Tübingen in the form of the Centre for Digital Education (see Table 9).

Another way of engaging both educators and industry partners is by acknowledging and addressing them in the policies and high-level documents guiding AI adoption and uptake. For example, the Belgian (Flemish community) paper outlines the strategic vision for the role of AI in the education system, delineating between and outlining the distinct responsibilities of educators and developers directly. The paper stresses the importance of adhering to responsible AI use and development principles for both; for the industry partners, this includes high ethical standards in the process of tool development, as well as ensuring that the digital literacy of users of their applications is sufficient for responsible use (Kenniscentrum Digisprong, 2023[302]). For educators, this includes evaluating the added-value of different AI tools in the classroom – understanding the technology available and weighing the different options against the needs of the schools and its student body.

Industry partners are a broad range of stakeholders in the private sector, working directly or indirectly on the development of tools and content for the public education system. Collaboration between them is also important to ensure that tools meet the standards and goals set out by policymakers. In Italy, there are several examples of multi-stakeholder collaborations which foster collaboration or provide free assistance and services to schools, educators, and students:

- *Generazioni Connesse (Safer Internet Centre)* is a national programme coordinated by the Ministry of Education and co-financed by the European Commission, bringing together a wide network of stakeholders, including law enforcement (Polizia Postale), universities, non-profits Save the Children, Telefono Azzurro, education platform Skuola.net, among others. The project supports schools in developing digital citizenship and online safety policies by offering teacher training, digital resources, campaigns, and helplines. It promotes a systemic, cross-sectoral approach to digital well-being in schools (Generazioni Connesse, 2025[303]; Ministero dell'Istruzione e del Merito, 2023[304])
- *AI-ENTR4YOUTH* is a collaboration between Intel and the non-profit Junior Achievement. Piloted in 2023, the programme introduced AI into secondary schools by providing teacher training and 52 hours of hands-on activities for students, including mentorship and prototype development (JA Italia, 2024[305]).
- *Ambizione Italia per la Scuola (Ambition Italy for Schools)* is a partnership between Microsoft and Fondazione Mondo Digitale and is a large-scale training programme aimed at enhancing students' and teachers' digital skills. Between 2019 and 2024, over 250 000 students and 20 000 educators took part. The initiative includes innovation hubs, school networks, and open resources such as "Enter the World of AI", a modular online course developed for classroom use (Fondazione Mondo Digitale, 2025[306]).

- *EdTech Italia,* a national association established in April 2022 that, promotes innovation in education by connecting companies, policymakers, and institutions, and by creating opportunities for collaboration and visibility. For example, it co-ordinated the "Startup Arena" at Didacta Fair 2023, Italy's largest school innovation event, where emerging companies showcased AI-powered learning tools, virtual reality applications, and sustainability-focused educational resources.
- *ImparIAmo a scuola con l'intelligenza artificiale (Learning at school with artificial intelligence)* was a research-action project coordinated by the non-profit Centro Studi Impara Digitale and EdTech provider Edulia Treccani Scuola which promotes the experimentation with AI in schools. In the 2023-2024 academic year, 328 teachers across 50 schools received training and implemented pilot lessons using AI tools. 1 800 students were also trained on incorporating genAI tools, such as chatbots, into their learning activities. Results were shared through public webinars and resulted in a national community of practice (Bardi, 2024[307]).

AI teacher training and continued professional development and support for teachers

Successful AI adoption hinges on teachers' capacity and buy-in. Teachers' digital and AI competences are central to ensuring appropriate and effective AI use in education. They also matter to AI adoption and use in practice as teacher perceptions of tool usability and usefulness influence their openness and willingness to adopt AI tools. As such, teacher training and continued professional development in AI is key to addressing two of the common barriers to AI uptake and effective use in schools.

In addition to integrating AI as a subject matter into initial teacher training, ongoing professional development opportunities and support in the form of tools, resources and information can be provided to educators to ensure that they have the skills and resources needed to understand and use new technologies. In-service teacher training in AI is especially critical in Italy, given its school system's teacher demographics, as outlined in the Introduction.

Examples of teacher AI training requirements and opportunities and of tools in support of AI use for teachers include:

- The **European Commission** has created tools to aid teachers' AI skills development, learning and information exchange. *eTwinning* is an online community that enables teachers and students across Europe to work together on projects, discuss in online groups, and develop their skills. *SELFIEforTeachers* is an online tool to help teachers reflect on how they are using digital technologies in their classrooms; teachers can use the tool identify the digital skills they have and areas for improvement (European Commission, 2025[308]; European Commission, 2025[309]).
- In **Sweden**, in order to teach AI as a subject, teachers are required to become authorised through a centrally controlled curriculum. Teachers already qualified to teach technology, mathematics, programming, interface design or web development need 15 credits in AI to be qualified to teach that subject. Teachers who are qualified in another subject in upper secondary school need 60 credits for qualification, which they can acquire at a universities and colleges around the country. The curriculum includes a combination of technical and theoretical courses. Information on the curriculum and course availability is disseminated by, Skolvert, the Swedish National Agency for Education within the Ministry of Education (Skolverket, 2025[310]).
- In **France** from 2025, a training programme dedicated to AI will be mandatory for students in certain general, technological, and vocational secondary school streams. The programme assesses students' competences and suggests a personalised training recommendations and materials. The training is available to all middle school and high school students and teachers who wish to attend. While the programme is aimed at students and options for teachers, it aims to alleviate some of the burden from teachers on ensuring that students are adequately prepared to use AI tools in the classroom (Ministère de l'Éducation nationale, de l'Enseignement supérieur et de la Recherche, 2025[311]).

- In. In **Chile**, the Ministry of Education published the Digital Competency Framework for Teachers, providing a roadmap for educators to integrate digital technologies into their teaching practices; reference point for both initial teacher training and ongoing professional development (Tertiary Education Quality and Standards Agency, 2024[312]).
- In the **United Kingdom (England)** the Department for Education published free support materials for staff and school leaders on integrating AI into their practices and institutions (Department for Education, 2025[313]). Similar materials were published by the **New Zealand** Ministry of Education (Ministry of Education of New Zealand, 2024[314]).

Italy's National AI Strategy 2024-2026 includes a dedicated education pillar which proposes introducing AI literacy in the curriculum beginning in primary school, with teacher training a core component of implementation (Agenzia per l'italia Digitale, 2024[291]). As a part of the national agenda for the digital transition of the education system, continuous professional development on AI is supported by a number of targeted investments and initiatives:

- In the *National Recovery and Resilience Plan (PNRR*), Investment 2.1 titled *Integrated Digital Teaching and Training on Digital Transition* allocates approximately EUR 800 million to establish a national, multidimensional training system, including 20 000 courses designed for 650 000 teachers, principals, and administrative staff. All training is aligned with the European DigCompEdu framework, which defines six areas of digital competence and progressive proficiency levels for educators. The training is envisioned to be delivered through the *Scuola Futura* platform, a training provider recognised by Ministry of Education and Merit to deliver training courses to secondary school. The platform already features more than 120 000 learning opportunities, ranging from MOOCs and blended courses to hands-on workshops which are coordinated by a national network of digital hubs and 52 territorial training centres. As of 2025, over 800 000 participants have engaged in these learning pathways, surpassing the original target (Ministero dell'Istruzione e del Merito, 2023[315]; FLC-CGIL, 2023[316]; European Commission, 2025[317]; Regione Lombardia, 2025[318]).
- Tenured teachers also have access to training courses via SOFIA (*Sistema Operativo per la Formazione e le Iniziative di Aggiornamento del personale della scuola*) (Ministero dell'Istruzione e del Merito, 2025[319]), a platform launched in 2016 by the Ministry of Education and Merit within the National Plan for the Digital School to serve as a digital catalogue connecting teachers with training opportunities (both free and paid) offered by companies and organisations certified by the Ministry.
- As part of the PNRR, *Équipe Formative Territoriali (EFTs)* are mobilised for localised support. EFTs are made up of certified teachers trained to assist schools in activities related to digitalisation and AI, including support in the areas of innovation of organisational models and of teaching methodologies. As part of this initiative, EFTs have assisted with the organisation of events such as Italy's *Next Gen AI Summit* and AI orientation labs, aimed at promoting engagement with digital tools and AI in education (Scuola Futura, 2025[320]; Ministero dell'Istruzione e del Merito, 2024[286]).

Available evidence for Italy indicates AI training initiatives for teachers can be beneficial. An Erasmus+ K3 project (AI4T) for multiple countries, including Italy, examined the impact of access to training materials including MOOC, textbooks and online webinars, on foundational AI concepts, AI-related competencies and attitudes among STEM and English secondary school teachers. For Italy, the study found statistically significant intervention effects on teachers' familiarity with AI technologies, confidence in recognising AI tools, and self-reported AI knowledge (AI4T, 2024[300]).

Just as with the development of educational materials and strategies for AI integration in the education system more broadly, governments can involve other stakeholders – such as industry partners – in the provision of teacher training. This could help ensure the timeliness and quality of training, as well as alignment between providers' offerings and their relevance in the context of the education system capacity to integrate AI. Box 5 provides details on a teacher training initiative led by the American Federation of Teachers, Microsoft, OpenAI and Anthropic.

To complement teacher training, and initiatives such as the EFTs that provide external support, strategies can include strengthening AI-specific technical support *within* schools. This can take the form of training and hiring of IT support staff who manage infrastructure and AI software and the establishment of AI mentors and communities of practice. In Italy, building on the *animatore digitale* figure from the Piano Nazionale Scuola Digitale, a network of “AI in Education” mentors, expert teachers or digital animators, could receive advanced training and a stipend to act as resource persons for clusters of schools, to assist with AI tool implementation, troubleshooting, and pedagogical integration. Italy’s PNRR investments in ITS (Istituti Tecnologici Superiori) Academies – the recently reformed high-tech tertiary institutes – could be leveraged to create specialisations in educational technology so that graduates can serve as school tech coordinators or EdTech developers. This not only fills a skills gap in schools but also helps to connect schools with Italy’s broader digital skills pipeline, engaging young talent.

Box 5. The National Academy for AI Instruction

The American Federation of Teachers (AFT), representing 1.8 million educators and local public employees throughout the United States, has partnered with some of the leading corporations in the generative AI market (namely, Microsoft, OpenAI and Anthropic) to launch an AI Academy offering training and tools for classroom use. Pilot workshops in July 2025 trained 200 New York City teachers, with the aim of collecting feedback to inform wider rollout. Full-scale in-person workshops are scheduled to begin in late 2025, with the goal of reaching 400 000 educators across the United States by 2030; representing 10 per cent of the teaching workforce with partners contributing USD 23 million in tools and support by 2030. The Academy aims to address the lack of structured, accessible AI training and provide a national model for an AI-integrated curriculum. Amid shifting federal priorities, uneven state-level initiatives and growing corporate involvement in public education, teachers face pressures to both understand new tools and manage their procurement. The Academy aims to ease this by combining training with access to partner-developed services.

Training is designed to be practical, showing educators how to use AI tools in educational settings, integrate AI literacy, ethical reasoning and creative problem-solving into curricula, and ensure safe use. It also offers credential pathways and continuing education credits, with further online learning opportunities. A further goal of the Academy is to involve educators in tool development. Consultations in 2024 and 2025 shaped the Academy and innovation labs and feedback processes are intended envisioned to refine it throughout the project. Among the services provided as part of the academy, educators will receive platform-specific benefits, computing access and engineering support to build custom, classroom-specific tools themselves.

Source: American Federation of Teachers (2025[321]), *AFT to Launch National Academy for AI Instruction with Microsoft, OpenAI, Anthropic and United Federation of Teachers*, www.aft.org/press-release/aft-launch-national-academy-ai-instruction-microsoft-openai-anthropic-and-united); OpenAI (2025[322]), *Working with 400,000 teachers to shape the future of AI in schools*, https://openai.com/global-affairs/aft/; White House (2025[323]), *Advancing Artificial Intelligence Education for American Youth*, www.whitehouse.gov/presidential-actions/2025/04/advancing-artificial-intelligence-education-for-american-youth/; Klein (2025[324]), *Microsoft, OpenAI Partner With AFT to Train Teachers on AI*, www.edweek.org/technology/microsoft-openai-partner-with-aft-to-train-teachers-on-ai/2025/07.

Procurement and funding models

The establishment of protocols, regulation, and procurement of technology at the system level is crucial to ensure that all schools, including those under-resourced, or otherwise at a higher risk of experiencing the challenges to fostering positive student outcomes outlined in this report, have equal opportunities to accessing these cutting-edge technologies. Teacher surveys indicate that there is already a gap in the use of AI tools between teachers working in fee-paying and public institutions, with private school teachers being more likely to incorporate the technology into the classroom, as well as receive guidance from school leadership, receive formal training, and have a school point of contact to approach with operational or ethical queries. As a result, teachers in socio-economically advantaged institutions reported feeling more confident about their use of AI (Katham and Mintacute, 2025[325]). A key consideration for policymakers is the degree to which AI EdTech systems and tools will be procured and implemented at a systemic level, as opposed to giving local educational authorities and / or schools the scope to identify and contract their own solutions (OECD, 2023[120]; Boeskens and Meyer, 2025[14]).

One approach involves the creation of a centrally funded programme, giving resources to schools to acquire AI platforms or services from an approved vendor's menu. In this case, rather than every school individually contracting vendors, countries centralise procurement to negotiate licences or partnerships with providers at scale, promoting cost-efficiency and consistency throughout the system. This is the model adopted in Estonia (see Annex A). Alternatively, countries commonly establish a framework agreement or a list of certified AI tools for regional education offices or school networks to procure solutions that best fit their context from a menu of approved tools, giving more agency to local authorities or schools in choosing the type of technology and providers. In other countries still, governments may establish legislation or more or less binding guidelines establishing principles and criteria for schools and AI system providers to adopt in their direct procurement and management of services. The choice of procurement and funding models is crucial to the uptake, sustainability, and ultimate success of AI tools in reaching their stated goals within the education system. Box 6 provides details on the experiences and challenges of AI textbook implementation in Korea.

In Italy, the 2025 national guidelines for the introduction of AI in schools lists the responsibilities of schools and AI system providers with reference to the EU AI Act of 2024, including on topics such as AI system monitoring and assessment by adequately trained staff for the former, and AI quality management and monitoring for the latter (Ministero dell'Istruzione e del Merito, 2025[326]). Individual schools are tasked with guaranteeing compliance with international and national security and data management standards and with the execution of ex ante evaluations of AI systems as part of their selection process (and, within these, of Fundamental Rights Impact Assessments in the case of high-risk applications). Individual schools are also responsible for ensuring GDPR compliance. In contrast, in other countries, schools may refer to centrally-provided framework agreements and catalogues of AI services schools, as is the case in France. At the EU-level, the *Model Contractual Clauses for AI (MCC-AI)* is a tool for public institutions, including educational bodies, to ensure compliance with the EU AI Act when procuring AI systems by providing contractual standards for high-risk AI in education and other sectors (European Commission, 2024[327]). These clauses emphasise requirements like risk management, data governance, human oversight, and transparency to guarantee trustworthy AI use.

Box 6. AI Textbooks in Korea: from national adoption plan to retraction and reclassification as optional educational material

In 2023, the Korean Ministry of Education (MOE) announced the AI Digital Textbook Promotion Plan, aiming to introduce AI-powered textbooks in mathematics, English, informatics and Korean language instruction at the elementary and secondary levels from 2025. AI-powered textbooks use AI to create customised content, adapting teaching material to students' needs and pace of learning. By gathering real-time data, they allow for continuous feedback and teachers to tailor teaching plans and approaches.

Korea's textbook publishing industry is regulated by government bodies, which directly publish textbooks or issue guidelines and standards for publishers to have their textbooks approved for use in the public education system. To prepare for the rollout of AI textbooks, MOE issued guidance to publishers, held public briefings, and organised events such as the *AI Digital Textbook Matching Day* to foster collaboration with developers. By March 2025, 76 AI textbooks were approved for use. Schools had to procure and implement AI-powered textbooks themselves, with allocated funding from the MOE. Upon rollout in March 2025, the Korean government data indicated that around a third of schools across the country had adopted AI textbooks for at least one subject, though differences in their uptake were pronounced across regions: 98 per cent of schools in Daegu versus just 8 per cent in Sejong.

In August 2025, the Korean government reclassified AI-powered textbooks from official textbooks to educational materials, restricting their legal and financial standing. Schools are now required to use non-AI textbooks to meet curriculum obligations, and AI editions have become optional add-ons without MOE funding support. The change undermined the sustainability of subscription-based models and signalled caution. The policy shift was motivated by perceptions of insufficient infrastructure and a lack of teacher training, in addition to scepticism concerning the benefits to student outcomes.

Source: Ministry of Education of Korea (2023[328]), *Briefing on the Plan for AI Digital Textbooks*, https://english.moe.go.kr/boardCnts/viewRenewal.do?m=0202&s=english&page=2&boardID=254&boardSeq=95291&lev=0&opType=N; Ministry of Education of Korea (2023[329]), *Textbook publishing companies and edutech firms to develop AI digital textbooks in Korea*, https://english.moe.go.kr/boardCnts/viewRenewal.do?boardID=265&boardSeq=94818&lev=0&searchType=null&statusYN=W&page=1&s=english&m=0201&opType=N; K-Book Trends (2025[330]), *AI Digital Textbook Policy and the Publishing Industry*, www.kbook-eng.or.kr/sub/trend.php?ptype=view&idx=1555&code=trend&category=77; Min-sik (2025[331]), *Around 30 percent of elementary schools use AI textbooks: data*, www.koreaherald.com/article/10445407; Jeong-yoon (2025[332]), *South Korea pulls plug on AI textbooks*, www.koreaherald.com/article/10546695 ; Jeong-yoon (2025[333]), *Seoul education chief backs move to make AI textbooks optional*, www.koreaherald.com/article/10384860.

Monitoring and evaluation of AI adoption and outcomes over time

The rapid evolution of capabilities (and associated risks) of AI tools means that the pilot implementation and capacity building, evaluation and adaptation, and scaling and mainstreaming are not sequential and the gradual expansion of coverage of tools needs to be accompanied by a continued emphasis on experimentation. The systematic evaluation and monitoring of student outcomes in relation to AI tool integration and AI as a subject can provide insights on tool effectiveness, influencing future decisions on AI procurement.

Data and outcomes from pilot projects and experimentation with different AI tools and classroom practices should shape the extent and form of AI integration in the education system. As a part of their recommendations published in 2023, the Danish Expert group on ChatGPT and other digital tools called for ongoing rethinking of assessment formats based on student outcomes and developments in AI technologies. The group recommended making the process of test reform more dynamic and participatory; shorter reform timelines will enable the education system to keep-up with the rapid pace of technological progress, while involving teachers in the reform process will ensure that the realities of assessment are reflected in the reforms. The expert group proposed "ongoing trials" of different forms of assessment to span across from primary to adult education, steering the Danish Agency for Education and Quality, the overseeing body, to allocate funds to initiate experiments of different assessment forms (Ministry of Children and Education, 2023[295]). Central authorities should publish findings from pilot projects so that private sector partners and educators alike can draw lessons from their experiences, using them to inform their design, implementation and uptake. Japan's Ministry of Education, Culture, Sports, Science and Technology adopted this approach following its recommendation in the *Guidelines for the Use of Generative AI in Primary and Secondary Education,* prepared by a study group. The guidelines have become Japan's guiding document on AI integration into the education system – they recommended the Ministry designate pilot schools that will systematically integrate generative AI tools into educational activities and school (Ministry of Education, Culture, Sports, Science and Technology-Japan, 2024[334]). The chief goal of the pilots is to promote the accumulation of knowledge, contributing to national-level discussions on the creation of effective educational practices.[3]

International large-scale skills assessments can likewise contribute to the public knowledge base on student outcomes. Box 7 provides details on the Media and Artificial Intelligence Literacy Assessment that will be introduced in OECD PISA 2029.

Box 7. The PISA 2029 Media and Artificial Intelligence Literacy Assessment

In 2029 PISA will introduce the Media and Artificial Intelligence Literacy (MAIL) Assessment to assess students' knowledge and understanding of how digital and AI systems work, the human role in their use, their social and ethical implications, and how to communicate, collaborate, and evaluate media critically. The MAIL Assessment is envisioned as a simulated environment, using functional tools modelled on the internet, social media and AI systems. Tasks may include verifying the accuracy of social media posts with the help of an AI assistant and a search engine, identifying AI-generated images, or evaluating privacy policies and terms of use.

Results will inform evidence-based policies to strengthen students' ability to engage with digital content and platforms effectively, ethically and responsibly. They will also show whether students have had opportunities to develop proactive, critical engagement in a world increasingly shaped by digital tools and AI, and provide insights into the impact of AI adoption in education systems.

Source: OECD (2025[335]), Empowering learners for the age of AI: An AI literacy framework for primary and secondary education (Review draft), https://ailiteracyframework.org.

At the classroom level, teachers can also play a role. In some contexts, they are provided with training and resources to continuously evaluate the impact that AI tools on student outcomes, whether those integrated as a part of system-wide adoption, or those used by students and teachers independently. For example, in the United States, the toolkit *Empowering Education Leaders: A Toolkit for Safe, Ethical, and Equitable AI Integration* provides guidance on mitigating risks related to AI implementation in the classroom and building a strategy for AI integration at the school-level, including monitoring and managing student outcomes and experiences (Cardona and Rodriguez, 2024[336]). The toolkit breaks down the decision-making and implementation process into modules with concrete steps, including discussion questions and evaluation rubrics that educators can use throughout the implementation and evaluation process. Similarly, the Oregon Department of Education published a worksheet designed to help school districts determine both their process for policy development as well as the specifics of that policy (Oregon Department of Education, 2025[337]). The use of student and teacher data requires robust governance consistent with the EU General Data Protection Regulation (GDPR) and national labour protections. In Italy, the *Statuto dei*

Lavoratori (Law 300/1970) prohibits surveillance or recording of employees by employers, a principle that could also apply to digital monitoring in schools. Upholding these standards is essential to ensure that AI adoption strengthens, rather than undermines, trust, professional autonomy, and ethical responsibility in education.

In Italy, the integration of AI and digital tools in education is accompanied by efforts to measure and monitor student outcomes. The PNRR is key to such efforts, with its emphasis on tracking digital competence development among students. To reach targets related to students' digital competence set by the PNRR, in 2025, INVALSI introduced a nationwide evaluation of student digital competencies. This prototypical assessment is based on the European DigComp 2.2 framework and examines multiple dimensions of digital literacy, such as data literacy, communication and collaboration, digital content creation , and user safety among Grade 10 students [see Considerations related to the adoption AI in the Italian education system, (INVALSI, 2025[70])].

Beyond growing efforts to regularly assess digital skills, Italy is also experimenting with AI integration in classrooms and evaluating its impact on teaching and learning through a two-year pilot programme outlined above. Italy's educational community is also contributing to the knowledge base through research and experiments that monitor outcomes of AI in teaching. For example, the non-profit Impara Digitale recently coordinated a large research-action project *"imparIAmo a scuola con l'Intelligenza Artificiale"* (*"Let's learn at school with AI"*) tracking AI impact on student skills and behaviour (see Engaging and bringing together educators and industry partners).

Alongside these initiatives, the AI4T project (AI4T, 2024[300]) uses a randomised controlled trial to measure how teacher training on AI affects both pedagogical practices and student learning, it involves around 90 schools and 450 teachers in Italy. The evaluation combines surveys, classroom observations, and interviews with teachers and school leaders, producing insights that are shared with policymakers at the European level. Similarly, surveys coordinated by INDIRE have begun to track how many teachers use AI, what objectives they prioritise, and what changes they observe in their classrooms. In parallel, the Ministry of Education has announced, and confirmed as part of the national guidelines on AI in schools, the creation of a dedicated section within the national "Piattaforma Unica" to systematically collect data on the adoption of AI tools in schools and support more structured monitoring over time (Ministero dell'istruzione e del merito, 2025[298])

These different strands of monitoring and evaluation illustrate an emerging culture of evidence, where feedback from educators and data from student assessments are both used to refine tools and guide national strategies. While still at an early stage, these activities provide a foundation for policymakers and educators to start reflecting on possible adjustments to areas such as assessment formats or teacher training in light of increasing AI exposure and ongoing efforts at integration into the education system. The goal remains to ensure that, as technological tools advance, education systems are able to gradually adapt and maintain attention to the skills that matter for students' development.

The transition to an AI-enabled education system should be guided not only by technological feasibility but by a shared vision of schooling as a civic, cultural, and human enterprise. National strategies should prioritise trust, transparency, and inclusion, underpinned by stable investment and participatory governance. Only through such an approach can AI become a genuine enabler of equitable, high-quality education in Italy and beyond.

Annex A. Background evidence and country practices

Examples of curriculum reforms in response to digital transformations

In 2014 England replaced its ICT (Information and Communication Technology) curriculum with a new Computing curriculum, making computer science and coding compulsory from primary through secondary education. The change was enacted via an Order under the Education Act 2002, with new statutory national curriculum programmes of study in Computing taking effect from September 2014 (Department of Education, 2013[338]). This reform was driven by recognition that the old ICT course was outdated. The Department for Education moved rapidly: the proposed reform was announced in February 2013, a public consultation was launched, and by June 2013 it was announced that the new Computing curriculum would be implemented the following year. An expert group (convened by the British Computer Society and Royal Academy of Engineering) co-developed the content, ensuring industry and academic input. The consultation drew thousands of responses on the subject name and content, reflecting broad stakeholder interest (Department of Education, 2013[339]). To support implementation, the government partnered with stakeholders (publishers, tech companies, teaching schools, professional associations) to produce teaching resources and training. A GPB 2 million programme trained 400 master teachers in computer science to mentor colleagues. This concerted support mitigated teachers' skills gaps and helped embed the new curriculum quickly in classrooms. The reform was phased in nationally in September 2014 for all maintained schools.

The change was legislated centrally but built on expert consensus (including a Royal Society report that defined key computing domains). The decision-making phase was notably short (about a year from proposal to final framework), thanks to high-level political backing and existing expert groundwork. Implementation was monitored through Ofsted inspections and research reviews to evaluate how schools delivered the new Computing subject (Ofsted, 2022[340]). England is regarded as an early mover in bringing coding to all pupils. This reform demonstrates agility in the recognition and decision phases, compressing them through strong political will and external expertise – though it required significant teacher upskilling to avoid an implementation lag (Department of Education, 2013[338]).

Almost 30 years ago, **Estonia** launched the Tiger Leap (Tiigrihüpe) programme with the goal to build up Estonian schools' technology infrastructure. The programme initiated the development of e-Estonia; a network of digital solution in public services provision, ranging from education to identity verification. In February 2025, the Estonian government announced AI Leap (TI-Hüpe), a programme to incorporate cutting-edge artificial intelligence applications into the education system, provide students and teachers with access to AI-based educational tools, and teach them the most effective ways to use them (Education Estonia, 2025[341]; E-estonia, 2025[342]).

The programme will include the systemic roll-out of ChatGPT Edu, a customised version of ChatGPT built for education systems, and related API services. ChatGPT Edu was designed for large-scale deployments across educational institutions. This offering includes OpenAI's latest models, GDPR compliance, enterprise-level security and controls with cost-effective pricing, allowing for rollout to every student, faculty and staff member in Estonia that is part of the target population. The collaboration will also include technical support and knowledge-sharing for dedicated use cases, such as custom GPTs that may remove the burden of administrative tasks from teachers and support students in building their creativity and critical thinking skills. Use cases can include feedback assistance, student support, study assistance, and lesson planning.

Estonia's deployment of ChatGPT Edu is the first by a government to ensure that students across an entire nation have access to the same AI technology irrespective of their family's socio-economic condition or circumstances. This decision build on the rapid adoption of generative AI in Estonia, which, as of Spring of 2025 is already among the top 15 countries globally for ChatGPT usage, with one active ChatGPT account for every four citizens. Aggregated usage data released by Open AI suggests that Estonians use ChatGPT primarily for tutoring and teaching, computer programming and writing. The scheduled launch of the programme is September 2025 involving students in grades 10th and 11th (around 20 000 students and 3 000 teachers). The programme will be expanded to vocational schools and a new cohort of 10th-grade students (additional 38 000 students and 2 000 teachers) in September 2026.

The main goals of the programme are to ensure equal opportunities for technology use, reduce the digital divide, and create a more cohesive and equal society. Students will be instructed on how to use AI wisely, while teachers will receive support in the customisation of learning content and methods to fit each student's needs, learning style, and pace. Starting in August 2025, teacher training courses will be conducted in co-operation with the Ministry of Education and Research.

The implementation of AI Leap can serve as a model for integrating AI solutions in other public-sector domains in Estonia, such as healthcare and transportation. AI tools are already integrated into Estonia's (and many other OECD countries') government administrative systems and in the provision of public services, including AI-powered chatbots, prediction models in healthcare settings, and models used in identifying patterns in traffic, agricultural and tax management.

In early 2025, the foundation TI-Hüpe was established for implementing the programme, overseeing the strategic management of integrating AI into the educational system. AI Leap is a broad, cross-sector collaboration launched with contributions from the Presidential Digital Council, the Ministry of Education and Research, and private sector leaders.

Finland undertook a comprehensive National Core Curriculum reform for basic education, finalised in 2014 and implemented in schools by 2016. The instrument was a renewed national curriculum framework issued by the Finnish National Board of Education (FNBE), which sets binding core objectives and content for all schools (Finnish National Board of Education, 2016[343]). A parallel reform of upper-secondary curriculum also occurred in this period. A key focus was future-oriented competencies: the new core curriculum introduced seven transversal competences, including ICT capability and multi-literacy, to be integrated across all subjects. Schools are now required to provide at least one interdisciplinary "phenomenon-based" learning module per year, linking areas like coding, science, and societal issues (Finnish National Board of Education, 2016[343]).

Finland's process was highly participatory and evidence-informed, aimed at minimising the recognition gap by proactively looking at "changes in the surrounding world" and their impact on student skills. The FNBE led an open process over 2012–2014: all relevant stakeholders (educators' unions, municipalities, researchers, parents, even students) were closely involved in drafting, and the wider public was invited to comment on curriculum drafts online (Finnish National Board of Education, 2016[343]). This extensive consensus-building stretched the decision-making phase, but built broad buy-in and clarity of purpose. The reform was structured in stages: first revising the distribution of lesson hours by law (deciding which subjects and skills to emphasise), then writing detailed content standards.

Finland's decentralised system means local education providers (municipalities and schools) had two years to develop local curricula aligning with the national core, tailoring implementation to local needs. This staged implementation reduced lag by allowing capacity-building – for example, teachers received training on the new competence-based approach and digital tools. The government provided resource support and used feedback from school self-evaluations to fine-tune implementation The reform remains in force, and its impact is monitored through national assessments and research. Notably, Finland's approach fostered system coherence: a clear vision (e.g. "school must take these changes into account") stakeholder ownership, and alignment of curriculum, teacher guidance, and assessment criteria. This coherence has helped narrow implementation and impact lags – though challenges like supporting teachers' digital pedagogy persist. Finland's case illustrates the power of inclusive design and forward-looking vision to ensure curricula stay relevant to technological and societal changes.

Korea recognised in the mid-2010s that AI and software innovation would be key to its economy, and that its hyper-competitive education system needed to foster creativity and coding skills. In 2015, the government revised the national curriculum to elevate computer science from an elective to a required component (Neethipudi et al., 2021[344]). The revised curriculum (2015) mandated coding/programming education for all students: from 2018, coding became a compulsory part of the practical 'Informatics' subject in middle schools (with at least one class period per week), and from 2019, upper-primary students (Grades 5–6) also receive basic programming instruction (British Council, 2017[345]). High schools were encouraged to offer advanced CS electives. The instrument was a national curriculum amendment issued by the Ministry of Education, in concert with the Ministry of Science and ICT for resource support.

Unlike Finland's slow consensus or New Zealand's phased consultation, Korea's approach was a top-down policy drive responding to global technological trends. The recognition gap was addressed at the highest political level: in 2014 the government launched a "Software-Centric Society" strategy, and by 2015 curriculum reform was on the agenda. The decision-making was rapid – the Ministry formed expert committees to define new content (emphasising computational thinking) and enacted the changes in the 2015 curriculum revision. To build acceptance, the policy was preceded by pilot programmes: dozens of pilot schools from 2014 tested coding classes, informing the nationwide implementation.

Implementation was phased regionally between 2018 and 2020. The government tackled the teacher capacity issue by retraining many existing teachers (e.g. maths or technology teachers) to teach basic programming, and by recruiting ICT professionals into teaching roles. A multi-ministry initiative provided funding for new computer labs and developed standard teaching materials. Public-private partnerships (with companies like Samsung and NAVER) offered volunteer instructors and coding camps to jump-start interest. Despite these efforts, South Korea faced some implementation lag – urban schools adopted the new curriculum faster than some rural ones, and many teachers initially felt underprepared (British Council, 2017[345]).

Nevertheless, by 2019 all middle schools were teaching the compulsory coding course, and an official survey showed improved student attitudes towards computing. This reform is in force, and South Korea continues to update it: by 2022, the government announced plans to integrate AI topics into the curriculum as well, aiming to become a leading "AI education" nation (Asia Pacific Foundation of Canada, 2021[346]). The Korean case illustrates a strong centralised push to shorten the decision lag and respond to industry 4.0 demands – albeit with significant ongoing investment to support teachers and reduce the impact lag on student outcomes.

Japan periodically revises its National Curriculum Standards (NCS, known as the Course of Study) roughly every 10 years. The latest overhaul occurred in 2017–2018, with phased implementation: new standards took effect in elementary schools in 2020, lower secondary in 2021, and upper secondary in 2022 (NCEE, n.d.[347]). This reform was extensive, covering all subjects and aimed at preparing students for a "Society 5.0" – Japan's vision of a, AI-augmented society. The 2008 reform aimed to address concerns that earlier policies (which had reduced curriculum content in the early 2000s to ease pressure) went too far and student skills suffered. The guiding principles of the 2008 reform were "solid academic prowess, richness in humanity, and health & fitness." It increased class hours in core subjects, re-emphasising fundamental knowledge, but also introducing periods for integrated studies to foster cross-curricular learning and inquiry. A notable change in the 2017-18 reform was the introduction of compulsory programming education: coding exercises were added in primary science and maths, a full programming element in lower secondary technology courses, and a new upper secondary subject “Information” covering programming, information security, data science and networks (NCEE, n.d.[347]) (OECD, 2020[270]).

Japan’s curriculum-making process is deliberative and centrally governed by the Ministry of Education (MEXT) with input from the Central Council for Education. The recognition of need was driven by concerns in the early 2010s about Japan falling behind in digital skills and the “fourth industrial revolution”. In response, MEXT’s 2016 strategic plan and the Education Council advocated rapid integration of new content (e.g. programming, active learning pedagogies). Decision-making still adhered to Japan’s long planning cycle: the new Course of Study was approved in 2017 after extensive expert committee work and public consultation. Japan’s reforms typically follow a long cycle (previous revisions were in 2008/09), but with systematic phasing to manage implementation (OECD, 2020[270]). For example, elementary schools were given from 2017 until 2020 as a preparation period to train teachers and adjust timetables for the new content. MEXT supported this with guides, model lessons and funding for equipment (e.g. for programming classes).

The National Curriculum Standard is mandated nationally, ensuring coherence and alignment with high-school and university entrance expectations. Japan closely monitors implementation through tools like the *National Assessment of Academic Ability* and has mechanisms to refine pedagogy. After the previous (2008) curriculum, for instance, MEXT observed issues and adjusted strategies (the 1998 relaxed curriculum had to be reversed due to falling results) (OECD, 2020[270]). For the current reform, continuous monitoring is in place. By 2020, the government also launched the “GIGA School” initiative to equip every student with a device, acknowledging that digital curriculum goals require proper infrastructure (NCEE, n.d.[347]). The reform is ongoing (fully rolled out by 2022) and considered successful in closing the recognition gap – Japan proactively identified AI and coding as critical, aligning curriculum with those future needs. However, challenges remain in the implementation phase: surveys show Japanese teachers still feel less confident in using technology than peers in many countries (OECD, 2020[270]), highlighting the need for sustained teacher support. Japan’s case underlines the importance of balancing deliberate planning with urgent adaptation – they accelerated certain content (programming) within an established cycle, using phased introduction to reduce shock to the system.

Japan’s implementation is top-down but it is supported by textbook revision, teacher training through lesson study, and gradual rollout. For instance, when programming became mandatory in primary schools (from 2020), MEXT funded training workshops and instructional guides. However, a challenge in Japan has been teacher workload and comfort with more student-centered pedagogies. To mitigate this, lesson plan resources and model schools demonstrated the new methods. Another mechanism is entrance exam reform – Japanese high school and university entrance exams are being updated to align with the new curriculum’s competencies (e.g. testing logical thinking and expression, not just rote memorisation). This alignment of assessment with curriculum goals is crucial in Japan’s exam-driven context. Japan’s case illustrates that even a traditionally rigid education system can move toward cultivating creativity and critical thinking, but it requires aligning many pieces (curriculum content, teaching methods, exams, teacher development) and sustained political will.

New Zealand’s national curriculum (for Years 1-13) was revised in the mid-2000s and published in 2007. The reform was the culmination of a curriculum review that started in the 1990s; an initial draft was ready by 1997 but was put on hold after concerns that changes were moving too fast and without enough teacher input (Mills, 2021[348]). The curriculum framework was redesigned with extensive involvement from educators and subject experts, and field trials in schools before finalisation. The result was a concise document laying out key competencies – thinking; using language, symbols, and texts; managing self; relating to others; participating and contributing – which are to be developed through all learning areas. It also articulated core values (e.g. excellence, equity, innovation, respect) and principles (such as Treaty of

Waitangi, future focus). Traditional subjects remained (maths, science, arts, etc.), but schools were given flexibility in how to deliver them.

In December 2017, New Zealand announced that Digital Technologies and Hangarau Matihiko content would be formally integrated into its national curricula (the English-medium New Zealand Curriculum and Māori-medium Te Marautanga o Aotearoa) (New Zealand Government, 2017[349]). Rather than a standalone new subject, this reform added two strands – "Computational Thinking" and "Designing and Developing Digital Outcomes" – within the Technology learning area for Years 1-13. It effectively made digital skills and computing concepts mandatory for all students up to Year 10, with optional specialisation in the senior years. The government officially approved these curriculum additions in late 2017 (New Zealand Government, 2019[350]).

From 2015–2017, the Ministry of Education worked with industry, educators, and community representatives to design the content, ensuring it connected with New Zealand's context (including Māori knowledge in the Hangarau Matihiko component) (New Zealand Government, 2017[349]). Draft content was released for public consultation in mid-2017; feedback from teachers, schools, parents and iwi (communities) was incorporated. Decision-making was relatively swift once needs were recognised: within a year, the new curriculum content was finalised. To avoid a long implementation lag, New Zealand took a phased support approach. The expectation was for all schools to integrate the new digital curriculum content by 2020, giving about two years lead time. Between 2018 and 2019, the Ministry rolled out an extensive support package for teachers and kaiako: professional development programmes, online resources, and networks to build teacher capability and confidence (New Zealand Government, 2017[349]). The Ministry also set up feedback mechanisms during the rollout ("we will seek feedback during implementation to enable adjustments"). This iterative approach allowed mid-course corrections and sharing of best practices, maintaining system coherence. The reform is in force as of 2020, and New Zealand's Education Review Office began evaluating how effectively schools have implemented Digital Technologies content. (New Zealand Government, 2019[350]) The structured support and clear mandate have largely kept the implementation on schedule. New Zealand's example highlights agility – moving from idea to action quickly – and the value of iterative, consultative implementation to ensure the curriculum stays responsive to technological change.

Italy: key national legislation and initiatives on digital technology and AI in schools

1994 D.Lgs. 297/1994 Testo Unico delle disposizioni legislative in materia di istruzione, Decree that lays the foundations for the introduction of information technology in Italian schools, establishing the general principles of the school system, underscoring the importance of technology in education.

2008 Piano LIM, interactive whiteboards plan: via an allocation of EUR 93 354 571, the plan provided 35 114 interactive whiteboards to schools and trained 72 357 teachers, with the objective of improving lesson interactivity and actively engaging students in the learning process.

2009 Progetti Cl@ssi 2.0 e Scuol@ 2.0, pilot projects involving 416 classes and 14 schools, total budget of EUR 8 580 000 and EUR 3.5 million, aimed at integrating technology into the daily activities of the classes and schools taking part, and promoting pedagogical innovation.

2015 Piano Nazionale per la Scuola Digitale (PNSD), National Plan for Digital Schools, introduced in 2015 and since then the main planning tool for the digital transformation of Italian schools. Between 2015 and 2021, EUR 1,9 billion were channelled via the PNSD in investments to improve digital infrastructure, digital skills, and learning support incl. via *animatori digitali* teachers and Future Labs for staff training.

2015 Legge 107/2015 La Buona Scuola, Law that implements the PNSD, emphasising digital training for teachers and students, made digital training mandatory for teachers, and integrated digital skills into school curricula.

2020 Proposte per una Strategia italiana per l'intelligenza artificiale, proposals for an Italian Strategy for Artificial Intelligence, Ministry of Economic Development: outlines key principles and objectives of a national AI strategy, including with regards to education and schools; emphasises critical role of teacher training, school curricula revision and updating to strengthen digital literacy.

2020 Linee Guida sulla Didattica Digitale Integrata: Ministry of Education decree n. 89/2020 Guidelines for Integrated Digital Teaching, makes the adoption in all schools of a school plan for digital teaching and learning integrated within schools' triennial *Piani per l'Offerta Formativa* (see section 5) mandatory; provides specific indications on requirements and modes of organisation (in part in response to Covid-related social distancing requirements)

2014-2021 Programma Operativo Nazionale (PON) 2014-2020, large-scale, EU-funded initiative with over EUR 3 billion invested to boost digital infrastructure and teaching environments, enhance digital skills of students and educators, strengthen digital administrative and institutional capacities; provides a framework to guide implementation, accountability, and evaluation for digital education in Italy going forward.

2021 Programma Strategico Intelligenza Artificiale Italia 2022-2024, joint Ministry of University and Research, Ministry of Economic Development and Ministry of Technological Innovation and Digital Transition strategy document underscores that AI should be a subject matter in all school grades, is a powerful tool for personalisation of education within the principles of equity and reliability; calls for investments in STEM across the school system in support of competences required to harness the benefits of AI and adoption of AI courses in all ITS curricula.

2024 Strategia italiana per l'Intelligenza Artificiale 2024-2026, Presidency of the Council of Ministers, Department of Digital Transformation and Agenzia per l'Italia Digitale document, includes a chapter and broad statements specific to education which emphasises promoting AI literacy among educators and students from primary school onwards, the development of a readily accesible online repository of teaching and learning tools, strengthening of tertiary IA education, specifically via AI courses in ITSs.

2021-2026 Next Generation EU - National Recovery and Resilience Plan PNRR – Piano Scuola 4.0, outlines the investments and implementation strategies for achieving the education-related objectives of the NextGenEU funds. The four main digital/AI-related areas of intervention are: school internet connectivity; classroom transformation and new tools for innovative teaching; teacher and school staff training and digital competences for learning; digitalisation of school administrations.

2025 National guidelines for the introduction of AI in schools, Ministry of Education

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Notes

[1] These actions include: *Agenda Sud*, a project of the Italian Ministry of Education aimed at reducing the educational gap between northern and southern regions, with a focus on reducing early school leaving in southern regions (a two-year project for the school years 2023/2024 and 2024/2025 financed partly by the PNRR); *Piano Scuola 4.0"*, a document highlighting specific areas of intervention and investment for schools included in the PNRR, addressing in particular the implementation of digital platforms for tutoring and mentoring support for dropout prevention and school choice support; and *Riforma dell'orientamento,* a national reform introducing the role of tutors in lower and upper secondary schools to support students in the school transition.

[2] While the Council of Europe uses the term 'plurilingualism' for referring to multiple language competences of individuals, European Union's official documents use 'multilingualism' to describe both individual competences and societal situations. This is partly due to difficulties making a distinction between plurilingual and multilingual in other languages than English and French.

[3] Findings from each pilot are accessible on the Ministry's website: https://leadingdxschool.mext.go.jp/ai_school/.