MAPPING INSIGHTS

AI IMPLEMENTATION BY (PRE-SERVICE) TEACHERS

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This report offers a comprehensive overview of the current landscape of Artificial Intelligence in Education (AIED), drawing on both academic research and practical insights from the field.

It contains **1)** an extensive literature review grounded and informed by academic literature and an analysis of European reports and policy guidelines. **2)** An overview of best practices regarding AIED. **3)** An analysis of AI in EU curricula. **4)** An analysis of focus group interviews with teachers and other stakeholders.

The insights from the previous actions result in a **5)** final gap analysis presented at the end of this mapping report.

The aim of this mapping is to better understand how prepared the education sector is for the integration of AI, and to identify the knowledge, needs, and challenges pre-service teachers, in-service teachers, and teacher educators face across various European countries when engaging with AI tools and technologies.

The report seeks to:

- Present an in-depth understanding of how AIED is currently being adopted and implemented in Europe.
- Analyse existing policies related to AI integration in secondary education.
- Identify current knowledge levels, needs, and challenges faced by educators in different national contexts.
- Map existing teacher training curricula that cover or use AI, with a focus on six countries: the Netherlands, Poland, Belgium, Austria, Norway, and Turkey.
- Outline the specific support required by pre-service teachers, in-service teachers, and teacher educators to effectively engage with AI in secondary education.

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1. Literature review

Artificial intelligence (AI) is making significant advancements into the educational landscape (Miao et al., 2021; Sperling et al., 2024; World Economic Forum, 2024). On the one hand, schools and educators are being tasked with the responsibility to guide children and youngsters in an AI-driven world and to empower them to critically examine issues like Fake News, Deep Fake Videos, or personalised advertising driven by AI-based algorithms. This responsibility has become increasingly apparent in light of the recent AI push, after ChatGPT made its way into education. As the use of AI tools in education has become irreversible, it requires the necessary support of teachers, ensuring that students can use them responsibly, based on well-informed considerations about benefits of such tools along with their deficiencies (Sperling et al., 2024), such as AI hallucinations, meaning that an AI system can generate unreliable or misleading responses (Miao et al., 2021). At the same time, the widespread availability of AI calls for a fundamental rethinking and redesign of teaching practices. Traditional assignments such as essays may no longer serve as the most effective means of assessing student learning, forcing educators to develop new, more AI-resilient assessment strategies. On the other hand, the integration of AI technologies into education presents significant potential. For instance, AI-driven data analysis can offer educators valuable insights into students' learning processes. The educational sector is increasingly recognising the opportunities afforded by AI. To effectively navigate both the challenges and the possibilities associated with these technologies, it is crucial that educators receive adequate support. A pivotal component of this support is ensuring that (pre-service) teacher education fosters a balanced and well-informed understanding of AI – an objective that constitutes a central focus of the AI-teach project.

In ***'1. Understanding artificial intelligence (AI) and its place in the classroom'***, the literature review explores how artificial intelligence (AI) is currently understood, applied, and

perceived within the context of education. It begins by clarifying what is meant by AI in education, including a definition and an overview of commonly used technologies.

Next, ***'2. Potential benefits, risks, and challenges of AI in education'*** gives insights into the potential benefits of AI in education, for both learners and teachers, followed by a discussion of the risks and challenges associated with the integration of AI.

The review then highlights the state-of-the-art in the European educational context in **'3. Current State of AI training initiatives for teachers in the European Educational Landscape'**. This section provides an overview of relevant training opportunities, associated policy frameworks, and practices related to AI integration in higher education, with a particular focus on (pre-service) teacher education.

In section **'4. Teachers needs related to training according to literature and research',** we examine the literature regarding the recent and current needs and experiences of (pre-service) teachers concerning the use of AI in schools.

Finally, '***5. Conclusion'*** offers a summary of key insights and reflections, discussing implications for both practice and policy, which can be used as a sound basis for the gap analysis later in this report.

1.1 Understanding artificial intelligence (AI) and its place in the classroom

Artificial Intelligence (AI) is a broad concept that covers a wide range of tools, applications and systems (Holmes et al., 2022). Although teachers and students often use AI technologies in their daily routines - often without even realising it - many still find it challenging to articulate what AI actually is (Holmes & Tuomi, 2022; Selwyn, 2024).

A widely used definition is provided by UNICEF (p. 16), which states: *"AI refers to machine-based systems that can, given a set of human-defined objectives, make predictions, recommendations, or decisions that influence real or virtual environments. AI systems interact with us and act on our environment, either directly or indirectly. Often, they appear to operate autonomously and can adapt their behavior by learning about the context."*

Holmes and colleagues (2022) consider this definition particularly relevant because it reflects the broad variety of AI: a differentiation can be made between generic AI tools (e.g., translation tools or recommendation systems), generative AI (e.g., ChatGPT, Co-Pilot) that creates new content based on prompts, and AI specifically designed for educational purposes (educational AI), such as adaptive learning platforms or automated feedback systems. In AI-teach we focus on how all three forms of AI impact teaching and learning practices. The definition of UNICEF (2021) is also relevant because it underscores the broad scope of AI and emphasises that AI systems do not, and should not, operate in isolation. This is especially important in education, where it is essential to consider the human actor who will implement and interact with technology. As AI becomes increasingly present in educational settings, understanding who uses these tools, what tools are being used and how they are integrated is crucial. In line with this, the European Union's AI Act classifies the use of AI in education as

“high-risk.” This classification reinforces the importance of human oversight, transparency, and accountability when implementing AI tools in schools and universities, especially those that function autonomously or significantly impact learning trajectories.

To make sense of the wide variety of AI tools in education, Holmes and Tuomi (2022) propose a helpful classification based on the primary user within the educational system. They identify three main categories in Artificial Intelligence in Education (AIED): (1) **Student-focused AIED**, including tools such as chatbots, intelligent tutoring systems, AI-assisted simulations and AI applications that support learners with disabilities. (2) **Teacher-focused AIED**, which involves tools like plagiarism detection software, classroom monitoring systems, orchestration tools and AI teaching assistants. (3) **Institution-focused AIED,** such as course planning software, admission and enrolment systems and AI tools that help identify students at risk of dropping out.

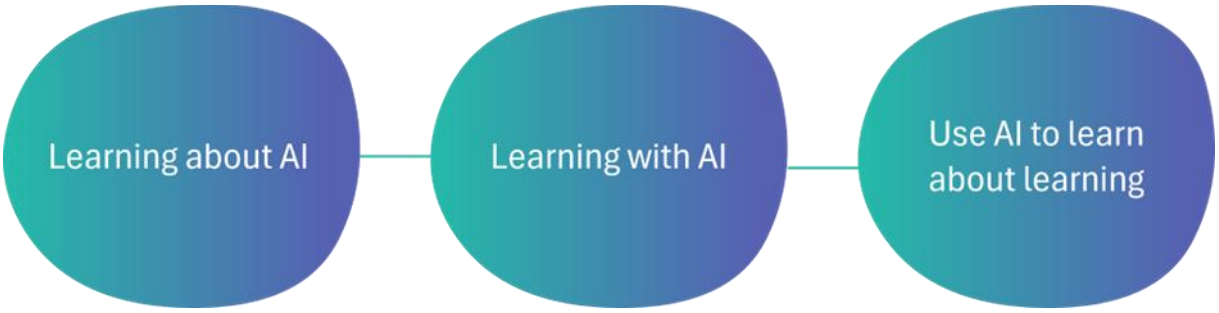
As the authors themselves note, this categorisation is an initial attempt to structure AI systems that are being used in education, and many tools do not fit neatly into one category - or may span several. Additionally, some of the mentioned tools are still in early development stages and are not yet widely implemented in practice (Holmes & Tuomi, 2022).

When looking into these AI systems, a growing question is: how do (pre-service) teachers integrate them into their daily practice? Holmes and colleagues (Holmes & Tuomi, 2022; Holmes et al., 2019; Holmes et al., 2022) have outlined various ways in which AI can be linked to education. In their 2019 framework, they proposed four key categories: (1) Prepare for AI, (2) Learning about AI, (3) Learning with AI, and (4) Use AI to learn about learning.

These categories have evolved over time. For instance, "Prepare for AI" is now often seen as part of "Learning about AI," emphasising not only technical knowledge but also broader

competencies such as AI literacy. The term "Learning about AI" is therefore now frequently used interchangeably with "AI literacy" (Holmes et al., 2022).

For the purposes of this project, we have chosen to adopt the updated three-part categorisation (Figure 1). In the sections that follow, each of these dimensions will be briefly explained.



(Figure 1: An overview of the three-part categorisation, visualising the possible connections between AI and Education).

1.1.1 Learning about AI

This involves both the human and technological dimensions of AI. On the one hand, it means preparing students and teachers to recognise the challenges and potential impacts of AI on society (human dimension). On the other hand, it involves a basic understanding of how AI works "under the hood" - the technical functioning of algorithms and systems (technical dimension). Together, these areas are also often referred to as *AI literacy*.

1.1.2 Learning with AI

This category refers to the use of AI systems to support both students and teachers. It includes tools that enable personalised learning, streamline administrative tasks, and assist in classroom management (Holmes et al., 2022).

1.1.3 Use AI to learn about learning

Through data analysis, most commonly via learning analytics, AI can provide valuable insights into students' learning processes (Long & Siemens, 2011). In doing so, the goal is to inform and support both learners and teachers by better understanding how learning unfolds (Holmes et al., 2022).

Although these categories offer a helpful framework, research has yet to fully clarify how AI is being integrated across different layers and levels of education. Many teachers explain that they are still searching for practical and sustainable ways to introduce AI-related topics and systems in their classrooms (Yim & Su, 2025). Using the framework of Holmes and colleagues (2022), we will further examine this and aim to build capacity, but also a critical understanding of how to exploit the opportunities offered by AI for teaching and learning.

1.2 Potential benefits, risks, and challenges of AI in education

AI has great potential to transform the design of future teaching and learning processes. A growing enthusiasm for AI in general is observed (Maslej et al., 2023; Miao et al., 2021; OECD, 2020, 2021). This surge in interest stems from the many anticipated benefits of AI for students. To start, there are expectations regarding positive impact on learning outcomes (Holmes & Porayska-Pomsta, 2023; Zhai et al., 2021; Zhang & Aslan, 2021). In addition, many believe that AI enables more personalised learning-offering tailored exercises, adaptive scaffolding, and customised assessments- which allows learners to progress at their own pace, moving away from the traditional 'one-size-fits-all' model (OECD, 2020; Selwyn, 2024). Others also see AI as a valuable tool for supporting students with special needs, for example, through applications like

speech-to-text or text-to-speech systems that assist with reading and writing (OECD, 2020).

It is important to note that AI does not only benefit students but also teachers (Holmes et al., 2023; Holmes & Tuomi, 2022; Sperling et al., 2024; World Economic Forum, 2024). AI can support them before, during, and after lessons by preparing lesson content, organising classes (e.g., creating student groups or assignments), generating exercises and tests, visualising abstract content, providing feedback, grading automatically, and monitoring student engagement and performance (Holmes et al., 2019; Holmes et al., 2022; Selwyn, 2024; World Economic Forum, 2024). One emerging area of interest is the use of teacher dashboards - intelligent interfaces that visualise student learning data. These dashboards can support more informed decision-making and improve teaching efficiency (Knox, 2023; OECD, 2021). In summary, many argue that AI has the potential to automate routine tasks, thereby freeing up time for teachers (Breines & Gallagher, 2020).

Although there is increasing excitement and numerous advantages associated with integrating AI into education across different levels, there are also a number of important questions and challenges, not only for the current context, but especially when looking ahead to the future (Holmes & Tuomi, 2022; World Economic Forum, 2024). The following section explores some of these complexities in more detail.

1.2.1 Technical complexities

Although AI is often presented as being intelligent enough to replace teachers, this is far from reality when it comes to currently available technologies (Selwyn, 2024). In practice, several technical obstacles still stand in the way, particularly at the level of hardware and software (Selwyn, 2024). These include limited access to high-quality equipment and compatibility issues

between AI tools and existing educational content (Filiz et al., 2025; Pritawi et al., 2025; Selwyn, 2024). In this same regard, personalisation is frequently cited as one of AI's key strengths, yet it is not always accurate or sufficient. As Selwyn (2024) explains, AI systems rely heavily on data, and when that data is flawed or incomplete, the risk of errors increases. For this reason, teacher agency and professional judgment remain crucial (Holmes et al., 2022; Selwyn, 2024).

Moreover, while there is no shortage of ambitious promises surrounding AI in education, many tools are still in their early development stages. For example, although adaptivity is often highlighted as a benefit for individuals, collaboration is equally vital for a meaningful learning process. Nonetheless, AI-supported collaborative learning environments have mostly been explored in academic settings and have yet to be widely implemented in everyday classroom practice (Holmes et al., 2022).

1.2.2 Ethical complexity

Within the field of ethics, human rights play a central role (Holmes & Tuomi, 2022). This is also a key concern when it comes to AI in education (Filiz et al., 2025). For example, the principle of human dignity emphasises that education should never be fully delegated to AI systems. Similarly, the right to data privacy and protection implies that student and teacher data should be safeguarded and that any data collected should serve the benefit of the individual (Holmes et al., 2022). We often recognise similar concerns and worries among teachers, raising questions around data privacy, fairness and transparency (Filiz et al., 2025; Holmes et al., 2022). In this respect, SURF (2022) created the Human Values Compass for educational technology, a practical tool designed to help various stakeholders in education reflect on ethical use of technology as well as concepts such as autonomy, human dignity and justice.

It is also important to reflect on how increased data visibility serves the interests of

learners. For instance, student-at-risk detection systems aim to identify students who may be struggling, but raise ethical concerns: How far should we go in collecting data without becoming intrusive? How and when should we inform students about such systems without undermining their motivation? And what happens when technology makes incorrect judgments (Holmes et al., 2022; Selwyn, 2024)?

Thus, questions around learner and teacher agency are becoming critical. How do we ensure that the boundaries of both actors are respected in AI-supported environments? How do we make clear what AI can and cannot do, and where human oversight must remain (Holmes et al., 2022)?

1.2.3 Implementation complexity

AI is rapidly developing in the educational technology industry, but its integration into education is progressing rather slowly. The implementation of new technology in education is often influenced by various stakeholders of the broad educational ecosystem that need to be taken into account. With regard to students' use of AI, teachers express concerns about learners becoming overly reliant on technology (Filiz et al., 2025). They fear this dependence might reduce creativity and effort among students (Filiz et al., 2025), as well as weaken the focus on critical thinking and human creativity within the learning process (Sperling et al., 2024; Miao et al., 2021; Zhai et al., 2021; Molenaar, 2022). A study of Feliz and colleagues (2025) further shows that teachers worry about the difficulty of detecting plagiarism and students' reduced critical engagement with accurate versus inaccurate information (Filiz et al., 2025).

For teachers, one of the biggest issues is the lack of time and the high workload, leaving them with limited capacity to engage in the search for sustainable AI integration (Filiz et al., 2025). Many teachers experience uncertainty about how to effectively incorporate AI tools into

their teaching practice — not only in terms of selecting the most suitable tools, but also in deciding which pedagogical strategies to adopt (Yim & Su, 2025). They are also challenged by the question of how to balance the roles between themselves and the AI tools (who will take control over what in the learning process of students). Teachers genuinely worry about the implications. In a study by Pratiwi and colleagues (2025), a majority of teachers expressed concern about how AI might complement (or in some cases, replace) aspects of their professional role. While they acknowledge that AI can be a contribution for humans in certain tasks, they also emphasise the importance of retaining a sense of ownership or agency and highlight the value of human contributions to education, such as providing emotional support, which they see as ever essential to the learning process.

Teachers sometimes express negative feelings such as frustration or distrust, often stemming from experiences with tools that are not user-friendly or fail to support their needs. These perceptions are also fuelled by a sense of inadequacy in technical or pedagogical knowledge (Filiz et al., 2025; Pratiwi et al., 2025; Yue et al., 2024). Due to limited knowledge and a lack of trust in AI tools, teachers often feel pressured to make pedagogical decisions that are expected to be evidence-based and grounded in student data generated by these technologies (Sperling et al., 2024; Holstein et al., 2020).

A qualitative study by Filiz et al. (2025) on teachers' perceptions of AI implementation in Turkey highlights the importance teachers place on addressing the barriers mentioned above through appropriate support and resources. These barriers can shape their perceptions, which in turn influence how and whether they integrate AI into their teaching practice (Guan et al., 2025). In line with this, Kim and Kim (2022) emphasise that successful AI integration relies heavily on experience; teachers need opportunities to engage with AI technologies to understand and appreciate their potential. This highlights a clear need for targeted training

aimed at strengthening teachers' technical as well as pedagogical knowledge and skills. The following section presents an overview of the current state of such training initiatives and guidelines in Europe, based on recent reports and policy documents.

1.3 Current state of AI training initiatives for teachers in the European educational landscape

Developing effective AI training programmes is challenging due to the rapidly evolving and diverse nature of AI technologies, making fixed curricula quickly outdated (Holmes & Tuomi, 2022). However, one key focus for navigating this dynamicity of AI is the promotion of AI literacy among teachers. Holmes et al. (2022, p. 5) define AI literacy as: *"Having competencies in both the human and technological dimensions of artificial intelligence, at a level appropriate for the individual (i.e., according to their age and interests)."*

Recently, the importance of focusing on Teachers' AI literacy has gained recognition from various initiatives led by the European Commission and related educational organisations (Sperling et al., 2024). For instance, the European Commission (2022) convened an expert group to publish guidelines aimed at assisting teachers in understanding AI in general, tackling misconceptions, and promoting considerations regarding ethical risks (European Commission, 2022). These guidelines are integral to the Digital Action Plan (2021-2027) of the European Union (2021), emphasising the need for increased collaboration on this topic on a European level. Recognising the impact of limited AI knowledge, these guidelines extend their focus to primary and secondary education, with the aim of providing educators with the necessary support and frameworks (European Commission, 2021). Moreover, the European Digital Education Hub (2023) launched an AI report advocating for the support of teachers in developing knowledge regarding teaching for, with, and about AI (European Commission, 2023). Recommendations include leveraging online courses, such as integrating "teaching with AI" into initial teacher education, establishing professional development pathways, and fostering peer teaching initiatives. The need to support teachers' use of AI is also recognised in one of the programmes

of the education department of the Council of Europe (2024), titled ‘Digital Transformation,’ which seeks to utilise technological advancements driven by AI to enrich education (Council of Europe, 2024). This initiative aims to expand knowledge of and access to AI technologies capable of enhancing learning and teaching experiences, as emphasised in the ‘Education Strategy 2030’. In addition, the programme underscores the importance of reevaluating pedagogical approaches and nurturing digital literacy among educators and students. Another similar focus is mentioned by UNESCO, as it advocates for a stronger focus on developing AI literacy among teachers, identifying it as a key topic for Digital Learning Week 2024 (UNESCO, 2024). In their report "Guidance for Generative AI in Education and Research," they stress the importance of adopting a human-centred approach to AI use, empowering teachers to confidently integrate AI into their practices and make informed decisions about its implementation (UNESCO, 2023). Finally, the OECD (2023) further echoes this opinion, advocating for teacher agency and professional learning opportunities through initial education and continuous development (OECD, 2024). They particularly emphasise the effectiveness of professional learning communities. One of the benefits described by OECD (2023) is the use of AI-enabled visualisations in deepening teachers' understanding of the learning process. To do so, teachers need to develop data literacy for which they should receive additional support (OECD, 2023). The focus on teacher competence is seen as a foundational step in enabling responsible, effective, and informed integration of AI into education. Furthermore, all these efforts (reports, guidelines, etc.) align with broader European priorities, for example, as documented in the EU AI Act.

That is the reason why the primary objective of this AI-teach project is to enhance the AI literacy of pre-service, in-service and teacher educators, thereby enabling children and youngsters to be maximally prepared through education to participate as active citizens in today’s and tomorrow’s AI-driven world.

When we look specifically at the participating countries in our AI-teach project, we observe that AI is receiving increasing attention in the context of (pre-service) teacher education. The following brief overview illustrates this trend.

1.3.1 Belgium

In Belgium, the Flemish government is increasingly focusing on the integration of AI in education. For example, the Department of Education and Training published the vision document “Responsible AI in Flemish Education”, which provides guidelines for the responsible development and use of AI in schools (Department of Education and Training, 2024). Additionally, the government is mapping teachers’ current use of AI and their needs, in order to develop tailored training programmes (Flemish Government, Department of Education and Training, 2025).

Several large-scale initiatives are also making their way into education, such as the Imec Smart Education At Schools programme. Through an annual call, teachers from primary, secondary, and adult education submit ideas to tackle classroom challenges with educational technology. An example is the KIKS project, which simplifies AI for high school students through an accessible online platform (imec, 2024). Another large-scale initiative is the ‘AI/XR in Your School’ Bootcamps: an example of how Flanders is investing in sustainable, practice-oriented professional development around artificial intelligence in education. By supporting schools over a two-year period, the programme not only focuses on the technical and pedagogical integration of AI and XR, but also on developing long-term policy to support these innovations. This initiative aligns with broader efforts across Belgium to empower teachers and school teams to use digital technologies in teaching and learning in a responsible and purposeful way. On the other hand, there are also smaller initiatives, such as research groups offering free online training on AI in

education, based on recent literature and research (e.g., https://itec.kuleuven-kulak.be/online-training-on-ai-in-education/). This initiative was very welcome, as it was accessed by over 1000 teachers in 3 months' time.

1.3.2 The Netherlands

The Dutch AI agenda for education starts at the national level with the AI Coalition for the Netherlands (AIC4NL). This coalition adopts a broad and integrated approach to stimulate and guide the development and application of AI in the Netherlands. It aims to position the country as a leader in human-centred and ethical AI by translating technological progress into societal and economic value. In this context, the coalition explicitly links and supports several key national initiatives contributing to the responsible and future-proof use of AI in education.

One of these initiatives is the National Education Lab AI (NOLAI). Following a 2022 report from the Dutch Education Council on the opportunities and risks of intelligent technology in education, the Dutch government allocated €80 million from the National Growth Fund for the period 2022–2032 to establish NOLAI (NOLAI, 2022). Hosted at RU, NOLAI facilitates collaboration among schools, academia, and industry, each playing an equal role in developing responsible intelligent educational technologies to meet educational needs. Guided by a co-creation programme and a scientific programme, NOLAI also features a reference framework on AI to foster shared language and enhance collaboration among schools, scientists, and businesses. Engaging secondary teachers in collaborative co-creation projects is challenging, as their experience with and knowledge about AI educational innovations is still limited.

The National Approach to Teacher Professionalisation (NAPL) complements these efforts by organising and supporting continuous professional development for teachers in primary, secondary, and vocational education. Within this programme, AI education is one of

the focal points, ensuring that teachers acquire the competencies to engage responsibly and confidently with AI innovations.

Another key development is the NPuls pilot hub 'Data & AI', which also operates within the framework of the National Growth Fund. NPuls serves all public vocational education and training schools, universities of applied sciences, and research universities in the Netherlands. It aims to improve the quality, effectiveness, and efficiency of education through the responsible use of data and AI, including innovations that enable learners to progress through education with personalised guidance and education on demand.

Finally, there is the "Empowering Educators in the Digital Transition" project, a collaborative initiative between Flanders and the Netherlands. This project supports both governments in designing, developing, and implementing reforms in digital education, with a strong focus on equipping teachers with the digital competencies they need to effectively integrate technology into their teaching practice.

1.3.3 Austria

Austria has been active in promoting AI knowledge among educational professionals through various initiatives, including policy documents and professionalisation efforts. One of those policy documents is the "Artificial Intelligence Mission Austria 2030", which was issued in 2018 by the Federal Ministry for Transport, Innovation and Technology and the Federal Ministry for Digital and Economic Affairs. This strategic document focuses on regulatory frameworks (ethics, legal), safety and security of AI, defining standards, AI infrastructure, data use and sharing, R&D, transfer, and uptake of AI, cooperation between education, research, and business, societal dialogue, and creating awareness.

Beyond this, the Federal Ministry of Education has issued a handbook "Engaging with artificial intelligence in the education system" in 2023 which aims to raise awareness for the topic among interested parties in the education system on the one hand, and on the other hand to provide basic information on how AI-based systems work and, above all, on their potential and possible applications in education. These efforts are accompanied by various practice-related approaches that aim to explore the AI potential for the field of education. One of those methods is the piloting of AI tools in selected schools, which leads toward the collection of good practice examples and didactic concepts and ideas on how to best use the potential of AI for teaching and learning. This was accompanied by the expansion of existing digital learning offers for teachers (e.g. MOOCs (Massive Open Online Course)) with sections referring to the use of AI-based tools and materials for teaching and learning. Furthermore, the Federal Ministry of Education has also issued in 2023 guidelines for upper secondary schools on the use of AI-based tools in the final exams – highlighting the potential, risks and aspects relevant for an assessment and providing basic orientation for dealing with AI-based applications in the context of final examinations in schools. Additional efforts in this context are connected to the Network eEducation Austria, which has currently more than 4.000 schools as members. The goal of the Network eEducation Austria is to support and foster digital developments in schools through different measures and activities. The current activities of eEducation Austria were complemented with additional activities to encourage schools, and school administrators in particular, to address AI in a sustainable manner in their school development process.

In addition to the above-described efforts, there are approaches focused on integration of the AI topic in the initial education, training, further education and continuing professional development for teachers, as teachers are the driving force behind developments in the education system and their continuing education and training are therefore of central importance. A currently (2025) ongoing teacher education reform includes a major revision and

restructuring of the curricula for the study programmes (Bachelor and Master level) for primary and secondary level teaching. The Quality Assurance Council (QSR) of Austria and the Federal Ministry of Education have defined new focal topics based on which the revision process should be done, and have given recommendations and set requirements for reforming the existing curricula and integrating the relevant focal topics. One of those topics refers to “Artificial intelligence, media education, digitisation, globalisation”, meaning that learning about AI and learning with AI must be addressed in all new curricula. Based on these recommendations and requirements, processes of curriculum reform have been initiated. The Austrian curricula for obtaining a teacher degree, both for bachelor's and master's primary level, have been consequently reformed, and integrate in an extensive way the AI topic. Valid from 1st of October 2025, these curricula should prepare pre-service teachers to use the AI potential for teaching, learning and assessment. Similarly, the existing bachelor's and master's curricula for obtaining a teacher degree for secondary level are currently being reformed, and a new curriculum for secondary level will be implemented from the winter semester 2026/2027 onwards. This curriculum should professionalise teachers at the secondary level to use the AI potential in educational settings.

1.3.4 Turkey

In Turkey, there is an active push towards the utilisation of AI in education. At the policy level, the National AI Strategy Plan (2021-2025) was implemented. Turkey launched a national strategy plan for AI containing guidelines and objectives for the implementation of AI across various sectors, including education. Additionally, in the 2024-2025 academic year, the Higher Education Council (YÖK) announced plans to equip students with AI competence through interdisciplinary research programmes.

Recently, the Ministry of National Education (2025) published the "Artificial Intelligence in Education Policy Document and Action Plan (2025-2029). The document, which includes strategic approaches for the 2025-2029 period, sets out strategic goals for the effective, ethical and inclusive use of artificial intelligence technologies in education. At the same time, studies are being carried out to establish AI-based learning analytics platforms, aiming to improve the digital skills of students and teachers, increase personalised learning opportunities, and strengthen quality and inclusiveness in education. In line with these main objectives, a total of fifteen policy steps and 40 action steps have been identified. Seventeen of these action steps are planned to be implemented within one year, ten within one to three years, and thirteen within three to five years.

Moreover, the National Artificial Intelligence Strategy 2024-2025 Action Plan has been launched. Prepared by the Ministry of Industry and Technology of the Republic of Turkey and the Presidential Digital Transformation Office, the action plan identified strategic priorities as follows:

- Training Artificial Intelligence Experts and Increasing Employment in the Field
- Supporting Research, Entrepreneurship, and Innovation
- Expanding Access to Quality Data and Technical Infrastructure
- Implementing Regulations to Accelerate Socioeconomic Harmonisation
- Strengthening International Collaborations
- Accelerating Structural and Workforce Transformation

Regarding AI-related projects, reference can be made to the FATIH Project, a large-scale initiative by the Turkish government aimed at enhancing technological infrastructure and resources in schools. While initially not specifically focused on AI, the project now encompasses the integration of AI tools to enhance teaching methods and support

personalised learning. Results indicate that the project primarily focused on hardware and found e-content to be unsatisfactory. Additionally, it highlighted issues such as unprepared teachers, sustainability problems, and disruptions in classroom practice. These issues were attributed to the abrupt top-down initiation of the project. Consequently, it is recommended to consult educational technology integration literature before launching such initiatives.

Turkey has also invested in establishing universities and research centres specialising in technology and AI. These institutions are engaged in developing AI applications for educational purposes and training teachers in the use of AI in their teaching. These projects and policy initiatives illustrate how Turkey views AI as a crucial tool for modernising and enhancing the education system. There is a clear need for the preparation of both current and future teachers. Previous project experiences highlight the importance of a bottom-up approach; first, understanding teachers' perceptions and needs and incorporating them into project implementation.

1.3.5 Poland

The “Polish Policy for the Development of Artificial Intelligence (2019 - 2027)” outlines several activities and objectives that Poland should achieve in the short term (until 2023), medium term (until 2027) and long term (after 2027). With the nation's growth in focus, endeavours have been divided into six areas: (1) AI and society, (2) AI and innovative companies, (3) AI and science, (4) AI and education, (5) AI and international cooperation, and (6) AI and the public sector.

Examples of activities and objectives established by Poland across short, medium, and long-term horizons, aligning with the goals to be accomplished within the AI-teach project, include: Short-term (until 2023), introducing mechanisms encouraging teachers to collaborate with experts from the private sector in order to obtain expert support in the preparation of

teaching materials and implementation of the teaching process, including through in-class support (after meeting the requirements provided for in the law); developing mechanisms to support teachers and educational staff in improving their qualifications and skills in the area of AI and modern technologies, along with tools for rewarding students and their teachers for outstanding achievements in these areas; supporting knowledge and experience exchange between educational institutions using modern technologies by promoting good practices using e-learning platforms designed for this purpose (e.g. in the MOOCs formula); providing educational content for schools and supporting them in teaching digital skills, including AI-related competencies. Medium-term (until 2027), preparing teachers to introduce issues related to artificial intelligence in particular subjects or fields of education. Long-term, Poland is the European leader in education in AI and other digital technologies at the secondary school level.

In addition to the policy document described above, the extensive research report titled "Polish Education in the Shadow of AI", conducted by Collegium Da Vinci in collaboration with experts, presents - based on data collected in 2023 from educational stakeholders, including students and secondary school teachers - challenges for the Polish education system in the context of the growing role of artificial intelligence. For example, the report shows that secondary school teachers have little faith in their own competence in using AI-based tools. This concern is further supported by Walkowiak and Kopciał (2023), who found that both pre-service and in-service teachers in Poland express a strong need for structured AI training and institutional support. The lack of systematic integration of AI-related pedagogy in teacher education programmes significantly limits teacher readiness.

This finding raises the question to what extent the short-term objectives set in the policy document that runs from 2019 to 2027 have been achieved. Promoting AI literacy, in particular

that of secondary education teachers, seems to require special attention. Nowak and Kuś (2022) emphasise that most Polish universities lack dedicated AI literacy or ethics modules in pre-service teacher education, further challenging the realisation of national policy objectives.

One recent initiative that reflects efforts to meet these short-term objectives is *CivicEduExpert*, an AI-driven digital assistant developed by Fobizz in 2025. Designed specifically to support teachers with lesson planning and didactic tasks, the tool is tailored to educators' needs and supports multiple languages, including Polish. It enables teachers to generate lesson ideas, create worksheets, suggest assignments, and adapt materials for different learning levels. While *CivicEduExpert* aligns with the national policy's emphasis on enhancing teacher competence in AI, its impact remains difficult to assess. As of now, there is no publicly available documentation of pilot programmes or formal integration into Polish schools or teacher-training curricula, suggesting that its adoption may still be in preliminary stages.

Meanwhile, programmes are being established within secondary education in Poland to foster students' AI literacy. In the AI for Youth programme, secondary school students gain knowledge and practical skills to create their own project using AI algorithms to solve social problems at the local or global level. However, programme evaluations (Digital Poland Foundation, 2023) have shown that while students report high engagement, nearly half of participating teachers felt underprepared to support AI-based learning, highlighting a disconnect between student opportunities and teacher preparedness.

Early this decade, Poland introduced an ambitious policy on AI, consisting of short-term (until 2023), medium-term (until 2027) and long-term (after 2027) objectives. Regarding AI in education, one of the set short-term goals was to provide support to teachers in order to improve their AI skills. Despite this target, data collected in 2023 shows that secondary school teachers have little confidence in their own AI competencies. This is consistent with broader

research, suggesting that the implementation of teacher-focused AI education support mechanisms remains insufficient (Walkowiak & Kopciał, 2023).

Also, recent Polish research highlights both the opportunities and challenges of integrating artificial intelligence into education. Zalewska-Bochenko (2024) offers a comprehensive analysis of AI's potential to transform the teaching process by increasing accessibility, enhancing flexibility, and personalising learning experiences. Her work also stresses ethical considerations, particularly around the equitable distribution of AI benefits, the risk of over-reliance on technology, and the need to balance innovation with human-centred pedagogical values.

Complementing this systemic perspective, Patkowski and Zieliński (2024) investigate the attitudes of key educational stakeholders - including pupils, teachers, students, and business representatives - toward AI in education. Their findings reveal a cautious optimism: while respondents acknowledge AI's capacity to support learning and efficiency, they also emphasise the necessity for regulatory frameworks and ethical guidelines to mitigate risks such as bias, misuse, and erosion of traditional teaching practices.

Together, these studies suggest that successful AI adoption in Polish education requires not only technological readiness but also a sound ethical and regulatory foundation, ensuring that innovation serves educational integrity and human development.

1.3.6 Norway

Since 2018, NORA, which stands for Norwegian Artificial Intelligence Research Consortium, has strived to strengthen Norwegian research, education and innovation in the field of AI by supporting the development of joint research projects between partners, the establishment of AI-related start-up companies, etc. In January 2020, the Norwegian Government presented its

National AI strategy. The aim of the strategy is to delineate policy actions for the upcoming years, aiming to optimise the opportunities that AI can offer to Norwegian individuals, businesses, industries, and the public sector. To equip the future workforce with technological literacy and the appropriate digital skills, the Norwegian Government is initiating reforms across all levels of education. Specifically, at the primary and secondary education level, the government envisions revising the curricula to incorporate greater emphasis on programming and computational thinking. To support teachers in these reform processes, professional development opportunities related to AI are offered through the Centre for Computing in Science Education (CSSE) and the Centre for Teaching and Learning in Science and Technology (KURT). An example of such a course is ProFag programming.

In addition to national initiatives, Norway is involved in international collaborations that aim to further develop digital or, more specifically, AI competencies of different stakeholders. A first example is Norway's participation in the Digital Europe Programme (DIGITAL), an EU funding programme (2021-2027) that supports projects in five areas, including AI, with the aim of bringing digital technology to businesses, citizens, and public administrations within the European Union. A second example is the involvement of Norway in the “Learn to Machine Learn” (LearnML) project. In light of this project, ArtBot has been developed, which is a game introducing primary and secondary education students to the core principles of AI and ML. Also, it should be mentioned that Norway recently funded six new research centres on AI, which are expected to produce research and applications of AI in various fields, including education.

In summary, Norway recognises the importance of AI literacy for teachers, and efforts are being made to integrate it into teacher education and classroom practices. However, ongoing professional development and support are crucial to ensure that teachers stay abreast of technological advancements, including AI.

Apart from the focus on AI within the governments of the aforementioned countries, it remains unclear to what extent AI is specifically addressed in the curricula of (pre-service) teachers. To address this, a thorough curriculum analysis of the participating countries in the AI-teach project is presented later in this report (see section 3 – AI in EU curricula).

1.4 Teachers' needs related to training according to literature and research

Although several governments are promoting the integration of AI in education, teachers do indicate several needs related to training initiatives or professional development. In reality, teacher training programmes often lack sufficient focus on AI, particularly in fostering a holistic understanding of both its technical and pedagogical dimensions (Guan et al., 2025). For example, it can be observed that pre-service teachers tend to use AI tools typically only when necessary. They often do not view AI as a collaborative partner and express limited knowledge of fundamental AI concepts and technologies (Guan et al., 2025).

Reservations to use AI may be driven by teachers' internal factors (Filiz et al., 2025; Guan et al., 2025). Psychologically, attitudes toward AI are crucial. Models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) highlight perceived ease of use and perceived usefulness as key predictors of behavioural intention or willingness to use tools in the classroom (Zhang et al., 2024). Other attitudinal aspects also play a role in AI adoption, including self-efficacy (Guan et al., 2025), trust in AI systems (Zhang et al., 2024), confidence (Hur, 2025), teachers' sense of agency (Brod et al., 2023) and so on. To address all these aspects, it is essential that AI training places sufficient emphasis on broader AI literacy so that teachers feel experienced to align AI tools with curriculum goals and teaching methods while being able to assess benefits and risks (Filiz et al.,

2025). Understanding which teacher tasks can or cannot be delegated to AI is also crucial (Guan et al., 2025).

When it comes to (pre-service) teacher training initiatives programmes, research consistently emphasises the need for both formal and informal support across multiple areas (e.g., Guan et al., 2025; Hur, 2025; Pratiwi et al., 2025). For example, Filiz et al. (2025) report that teachers seek support for technical and operational guidance, curriculum alignment, ethical considerations, flexible professional development, and so on. Specifically, teachers value support that combines theoretical insights with hands-on, practical strategies. To guide teacher development, several frameworks have been proposed, such as the DigCompEdu framework (European Commission, 2017), which focuses on 22 digital competencies across six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating students' digital competence. A recent extension includes AI-specific competencies such as data literacy, computational thinking, ethical use of AI, and preparing students for an AI-driven world (Bekiardis & Attwell, 2024). Finally, the UNESCO AI Competency Framework for Teachers is presented, defining five domains -human-centred mindset, AI ethics, AI foundations, AI pedagogy, and AI for professional growth - each with progression levels from acquisition to creation.

Regarding (pre-service) teacher training programmes, Guan et al. (2025) emphasise that a strong sense of professional community enhances teachers' confidence and readiness to adopt AI. This community can exist at the school level - for example, through knowledge sharing among colleagues - but also at broader levels, such as partnerships between teachers and EdTech providers or training designers. Co-creation processes, as suggested by Pritawi et al. (2025), can foster a sense of ownership and lead to more tailored, context-sensitive support.

1.5 Conclusion

From the above description of international projects, initiatives, and studies, several conclusions can be drawn: There is a clear need for teacher AI literacy and various initiatives in diverse forms to address this need. Teachers generally hold positive perceptions towards the potential of AI technology, but this contrasts with their knowledge and competencies regarding AI adoption in education. Additionally, they experience various feelings of uncertainty, distrust or lack of self-efficacy due to AI challenges (e.g., ethical, technical). This is not only observed in the described partner countries but is also confirmed by others.

Regarding support initiatives, it is evident across all partner countries and also recognised internationally that this is a timely and intriguing issue. For instance, findings from Ferede and colleagues (2022) and corresponding work by Schildkamp and colleagues (2021) suggest that both sufficient opportunities for professional development and adequate technical support are crucial conditions to meet as a means to face the implementation challenges of new technology. The research found that not one specific type, but various support initiatives are desired by teachers. This is also acknowledged by each partner country of the AI-teach project, revealing preferences ranging from on-campus courses to hybrid initiatives to e-learning, aiming to reach a diverse audience with varying levels of prior knowledge. Furthermore, it is recommended to invest in tailored training. In this regard, these professionalisation initiatives need to prioritise connection and co-creation with teachers.

All previously described insights are foundational building blocks of the AI-teach project. As we strongly believe that it is not the technology that makes the difference, but the pedagogical way in which it is being used (Clark, 1994), we do not approach the project from a technological perspective, but from a human perspective; thus, we focus not only on the

potential of intelligent technology but also on the collaboration between teachers and intelligent technology.

(Pre-service) teachers are key stakeholders within the AI-teach project. The starting point is their needs and perceptions from a broad perspective, also exploring agency, trust, and so forth. We emphasise co-creation with (pre-service) teachers as well as teacher educators, thereby employing a bottom-up approach. In this manner, we aim to develop various tailor-made professionalisation initiatives according to the principles of DBR (McKenney & Reeves, 2018).

We will do so by gathering more insights through an analysis of focus group interviews with teachers, a best practices analysis and a curriculum analysis to further investigate the gaps within the field of AI implementation in education.

2. European best practices in AIED

The following section of this mapping report presents an analysis of best practices in Artificial Intelligence in Education (AIED) across Europe. It synthesises 21 European case studies (Appendix 1), with a particular emphasis on teacher education. The selected cases span a range of contexts, institutions and educational levels, and include diverse AI applications, varying between creative classroom tools and policy-aligned professional development frameworks. All three of Holmes' AI domains are represented (Appendix 3), and the selection includes initiatives targeting both pre-service and in-service teachers. The analysis identifies common strengths, such as ethical awareness, pedagogical alignment and collaborative learning, while also highlighting challenges, including gaps in teacher AI competence, and complexities in assessment. These findings lead to a set of recommendations, including the implementation of iterative feedback loops, the cultivation of success experiences, and the prioritisation of pedagogical objectives over technological novelty. The section concludes by underscoring the importance of authentic and practical applications of AI, guided by a clear pedagogical vision, to ensure that AI functions as a meaningful partner in education rather than a disruptive force.

2.1 Methodology

To identify implementations of Artificial Intelligence in teacher education across Europe, a structured methodology was applied to ensure relevance, innovation, impact, transferability and contextual fit. Each participating Higher Education Institution (HEI) was invited to submit two national good practices, ideally representing both student-level (e.g., learning support) and teacher-level (e.g., management support) applications of AI. In some cases, institutions submitted three good practices, as each addressed a different angle. In addition to these national contributions, five other European good practices – sourcing from other countries –

were included to broaden the scope of the analysis. This resulted in a total of 21 case studies (Appendix 1).

The following **criteria** guided the selection of good practices:

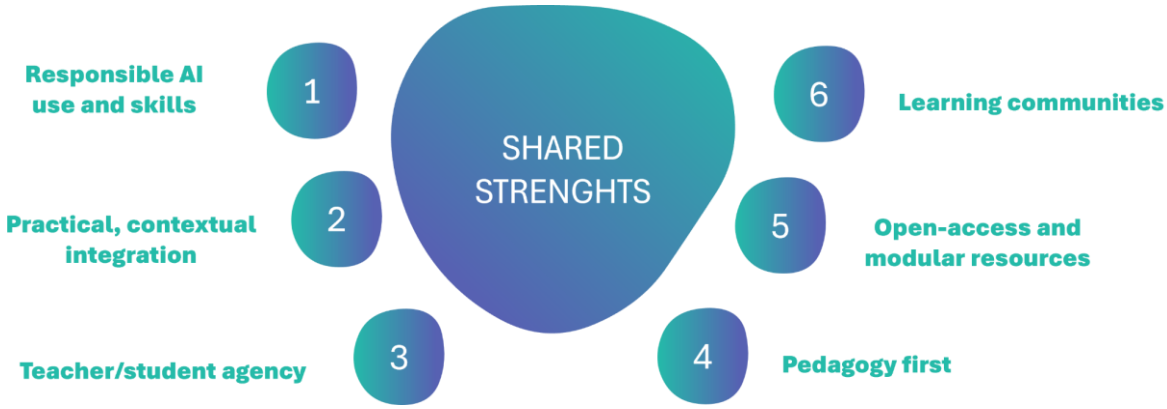
1. **Relevance**: The AI implementation must be embedded within a teacher education programme, either pre-service or in-service.
2. **Innovation**: The practice should demonstrate a novel or forward-thinking use of AI, going beyond generic applications like lesson generation via ChatGPT.
3. **Impact**: The initiative must show evidence of measurable or observable effects on teaching, learning, or institutional practices.
4. **Contextual Fit**: The case study should reflect local educational needs and be situated within the national or institutional context.
5. **Scalability or Transferability**: The good practice should have potential for adaptation in other educational settings or countries.
6. **Evidence**: Documentation, data, or reflective materials (formal or informal) must be available to support the analysis.

Each good practice was examined using a **set of guiding questions** (Appendix 2) that explore the rationale, implementation, strengths, challenges, and outcomes of the AI initiative. This methodology ensures a comparative analysis of innovative AI practices in teacher education in the partner countries.

This report uses 'best practice' to denote good practices that meet our evidence and transferability criteria. We use individual 'case studies' to refer to examples of implementation which provide the contextual detail underpinning these conclusions.

2.2 Strengths in European AIED initiatives

The analysis of the 21 European best practices in AIED (Appendix 1) reveals strengths which can be grouped into six overarching themes (Figure 2). Each factor will be discussed using concrete examples from the field.



(Figure 2: An overview of the six shared strengths, detected in the analysed EU best practices.)

A consistent strength across many good examples of implementation is **the emphasis on responsible AI use**, including attention to bias, authorship and ethical implications. In case study 1 (Making AI tangible) and 18 (Generation AI) specifically, critical reflection on training data, discrimination, and the societal impact of AI was highlighted. These initiatives go beyond technical proficiency, fostering ethical reasoning and critical digital AI literacy among both teachers and students. This skill was also emphasised as vital in the literature review (see section 1) and is often referred to in the European curricula examined (see section 3).

The case studies also demonstrate how successful implementation is often linked to **AI being integrated into practical educational contexts**. This ranges from lesson planning and assessment to creative and interdisciplinary projects. For example, in case study 2 (Understanding AI), teaching materials were developed which enabled students to design a

bionic AI-controlled robot arm. In case study 5 (Storyline in Natural Science), generative AI was combined with the storyline method in science education, allowing trainee teachers to explain abstract concepts to pupils in a more accessible way. In case study 12 (Digital literacy and AI in education), students are guided to use AI to create ready-to-teach lesson sequences aligned with the curriculum. These examples and other case studies often show that AI is used to make complex assignments more feasible and less time-consuming.

This strength is closely connected to the previous one and was also mentioned in the literature review. A significant number of projects emphasised **the importance of co-design**. When teachers and students are actively involved and have a voice in the development and use of AI, it fosters both ownership and creativity. Case study 10 (MOVEL), for example, demonstrates how encouraging teachers to critically reflect on AI's role and redesign their own teaching practices can be highly effective. Similarly, case study 15 (BRIDGE-ELT) highlights teacher involvement as a key feature: educators not only experience AI-supported assessment and tutoring but also contribute to the development of equitable and inclusive AI-aware ELT (English Language Teaching) activities. Although this latter bottom-up approach is still being rolled out, the co-design elements are already cited as a key lesson learned. These case studies highlight how AI can empower rather than replace educators.

Another strength often mentioned across several best practices is the value of building **learning communities** through peer feedback or (cross-)institutional collaboration. Case study 20 (AI4Ed), for instance, emphasises that collaboration with multiple stakeholders – in combination with a continuous feedback loop – is essential for achieving meaningful impact and scalability. Such collaborative methods appear to help grow an improvement-oriented educational culture. In other examples, including case studies 3, 14, 15, and 16, collaboration is a central feature of the Erasmus+ projects, serving as a key driver of innovation. Notably, it is not

only the social dimension that supports stakeholders, but also the diversity of educational contexts in which they operate.

The collaborative nature of many (international) case studies underscores the importance of developing **open educational resources (OERs)**. In the context of Erasmus+ projects, such materials are made available through the Erasmus+ Project Results Platform. **Transferability and long-term impact** are essential criteria for securing funding. For example, in case study 16 (ChatLearn), an open-source teaching chatbot system was developed. Other AI-focused projects designed ready-to-use lesson sequences (case study 12 – Digital Literacy and AI in education), an AI-integrated MOOC platform for ELT teachers (case study 15 – BRIDGE-ELT) and a flexible AI toolkit and training modules**,** aligned with European frameworks such as DigCompEdu (case study 20 – AI4Ed) or openly available educational AI assistants, Study Buddy and Teacher Mate (case study 19 – AI4edu). The **adaptable and freely accessible** nature of these resources is a clear feature of successful best practices.

Lastly, an analysis of the European case studies reveals that **AI should contribute pedagogical added value** rather than merely automate repetitive tasks. In short, pedagogy 'must come first'. In this regard, AI can support innovative and creative learning designs. Case Study 17 (ChatGPT in EFL) demonstrated how generative AI can scaffold both language learning and assessment. A similar approach was observed in case study 11 (AI-Sandbox), where AI facilitated the experimental phase of exploring subject-specific questions. Likewise, case study 6 (AI in Mathematics) employed AI to enhance pedagogical strategies aimed at addressing conceptual learning challenges. In these examples, AI functions as a cognitive partner, helping to formulate pedagogical responses to more complex educational issues.

Taken together, the best practices examined illustrate that AI can serve as a powerful ally in education – provided that its integration moves beyond tool-centric adoption. A

pedagogically grounded, ethically aware and collaborative approach is important to ensure that AI strengthens teacher agency and fosters creativity within classroom practices.

2.3 Common challenges in implementing AIED

Based on the analysis of the studied AIED best practices (Appendix 1), six challenges were identified that need to be addressed to ensure effective and sustainable AI integration in educational contexts. Some challenges are technical in nature, whereas others are pedagogical and institutional (Figure 3).

(Figure 3: An overview of the six main challenges detected in the analysed EU best practices.)

In some case studies, **technical barriers** were cited as obstacles to AIED integration. In some, limited access to safe and freely available AI tools was the primary issue, in others, the absence of institutional policies or difficulties integrating AI with existing platforms posed significant challenges. In case study 10 (MOVEL), for instance, participants encountered difficulties accessing AI tools due to licensing restrictions and institutional limitations. Trainers had to develop workarounds using open-access examples. The absence of institutional policy frameworks initially prevented the use of certain AI tools in case study 11 (AI Sandbox). This highlights the need for governance structures to support experimentation with AIED.

Secondly, **teachers sometimes feel** overwhelmed by the rapid evolution of AI and **lack the confidence or training** to integrate AI meaningfully into their own classroom practice. In case study 8 (AI in Teaching English to Young Learners), participants showed varying levels of digital readiness, requiring the course to emphasise critical evaluation over tool-specific training. In case study 13 (AI in education – VU Amsterdam), teachers expressed uncertainty about AI's capabilities and ethical implications, which was addressed through basic algorithm literacy and policy-writing exercises. In case study 21 (Bootcamp AI/XR), the intensive, hands-on format was found to be effective in making AI more tangible, thereby demystifying the technology and relieving fear among participants.

Time pressure, overloaded curricula and lack of institutional alignment also seem to hinder the integration of AI into teacher education. In case study 12 (Digital literacy and AI in education), teachers struggled to find time and space for AI within an already full curriculum. The course addressed this by encouraging small-scale, subject-specific integration. In case study 20 (AI4Ed), the project had to accommodate diverse national and institutional contexts, requiring a modular and flexible design to ensure uptake. Institutional alignment plays a crucial role in overcoming these challenges.

Many higher education institutions (HEIs) have developed guidelines, practical tools categorised by professional roles and modular professional development courses, particularly in relation to generative AI (GenAI). In Belgium, for example, the KU Leuven and UGent associations have created comprehensive overviews to support lecturers and streamline implementation (KU Leuven Education, n.d.; Education Tips UGent, n.d.). Comparable initiatives are emerging in secondary education, such as at Guldensporencollege (Digi-taal@GUSCO, n.d.).

A significant concern which was brought up a few times was the need for **fairness,**

transparency and validity when dealing with AI-mediated assessments. On the MOOC-platform (case study 15 – BRIDGE-ELT), which includes AI-supported assessment, questions were raised about bias and explainability. The project addresses this through explainable AI features and teacher oversight. Another approach to tackle the question of valid and fair assessment is using collaborative validation and creating prompt refinement to ensure that AI-generated feedback is pedagogically sound and ethically appropriate (case study 17 – ChatGPT in EFL).

The fast-evolving AI landscape also poses challenges for long-term and relevant tool adoption and maintenance. In case study 16 (ChatLearn), it was noted that although the chatbot was effective, it is no longer in use, **raising concerns about sustainability.** However, the project mitigated this by open-sourcing its materials. In case study 18 (Generation AI), the sustainability question was addressed through iterative co-design, a modular approach and open-access resources that can evolve along with technological developments.

A last challenge that needs to be addressed in order for AI to be integrated in AIED more widely is the **diverse educational contexts** in which these AI tools and frameworks should be able to work. Adaptability to different subjects, school types and learner needs is crucial to becoming successful. In case study 19 (AI4edu), the project explicitly addresses digital equity and context diversity through participatory design and iterative feedback loops. Two approaches that were already mentioned in section 2.2 (p. 36). In case study 5 (Storyline in Natural Science), it was clear that in order to support creativity and critical thinking across varied learner profiles, the integration of AI required careful adaptation. A 'one-size-fits-all' approach should be avoided.

Based on these challenges and the strategies used across the case studies, it is recommended that:

1. Institutions develop **clear policies and pay enough attention to infrastructure and access to tools**, so that responsible AI experimentation is possible.
2. **Invest in teacher professional development** that combines technical skills with ethical and pedagogical reflection.
3. **Embed AI gradually into existing curricula**, starting with small, subject-specific activities to avoid overload.
4. **Ensure transparency and fairness in AI-supported assessment**, including explainable AI features and human oversight.
5. **Design for sustainability** by using open-access, modular resources that can evolve with technological change.
6. **Adapt AI initiatives to local contexts**, ensuring inclusivity, cultural relevance and responsiveness to diverse learner needs.

These insights provide a foundation for future work in Work Package 3 and beyond, supporting the development of content portfolios and policy recommendations that are both evidence-based and context-sensitive.

2.4 Recommendations for future AIED practice

Drawing on the insights from section 2.2 *Strengths* and section 2.3 *Challenges*, this section outlines a set of actionable recommendations to support the meaningful integration of AI in education. These suggestions aim to balance innovation with practicality, ensuring that AI enhances - not complicates - teaching and learning. By addressing both opportunities and barriers, the following strategies provide a roadmap for educators, institutions and policymakers.

1. Start small and build feedback loops

Begin with manageable, low-risk activities to avoid overload and foster early success. Starting with one lesson or module helps teachers gain confidence and refine their approach through peer feedback and iteration. This is connected to the personality of the teacher and the vision of the institution. In some cases, a short bootcamp-style approach can also be successful.

2. Prioritise pedagogy over technology

AI should serve pedagogical goals – not drive them. AI can be seen as a partner to enrich inquiry-based and reflective learning, embedded in strong instructional design. Find meaningful ways to integrate AI for pedagogical objectives, instead of just using AI because it is simply available.

3. Use AI as a cognitive partner to foster agency

As was also mentioned in the literature review, AI should complement - not replace – teachers. Building literacy gradually is essential. Therefore, it is important to allocate time and space to foster both teacher and student agency, while demonstrating how AI can support planning and assessment in a co-design approach.

4. Address misconceptions and build successful experiences

Teachers (and students) often fear AI or misunderstand its role. Therefore, use hands-on, creative activities to demystify AI and build trust. Successful experiences reduce resistance and foster curiosity.

5. Make AI tangible through practical tools and diverse contexts

Demonstrate how AI becomes meaningful when students engage with it in authentic, multimodal ways - such as through language, images and multimedia, etc. - allowing it to adapt more quickly and effectively to diverse educational settings.

6. Embed AI in existing courses rather than adding an extra burden

Integrate AI into current modules to avoid increasing workload. This is in line with what was also established in section 'Implementation complexity' of the literature review (section 1.2.3 – p. 14).

7. Build communities of practice for peer support

Collaborative learning and peer feedback strengthen AI integration. Multidisciplinary networks where educators can experiment and share experiences are proving to be successful.

8. Emphasise curriculum relevance and collaborate with policymakers

AI activities should align with national or European frameworks (e.g., DigCompEdu, LifeComp). Policy alignment supports legitimacy, a concern teachers also voiced in the focus group interviews (See section 4.4.1, p. 65). Moreover, this recommendation also helps build scalability and long-term impact.

9. Develop transparent assessment criteria for AI-enhanced learning

Teachers need clear guidelines for evaluating AI-generated work. Establishing well-defined AI-use policies and investing in collaborative validation processes can help ensure fairness and quality in AI-supported assessment practices.

10. Plan for sustainability: prioritise using open-source tools with a long-term support plan

Choose open-source, adaptable tools and create reusable resources for long-term integration and ethical governance.

In summary, the successful integration of AI in education requires a pedagogically grounded approach that empowers both teachers and learners. By starting small, fostering collaboration and aligning with existing frameworks, educators can build confidence and competence while avoiding unnecessary complexity. Prioritising transparency and sustainability ensures that AI becomes a trusted partner in the learning process - one that supports creativity and equity, and reduces the administrative workload across diverse educational contexts.

3. AI in European teacher education curricula

To complement the analysis of best practices, this section presents a comparative screening of teacher education curricula from several European Higher Education Institutions. Using Holmes' framework - 'Learning about AI', 'Learning with AI', and 'Use AI to learn about learning' - the screenings reveal a varied landscape of AI integration. Whereas some programmes demonstrate emerging efforts to embed AI within digital literacy and pedagogical modules, others reflect limited or informal exposure. The findings underscore the need for structured and ethically grounded curriculum reform and a strong implementation to prepare future educators for AI-rich learning environments.

3.1 Methodology

To map the current state of Artificial Intelligence (AI) integration in teacher education across Europe, this study conducted a structured screening of eleven curricula from partner institutions in six countries: Austria, Belgium, the Netherlands, Norway, Poland, and Turkey (Appendix 4). The screenings aimed to capture both the presence and depth of AI-related

content in initial teacher education programmes, using a standardised template to ensure consistency and comparability. This template was divided into four parts (Appendix 5): curriculum overview (part 1), mapping AI content using Holmes' framework (part 2), cross-curricular and practical integration (part 3), and gaps, strengths and planned reforms (part 4). Each institution completed the template based on its current curriculum documents and internal consultations. The responses were analysed, with thematic coding aligned to Holmes' framework and compared with one another. This approach enabled the identification of gaps and promising practices in AI integration across diverse educational contexts.

3.2 Comparative analysis of AI integration in EU curricula

The comparative analysis of AI integration across teacher education institutions in Austria, Belgium, Poland, Norway, Turkey, and the Netherlands (Appendices 4 and 5) reveals a landscape marked by innovation, but also inconsistency. Some countries demonstrate structured and embedded approaches, others rely more heavily on conceptual frameworks or individual initiative.

A first observation is that **AI integration varies significantly across countries, institutions and educational levels**. The curriculum analysed by the Austrian partner stands out for embedding AI across primary education modules, whereas the curricula studied by the Belgian partners sometimes lack structured AI content. The curricula selected by the Polish and Norwegian partner institutions tend to emphasise policy-level frameworks over curriculum-level implementation.

Throughout the studied curricula, **Holmes' Framework is widely acknowledged but inconsistently applied**. Institutions such as VIVES-University of Applied Sciences (VIVES -

Belgium) and Middle East Technical University (METU - Turkey) integrate it explicitly across courses, whereas others - like HAN-University of Applied Sciences and Radboud University (HAN and RU – the Netherlands) and the Private University College of Teacher Education Augustinum (PPH Augustinum - Austria) refer to it more loosely, often limiting its use to electives or workshops.

The first AI domain of Holmes, **Learning about AI, is the most consistently addressed**. Several programmes include foundational knowledge about AI, ethics and societal implications. This is the case in the analysed curricula in Austria, Belgium, and Turkey. In contrast, the analysed programmes by the Polish and Norwegian partner institutions - for now - offer more conceptual coverage, lacking depth at the course level.

In the domain of **Learning with AI, practical application is evident** in the curricula studied by VIVES (Belgium) and METU (Turkey), particularly in didactics and thesis work. VIVES integrates AI tools into multiple courses, such as Educational Science, DigiTAAL, and VTL Educational Technology, with hands-on training and examples of AI use in evaluation and differentiation. **However, systematic assessment frameworks are often missing**, even in countries like the Netherlands and Austria (HAN/RU and PPH Augustinum), where AI tools are present in the studied curricula. HAN offers AI workshops across multiple years, but integration into the core curriculum and assessment remains limited.

The last domain, **Use AI to learn about learning, remains the least developed**. The curricula studied by the Austrian and Turkish partner institutions provide intermediate-level coverage, including learning analytics and personalisation. The curricula selected by the Dutch and Belgian partners touch on related tools such as dashboards, but often superficially. At VIVES (Belgium), dashboards are introduced in XR apps, but data literacy and interpretation are not deeply addressed. HAN students (the Netherlands) may encounter AI-supported tools

during internships, but this is largely dependent on individual initiative and trainer encouragement. The analysed programmes in Poland and Norway show minimal engagement with this area.

Furthermore, it was noted that some programmes (e.g., in Austria and Turkey) **include AI-incorporated inclusion and personalisation in education modules**, **whereas others mention personalisation only conceptually**, without real implementation. The curriculum selected by the Polish partner lacks explicit inclusion-related AI content altogether, but curriculum reform is underway.

Reform efforts are currently under construction in Austria, Turkey, the Netherlands, and Poland, aiming to embed AI more systematically. Belgium, however, is awaiting input from broader initiatives such as AI-teach before initiating reforms. HAN (the Netherlands) is actively developing criteria for AI integration within its "Learning with ICT" outcome, which will be embedded in future curriculum and assessment structures.

One of the concerns noted in the section on Best Practices (see 2.3) was the observation that AI content is frequently delivered through elective courses and workshops. A similar finding holds for the studied curricula. **AI is predominantly introduced through non-compulsory formats**. Institutions in the Netherlands and Belgium rely heavily on electives, while Turkey's CEIT minor offers a more structured approach. The partner institution in Austria integrated AI into mandatory modules, particularly in primary education.

Written guidelines concerning AI use vary widely. Institutions like VIVES (Belgium), HAN (the Netherlands), METU (Turkey) and RU (the Netherlands) provide detailed internal policies. VIVES, for one, offers a comprehensive internal website with ethical guidelines, acceptable use cases and examination regulations. HAN has published a university-wide framework and assessment guide. The University of Rzeszów (UR - Poland) and PPH

Augustinum (Austria) have university-wide policies (although with uneven enforcement), while the Western Norway University of Applied Sciences (HVL - Norway) has some guidelines, but not to the same extent as the other institutions.

As a result, **AI integration is driven by individual lecturers rather than institutional strategy, leading to fragmented implementation**. This leads to uneven exposure and a lack of coherence across years and subjects. Institutions such as RU (the Netherlands), HAN (the Netherlands), and METU (Turkey) show ambition but face challenges in achieving coherence and scalability. VIVES (Belgium) has taken steps to support lecturers through internal professionalisation trajectories and educational technological support, although participation remains voluntary.

The comparative review underscores the urgent need for coherent and structured AI integration in teacher education. Promising practices exist, but many institutions still rely on fragmented efforts and individual initiative. Holmes' framework offers a valuable lens, but its inconsistent application limits its impact. To move forward, institutions must invest in curriculum reform and institutional policies that embed AI across all domains of teacher education. Establishing shared competencies and fostering cross-disciplinary collaboration will be essential to prepare future educators for an AI-enhanced learning environment.

3.3 Recommendations and future directions based on EU curricula

The comparative analysis of AI integration across eleven European teacher education curricula (Appendices 4 and 5) reveals promising practices alongside notable gaps. To support coherent and future-proof AI integration, the following recommendations are proposed. Each is grounded in the findings from the curriculum screenings and aligned with Holmes' framework.

1. Establish structured AI learning pathways across all years

Design a coherent progression of AI literacy that spans all years of teacher education, ensuring coverage across Holmes' framework domains. Begin with foundational concepts and gradually introduce more advanced applications, aligning content vertically from bachelor's to master's levels to support cumulative learning.

2. Mandate AI integration across all teaching subjects and levels

Ensure AI is systematically embedded across all subjects and educational levels, from primary to secondary teacher education. Avoid restricting AI to ICT or elective modules; instead, integrate it into core disciplinary content to promote relevance and pedagogical depth.

3. Create minimum guidelines and assessment standards for AI use

Develop institutional policies that offer clear and consistent guidelines for the ethical and pedagogical use of AI, including standards for assessing AI-assisted activities. Move beyond informal, lecturer-dependent practices towards transparent, institution-wide frameworks that define authorship, data usage, assessment criteria, and academic integrity in AI-supported learning environments.

4. Strengthen the "Use AI to learn about learning" domain

Expand curricular focus on learning analytics, personalisation, and data-driven insights. Equip future teachers with data literacy skills and the ability to interpret dashboards and analytics tools, enabling them to understand and optimise AI-enhanced learning processes.

5. Introduce cross-curricular AI projects and practicum applications

Promote interdisciplinary AI projects and integrate AI into fieldwork applications. Encourage student teachers to engage in AI-themed research, internships and teaching placements that reflect real-world educational contexts and nurture innovation.

6. Ensure AI is assessed as part of final competencies

Include AI-related competencies in formal evaluations and graduation criteria. Ensure that students are not only exposed to AI tools but are also assessed on their ability to use them ethically and effectively within pedagogical frameworks.

7. Provide mandatory and adaptive professional development for lecturers

Implement structured and ongoing professional development programmes for educators that address both technical proficiency and pedagogical integration of AI. Move beyond optional workshops and ensure training is responsive to diverse needs and evolving technologies.

8. Use AI to foster inclusion, differentiation and equity

Use AI tools to support inclusive education and personalised learning pathways. Ensure that ethical and accessibility considerations are embedded in AI use, enabling teachers to address diverse learner needs and promote educational equity.

9. Monitor and evaluate AI use in student assignments and learning outcomes

Establish mechanisms to track and evaluate how students use AI tools in their learning. Develop feedback loops and data-informed strategies to assess the impact of AI on student outcomes, ensuring continuous improvement and responsible use.

To ensure meaningful AI integration in teacher education, institutions must move beyond isolated initiatives and toward systemic reform. The recommendations above provide a

blueprint for embedding AI across curricula, pedagogy, assessment, and professional development. By aligning efforts with Holmes' framework and using existing best practices, European teacher education programmes can prepare future teachers to navigate AI-enhanced learning environments with confidence and competence.

4. Analysis of focus group interviews

This section presents an analysis of focus group interviews conducted across all six partner countries. These interviews captured diverse perspectives on AIED from multiple stakeholders (see 4.1 Methodology). The inquiry focused on barriers for AI adoption, factors influencing confidence, policy requirements, and ethical concerns regarding current and future AI use. To analyse the integration of artificial intelligence in education, this section applies the same Holmes et al. (2019) framework used throughout this report.

4.1 Methodology

The focus group interviews followed a semi-structured format based on a set of questions that were agreed upon after a discussion, including all partner institutions. The format used was based on Brod et al. (2023), Cukurova & Miao (2024), Davis (1989), Holmes et al. (2022), and Molenaar (2022). The questions for the interview were divided into 4 parts (Appendix 6): introductory questions on professional roles and self-assessed experience with AI (part 1), an exploration of professional development, support needs, factors enhancing confidence and existing barriers (part 2), AI integration in education (using Holmes' framework) (part 3), and finally, participants discussed ethical and policy considerations concerning data protection (GDPR), bias, accessibility, and accountability, before offering closing reflections and specific

recommendations (part 4). The goal of using this question framework (Appendix 6) was to ensure comparability across the participating countries.

There were 48 participants (Appendices 7 and 8) from six European countries involved: Austria, Belgium, the Netherlands, Norway, Poland, and Turkey. Because of AI-teach's scope, a wide range of educational roles was represented, including teachers across secondary (lower and higher secondary) and vocational levels, teacher educators and researchers in higher education, policy makers at ministerial and regional levels, ICT coordinators, strategic advisors, and pre-service teachers. This diversity ensured a broader perspective on AI integration challenges and opportunities across the systems. For instance, specific country profiles showed varied levels of experience. In some focus group interviews, teachers were actively involved in AI pilot projects, and others, particularly in Norway, placed a strong emphasis on GDPR compliance. In Turkey, on the other hand, a notable focus was on inclusive practices for disadvantaged students.

4.2 Shared factors enhancing confidence and shared barriers

The focus group discussions revealed an interplay between enabling conditions that foster confidence in using AI in education and structural or perceptual barriers that obstruct its adoption (Figure 4 – Appendices 6,7 and 8). These insights, drawn from multiple European contexts, largely correspond with the findings (strengths, challenges and recommendations) discussed in the previous sections. As was to be expected, they also underscore both the opportunities and challenges inherent in integrating AI into practice.

Focus group interviews					
Confidence	ICT experience	Instituttional support	Peer collaboration	Experimentation freedom	Workload reduction
Barriers	Time constraints	Policy & guidelines gaps	Fear (of bias, ...)	Limited infrastructure & budget	Resistance among colleagues

(Figure 4: An overview of factors enhancing confidence and barriers for AI adoption in education, according to the focus group interviews.)

4.2.1 Factors enhancing confidence

Participants consistently emphasised that confidence in adopting AI is strongly linked to **prior exposure to digital technologies and established ICT practices**. Teachers with a background in digital pedagogy reported feeling better equipped to evaluate and integrate AI tools effectively. **Institutional endorsement** emerged as another critical factor: the provision of approved, GDPR-compliant tools and clear guidance from **school leadership or national authorities** reassured teachers of the legitimacy and safety of AI use.

Opportunities for **low-stakes experimentation** were repeatedly cited as essential. Teachers valued environments where they could try AI applications without fear of sanctions or reputational risk, enabling iterative learning and reflective practice. **Peer exchange and collaborative learning communities** further reinforced confidence, as sharing experiences and strategies within professional networks reduced uncertainty and normalised AI use. Finally, **perceived benefits**, such as workload reduction in lesson planning and administrative tasks, and the potential for genuine personalisation of learning, were powerful motivators for engagement. These findings also correspond with the insights provided in the previous sections (literature review, best practices and curriculum screenings).

4.2.2 Barriers for AI adoption

Despite these confidence-building factors, participants identified several persistent barriers. Foremost among these was the **lack of time for professional development and classroom experimentation**. Teachers described competing priorities and rigid schedules that leave little room for acquiring new competencies. **The absence of clear policies and ethical frameworks at institutional or national levels** compounded this challenge, creating ambiguity around acceptable practices and responsibilities.

Concerns about the reliability of AI outputs were widespread. Fear of errors, misinformation and algorithmic bias undermined trust, particularly in high-stakes contexts such as assessment or inclusion. **Technical and infrastructural limitations**, ranging from inadequate hardware to restricted budgets for licensed tools, further constrained adoption, particularly in resource-limited settings. Additionally, cultural and attitudinal **resistance among colleagues**, often rooted in perceptions of AI as irrelevant or as a threat to professional identity, emerged as a significant obstacle. Some participants also highlighted **practical frustrations**, including tool overload and the complexity of prompt engineering, which can deter sustained engagement.

4.2.3 Job profile-inspired nuances

The composition of the focus groups (Appendices 7 and 8) showed diversity in professional roles and levels of AI expertise, which shaped the perceived needs and the proposed recommendations. Participants included teachers in (lower and higher) secondary and vocational education, teacher educators, policy advisors, ICT coordinators, and pre-service teachers. This heterogeneity influenced confidence levels and detected barriers.

Across all countries, a clear pattern emerged: **AI experience correlated strongly with subject specialisation and institutional role**. Language and ICT teachers, as well as policy makers and teacher trainers, tended to report higher levels of competence and confidence, often engaging in pilot projects or institutional initiatives. In contrast, pre-service teachers and teachers from other disciplines were more likely to identify foundational AI literacy as a need.

Linking participant roles to the findings within each country further supports these dynamics:

- **Belgium**: experienced ICT coordinators and (policy) advisors pushed for systemic frameworks (aligned with the EU AI Act) and mandatory professional development, whereas the pre-service teacher highlighted gaps in the current curricula.
- **The Netherlands**: strategic advisors and ICT innovators reinforced calls for EU-level standards, quality assurance, and attention to ecological impact.
- **Norway**: the presence of a Ministry representative underscored the need for legal clarity and curriculum integration, whereas teacher educators stressed relational learning and warned for emotional attachment risks.
- **Poland**: advisors and academics advocated for structured professional development and ethical guidelines. Meanwhile, STEM teachers revealed confidence gaps and raised concerns about “edutainment” replacing meaningful learning.
- **Turkey**: R&D coordinators and CEIT graduates drove advanced use cases, whereas more experienced teachers and administrators reflected resistance and the need for mentoring, alongside fears of dependency on AI tools.
- **Austria**: a mix of teachers and university professors highlighted tensions between classroom practice and theoretical integration, advocating mandatory training and infrastructure investment.

These variations illustrate how professional roles shape priorities, underscoring the need for differentiated, context-sensitive approaches to AI adoption in education.

4.3 Ethical and other concerns

One of the barriers mentioned in the previous sections was 'fear of bias, societal impact, etc. ' The ethical dimension of AI integration in education emerged as a universal priority across all focus groups. Participants consistently underscored the need for sturdy frameworks to safeguard data and maintain pedagogical integrity. These concerns were not limited to GDPR compliance but extended to broader questions of relational learning and equity.

4.3.1 Shared ethical concerns

1. Data protection and transparency

Compliance with the General Data Protection Regulation (GDPR) was repeatedly identified as non-negotiable. Teachers expressed uncertainty about where and how data are stored, the extent of third-party access, and the mechanisms for ensuring compliance. Calls for greater transparency regarding tool functionality and data handling were pervasive, reflecting a desire for clear, verifiable standards.

2. Ownership of AI-generated content

Participants raised questions about intellectual property and authorship when using AI-generated materials. Concerns centred on whether content produced by AI could be legitimately claimed by educators or students, and how such practices align with professional integrity and assessment norms.

3. Bias and fairness

The risk of algorithmic bias and stereotyping in AI outputs was highlighted across all countries.

Teachers stressed the importance of equipping students with critical evaluation skills to interrogate AI-generated content, thereby mitigating the perpetuation of cultural or gendered stereotypes.

4. Balancing personalisation with social learning

While personalisation was viewed as a potential strength of AI, educators cautioned against its unintended consequences. Excessive individualisation, they argued, could erode opportunities for collaborative learning and diminish the relational aspects of education that underpin social competence.

5. Accessibility and inclusion

Ensuring that AI tools support diverse learners, including those with special educational needs and students from disadvantaged backgrounds, was considered essential. Participants warned that poorly designed systems or AI-tool subscriptions risk exacerbating existing inequalities rather than promoting inclusion.

6. Cognitive and psychological impact

Concerns extended to the mental health and cognitive development of learners. Teachers noted the potential for reduced attention spans, dependency on automated feedback and a decline in deep, reflective learning. These issues were framed as pedagogical risks requiring proactive mitigation strategies.

4.3.2 Country-specific nuances

Although the concerns mentioned in this section were broadly shared, distinctive emphases emerged connected to national contexts:

- **Norway**: participants voiced concerns about emotional attachment to AI systems and

the erosion of relational competence. These worries were amplified by the lack of standardised tools and unclear legal frameworks. It was also noted that AI could undermine critical thinking if used without guidance by educators.

- **Turkey**: discussions highlighted the risk of learned helplessness and "addiction" to AI tools, raising questions about autonomy and self-regulation in learning. Participants also pointed to negative attitudes toward technology and called for clear protocols and monitoring systems to ensure responsible use.

- **Belgium and the Netherlands**: participants debated the ecological impact of large-scale AI deployment and fairness in adaptive learning systems, alongside concerns about over-monitoring students through analytics. Both countries emphasised the need for coherent policies to avoid fragmentation.

- **Poland**: strong concerns were expressed about the erosion of critical thinking and the risk of cognitive dependency on AI. They also highlighted privacy and bias issues, and the growing influence of big tech in education.

- **Austria**: teachers stressed fairness and accessibility, warning that paid tools could exacerbate inequalities. In inclusion contexts, unresolved tensions between accessibility and data protection were noted. Concerns also included performance stress linked to real-time analytics and accountability for AI outputs.

The ethical and practical concerns articulated by participants underscore that the integration of AI in education cannot be approached solely as a technical or operational challenge. Though issues such as GDPR compliance and transparency represent foundational requirements, the

discussions revealed deeper pedagogical and societal implications, ranging from ownership of AI-generated content and risks of bias to questions of relational learning and cognitive well-being. These concerns are not peripheral; they shape the teachers' willingness to engage with AI and influence the conditions under which adoption can occur responsibly.

Building on these insights, the subsequent section turns to needs and recommendations for AIED**.** It explores how the priorities identified can be translated into actionable measures. These recommendations aim to ensure that AI adoption goes beyond meeting compliance standards but also aligns with the core values of equity and human-centred education.

4.4 Recommendations based on focus group interviews

The focus group interviews showed a mix of opinions about what is needed for successful AI adoption in education. Participants highlighted that it is not just about basic technical skills; they expressed the importance of addressing structural, curricular, ethical, and relational dimensions of AIED. These insights can lead to practical recommendations that help shape strategies and policies at both the national and European levels.

4.4.1 Identified Needs

Across all countries, participants stressed the urgent **need for structured and continuous professional development**. They pointed out that one-off workshops are insufficient to build sustainable competence; instead, participants advocated for learning models that include **peer mentoring, collaborative networks and communities of practice**. Such approaches were seen as essential to build confidence, share best practices and maintain adaptability in a rapidly changing AI landscape.

A second universal need concerned **policy-level frameworks and funding strategies at the national level**. Teachers repeatedly noted the lack of clear national guidelines on ethical use, data protection and pedagogical integration. This ambiguity not only creates uncertainty but also amplifies risk perceptions, particularly around GDPR compliance and bias mitigation. Participants called for strong governance structures supported by dedicated funding streams to secure infrastructure, licenses for reliable, high-quality tools, and equitable access across schools.

The **integration of AI literacy into teacher education curricula** also emerged as a priority across all contexts. Participants underscored that foundational knowledge must include technical concepts such as algorithms, data flows, and prompt engineering, as well as ethical awareness and critical evaluation skills. This literacy should not be confined to optional courses but embedded as a mandatory component of both initial teacher education and in-service training programmes.

All the previously mentioned factors have been repeated several times in various sections of this mapping report. However, the focus group interviews also revealed **differences between countries** that add to these shared needs. For instance, participants from Belgium and Poland emphasised the creation of model classrooms and collaborative networks to promote experiential learning. The participants from Turkey highlighted the importance of branch-specific training and access to paid tools to ensure subject-relevant integration. The participants from Norway prioritised legal clarity and curriculum mapping, while the ones from the Netherlands emphasised alignment with the EU AI Act and the establishment of quality benchmarks for educational tools.

4.4.2 Actionable Recommendations

Moving on from the diverse needs discussed earlier, the recommendations below focus on turning these insights into practical strategies. Focus group participants from various countries highlighted shared priorities such as ongoing professional development. But their insights also pointed to specific challenges influenced by local conditions. The recommendations aim to guide both national and European levels, ensuring that all aspects of AI in education - structural, curricular, ethical, and relational - are taken into account. These proposals seek to fill current gaps but also to encourage a thoughtful approach to adopting AI in educational systems.

1. Develop national and EU-aligned AI guidelines and competency frameworks

Focus group participants across all countries emphasised the urgent need for clear, authoritative guidelines that define the ethical, legal and pedagogical parameters for AI use in education. These frameworks should articulate compliance standards for GDPR, establish protocols for data security, set benchmarks for fairness and create transparency in AI-driven systems. Beyond technical compliance, guidelines must address relational and cognitive dimensions, ensuring that AI supports, not replaces, human interaction and critical thinking. At the European level, harmonised standards would reduce fragmentation and provide a coherent reference point for national policies, mitigating the risk of uneven adoption and inequitable access.

2. Embed AI literacy and ethics in teacher education (curricula)

A common thread that emerged in our focus groups was the need to weave AI literacy into both initial teacher education and ongoing training for existing teachers. This literacy should cover not just the basic technical aspects, like understanding algorithms and prompt engineering, but also the ethical considerations and skills for critical evaluation. Educators need to be trained to

analyse AI outputs, spot biases and help students learn to use these tools responsibly. By making these skills a required part of teacher training, we can create a more prepared educational system. This strategy also reinforces the idea that AI should serve as a helpful tool, not replace human interaction, ensuring that the essence of student-centred learning remains intact.

3. Provide quality-assured tools and licensed access

Teachers have raised serious concerns about the growing number of unverified tools and the lack of a centralised system to ensure their quality. To address these issues while upholding ethical and educational standards, participants proposed establishing a European repository for vetted AI tools. This repository should have strict compliance checks for GDPR, ensure transparency in how data is handled, and also demonstrate clear educational benefits. Additionally, it is crucial to have funding mechanisms in place so that schools can obtain licensed tools and improve their infrastructure. Without this support, access gaps will continue to widen, making it difficult to achieve equity and fully harness the potential of AI in education.

4. Foster collaborative learning communities and continuous professional development

One-off workshops were widely regarded as inadequate for building sustainable competence. Instead, participants asked for continuous professional development models that prioritise collaboration and experiential learning. Effective strategies include peer mentoring, interdisciplinary exchange of best practices, spaces for troubleshooting challenges and workshops that focus on practical, pedagogical integration. These approaches should be embedded within institutional structures and supported by national policies, so that professional learning keeps pace with technological evolution.

5. Encourage pedagogical approaches combining AI with human interaction

Finally, participants stressed that AI should complement, not replace, the relational and cognitive dimensions of teaching. Pedagogical strategies must be designed to make the most of AI's strengths in personalisation and efficiency while still safeguarding opportunities for social learning and critical reflection. This balance is essential to prevent over-reliance on automated systems and to maintain the development of higher-order thinking skills among students. Recommendations included integrating AI into cooperative learning tasks and using AI-generated insights as prompts for discussion.

The recommendations presented in this section reflect a strong consensus among participants and echo the suggestions that were put forward in the previous sections: AI should serve as a supportive tool rather than a replacement for teachers, helping to enhance learning and still preserving critical thinking and human interaction.

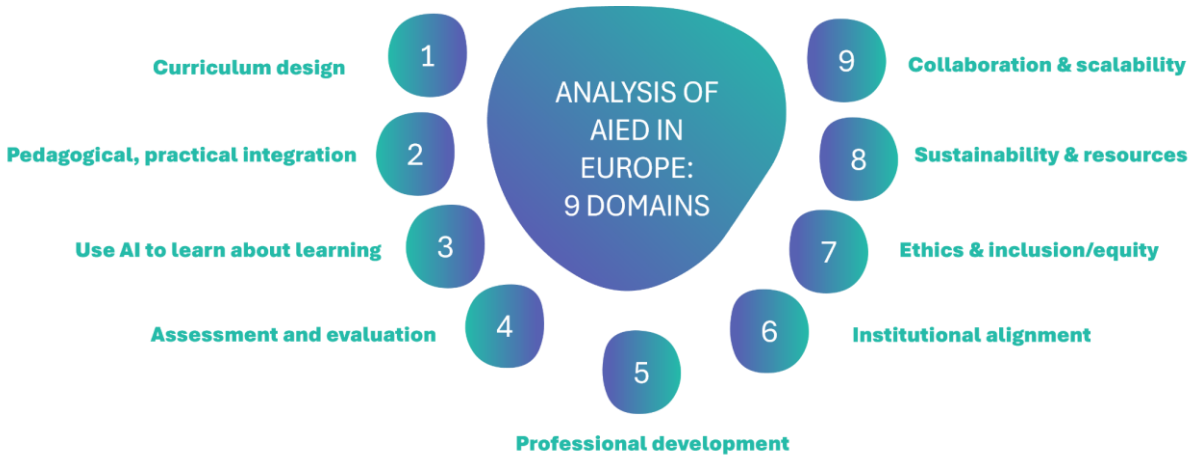
The next chapter will move beyond all the previous sections and provide a **comprehensive gap analysis**, bringing together findings from all components of this report: the literature review, curriculum screenings, best practices, and focus group interviews.

5. Gap Analysis

To guide future directions in teacher education regarding AI integration, this section summarises the insights that were mentioned in the previous sections. The aim is to provide a comprehensive overview of current best practices and challenges across diverse European contexts. This synthesis draws on **four sources**:

- a literature review (Section 1),
- an evaluation of 21 European best practices in AIED (Section 2; Appendices 1, 2 and 3),
- a comparative analysis of AI integration across eleven European teacher education curricula (Section 3; Appendices 4 and 5), and
- focus group interviews conducted in six participating countries, involving 48 participants from Poland, the Netherlands, Norway, Belgium, Austria, and Turkey (Section 4; Appendices 6, 7 and 8).

Based on these analyses, **a matrix** was compiled (Appendix 9). The findings are organised into nine domains. In the following sections, the strengths, gaps and recommendations are presented according to these nine dimensions (Figure 5).



(Figure 5: An overview of the nine domains, compiled in the gap analysis matrix (Appendix 9).)

5.1 Strengths in AI integration across European education

The analysis of AI integration across European education programmes reveals a number of promising strengths that can serve as foundations for future development (See matrix – Appendix 9). First, **several institutions have successfully embedded critical AI digital literacy ("Learning about AI" and "Learning with AI")** into their curricula. The Austrian and Turkish partner institutions stand out for their structured inclusion of AI, demonstrating alignment with Holmes' framework and offering students exposure to AI concepts early in their training. In the focus group interviews, it was noted that the possibility of low-stakes experimentation enables confidence, which helps translate curricular aims into classroom activities.

Pedagogical, practical integration is another area of strength. Institutions such as VIVES (Belgium) and METU (Turkey) have incorporated AI into lesson planning and didactic strategies, ensuring that technology supports rather than drives pedagogy. This approach is echoed in several best practices, where AI is used to enhance instructional design and foster deeper learning.

Some programmes have begun to address the domain of "Use AI to learn about learning," with intermediate-level coverage in the Turkish and Austrian partner institutions. Tools such as dashboards are introduced in institutions like VIVES (Belgium) and HAN (the Netherlands), offering initial steps toward data-informed teaching practices. Focus group participants concur, but caution that analytics must be kept in check to preserve social learning and avoid over-individualisation and over-monitoring.

Assessment and evaluation practices also show emerging strengths. AI-supported thesis work is evident in VIVES (Belgium) and METU (Turkey), while HAN (the Netherlands) is piloting frameworks for AI-enhanced assessment. These efforts reflect a growing awareness of the need to evaluate AI competencies within formal education.

Professional development initiatives, such as internal training at VIVES (Belgium) and bootcamp-style formats in best practice projects, demonstrate effective models for building educator capacity. **Co-design approaches**, as seen in MOVEL and BRIDGE-ELT (Appendix 1), further empower teachers to shape AI integration in meaningful ways. The building of communities of practice and the importance of peer support are also clearly valued by focus group participants and were underscored in the literature review.

Institutional alignment is supported by policy frameworks e.g., in HAN (the Netherlands), VIVES (Belgium), and METU (Turkey), providing a foundation for consistent implementation. **Sustainability** is also addressed through the use of open educational resources (OERs) and modular formats, as demonstrated in projects like ChatLearn and AI4Ed (Appendix 1).

Finally, **inclusion and equity are actively promoted in some analysed curricula**, with the Austrian and Turkish partner institutions integrating AI tools to support personalised and accessible learning. Collaborative efforts across (e.g., Erasmus+) projects highlight the value of **peer feedback and cross-institutional partnerships**, offering scalable models for innovation in this domain.

5.2 Gaps in AI integration across European education

Despite notable strengths, the analysis reveals several persistent gaps that hinder the coherent

and equitable integration of AI in education (see matrix - Appendix 9). The first challenge concerns the **fragmented nature of curriculum design**. AI is frequently confined to ICT or elective modules, resulting in limited exposure and a lack of structured progression across Holmes' framework domains. Few programmes offer compulsory, coherent pathways that span the full duration of teacher education. This gap was echoed in focus groups, where participants stressed that AI literacy should be mandatory and embedded across subjects rather than treated as an optional add-on.

Pedagogical, practical integration remains uneven. Some institutions embed AI into teaching practices, but many still isolate AI content within ICT modules or in 'extra assignments', failing to connect it with subject-specific pedagogy. Focus group discussions reinforced key findings from the literature review: teachers warn for superficial AI use, reducing AI to "edutainment" rather than meaningful learning (Poland), and they emphasise that relational learning in education remains important. Therefore, it is necessary to avoid over-reliance on AI systems (Norway) and focus on pedagogy-first approaches.

The domain of **"Use AI to learn about learning"** is particularly underdeveloped. Learning analytics and personalisation are often treated superficially, and teacher training in data literacy is largely absent. Without the ability to interpret and apply data insights, educators may struggle to utilise AI for meaningful learning outcomes. Focus group participants added that dashboards and predictive analytics, while promising, can create stress/over-monitoring and accountability concerns if introduced without clear guidance (Austria and Belgium).

Assessment practices also present challenges. AI-supported learning is rarely included in formal evaluations, and transparent criteria for assessing AI-generated work are lacking. Concerns about fairness and the need for human oversight further complicate the integration of AI in assessment frameworks. Teachers in several countries raised questions about ownership

of AI-generated content, reinforcing the need for clear protocols alongside assessment standards.

Professional development is another area of concern. Training is often optional, superficial, or inconsistent across institutions. Many educators report low confidence in using AI, and adoption remains uneven. Focus groups highlighted time constraints and tool overload as practical barriers, and emphasised that one-off workshops are insufficient. Instead, teachers called for collaborative formats such as peer mentoring and communities of practice to build confidence and share best practices. Without structured and adaptive training, teachers may remain ill-equipped to integrate AI in an effective way.

Institutional alignment is limited, with AI integration frequently driven by individual teachers rather than coordinated governance structures. This leads to inconsistent implementation and a lack of strategic direction. Focus group insights added that educators value legal clarity and alignment with broader frameworks such as the EU AI Act, pointing to the need for governance that combines compliance with pedagogical vision within the institutions. In this context, inadequate infrastructure and/or unequal access to responsible AI tools in various institutions also play a role.

Sustainability poses a long-term challenge. Many initiatives rely on proprietary tools that risk becoming outdated, and few programmes have strategies for updating and maintaining resources over time. Teachers also expressed concern about rapid tool evolution and the absence of protocols for retiring or replacing tools, which can lead to overload and inequity. In that respect, it was also noted that inclusion and equity, though conceptually acknowledged, are rarely operationalised in curricula. As a result, vulnerable learners end up not getting the support they need.

Finally, **collaboration and scalability** are constrained by the limited presence of cross-curricular AI projects/pilots and the absence of scalable, cross-institutional practices. Focus groups reinforced the importance of communities of practice and peer support as mechanisms to scale innovation and normalise AI use across diverse contexts. Without shared resources and coordinated efforts, innovation remains localised and difficult to replicate.

5.3 Strategic recommendations for European AIED integration

To address the gaps and build on existing strengths mentioned in this chapter so far, a set of strategic recommendations is proposed to guide future development in AI integration within teacher education (See matrix – Appendix 9).

First, institutions should **establish structured AI learning pathways that span all years of teacher education and align with Holmes' framework**. This includes mandating AI integration across all subjects and levels, ensuring that exposure is not limited to ICT or elective modules. Moreover, AI literacy should not only cover technical foundations, but also have ethical awareness and critical evaluation skills as compulsory components.

Pedagogical, practical integration must be prioritised. AI should be embedded into existing courses and treated as a cognitive partner that supports instructional goals. This requires a shift from tool-centric and sometimes superficial approaches to pedagogy-first design, enabling educators to use AI meaningfully across disciplines and maintain relational learning in education.

The domain of "Use AI to learn about learning" should be strengthened through dedicated modules on learning analytics, personalisation, and dashboard interpretation.

Teachers must be equipped with data literacy skills to critically engage with AI-enhanced learning environments. Without these skills or clear guidance, analytics raise accountability concerns and can create over-monitoring, causing stress.

Assessment frameworks should include AI-related competencies as part of final evaluations. Transparent and explainable criteria must be developed, and human oversight should be maintained to ensure fairness and validity in AI-supported assessment.

Professional development should be mandatory, adaptive, and ongoing. Bootcamp-style formats and communities of practice can support peer learning and foster confidence among educators. Institutions need to focus on capacity-building and encouraging collaboration across different fields to promote sustainable practices effectively. But, all this is only possible if enough time for training is allocated to teachers.

Next to investing enough in capacity-building**, institutions** should also **focus on internal alignment** and **collaboration with (national and European) policymakers** to install legal clarity (e.g, EU AI Act). The creation of governance mechanisms will support implementation.

Sustainability should be a guiding principle. Programmes should adopt modular, open-access resources and establish long-term update strategies. This will prevent reliance on proprietary systems that may lose relevance over time. Focus groups added that rapid tool evolution and tool overload are practical concerns, making quality-assured repositories and clear maintenance protocols essential.

It is also necessary that adaptive learning technologies and accessibility features to **support diverse learner needs** (See matrix – Appendix 9) are implemented. But, focus groups

warned that poorly designed systems or paid tools risk exacerbating inequalities, reinforcing the need for equity-driven design.

Finally, **collaboration and scalability should be enhanced through cross-curricular AI projects and practicum applications**. Institutions should work together to build shared repositories, pilot joint initiatives, and scale successful practices across borders since these kinds of peer exchange communities are critical for confidence-building and innovation, making them central to scaling successful practices.

These recommendations (see matrix - Appendix 9) provide a blueprint for systemic, ethically grounded, pedagogically rich, and teacher-driven AI adoption, ensuring that teacher education programmes prepare educators to use AI effectively in a future-ready learning environment. It is important to note that these overarching recommendations were not mentioned just once; rather, they emerged consistently throughout various chapters of this report, reinforcing their significance and the need for a comprehensive approach to AI integration in education.

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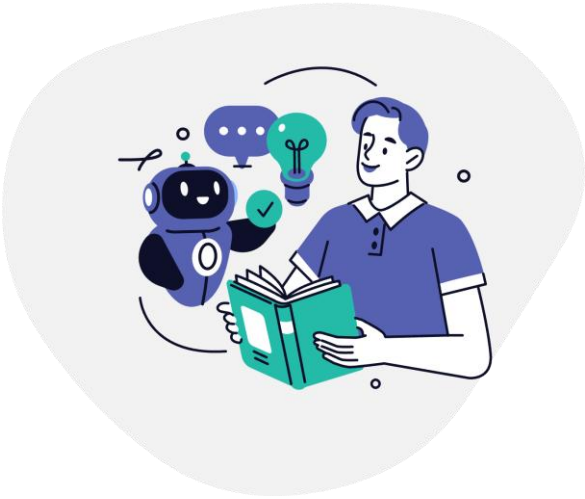

Appendices

Appendix 1 – List of European best practices

1	**Making AI tangible – art, didactics and reflection**	Austria	Lesson plans, OER, workshop formats	heike.krause@pph-augustinum.at (Teacher educator)
2	**Understanding AI – a bionic modular robot arm**	Austria	AI-controlled robot arm, inclusive teaching materials	heike.krause@pph-augustinum.at (Teacher educator)
3	**Paideia – Preparing teachers for the AI development in education**	Belgium	AI&EDcomp framework, online curriculum	www.paideiaproject.eu
4	**VAIA – Vlaamse AI Academie**	Belgium	AI training programmes	www.vaia.be
5	**Storyline in natural science**	Norway	AI-enhanced Storyline lesson designs	Røsland, G. V. & Hoem, J. (2025). Storyline ved bruk av KI [Storylines and the use of AI]. In Elstad, E., & Korbøl, K. (Eds.). Kunstig intelligens i skolen [Artificial intelligence in school]. Fagbokforlaget.
6	**Use of AI in mathematics education (Socratic dialogues)**	Norway	AI-supported Socratic dialogue tasks	Hauge, I. O. & Rekstad, M. (2025). Bruk at kunstig intelligens i matematikkundervising [The use of artificial intelligence in mathematics education]. In Elstad, E., & Korbøl, K. (Eds.). Kunstig intelligens i skolen [Artificial intelligence in school]. Fagbokforlaget.
7	**CivicEduExpert**	Poland	AI-powered lesson planning assistant	www.fobizz.com/en/poland-new-subjects-2025/
8	**AI in teaching English to young Learners**	Poland	Elective course, AI-integrated lesson plans	http://www.pedagog.uw.edu.pl/ Link to course (University of Warsaw)
9	**EUonAIR – Center of excellence for responsible AI and education**	Poland	AI curriculum, workshops, seminars	www.euonair.eu/en/core-pillars/center-of-excellence-for-responsible-ai-and-education
10	**MOVEL – Responsible AI integration**	The Netherlands	Online module, portfolio-based assessment	www.han.nl/opleidingen/master/ontwerpen-van-eigentijds-leren/deeltijd/ Link to online module (edition 2024/2025)

11	**AI-Sandbox**	The Netherlands	Institutional sandbox, policy input	www.han.nl/onderwijsondersteuning/leren-werken-met-ict/artificial-intelligence/han-ai-sandbox/ Link to video - AI support in instructional design
12	**Digital literacy and AI in education**	The Netherlands	Ready-to-teach lesson sequences	www.ru.nl/opleidingen/onderwijs-voor-professionals/overzicht/digitale-geletterdheid-en-ai-in-het-onderwijs
13	**AI in education – VU Amsterdam**	The Netherlands	AI-use policy documents	www.vu.nl/nl/onderwijs/professionals/cursussen-opleidingen/workshop-ai-in-het-onderwijs/data-en-contact
14	**AiDA – AI assistant for CPD**	Turkey	AI self-assessment tool + CPD assistant	www.aida4teachers.com
15	**BRIDGE-ELT**	Turkey	AI-integrated MOOC platform	www.bridgeelt-fedu.metu.edu.tr/
16	**ChatLearn**	Finland	Teaching chatbot system (open-sourced)	www.oph.fi/en/news/2025/erasmus-project-led-oulu-university-used-chatbot-personalise-higher-education-students
17	**ChatGPT in EFL**	Spain	Validated lesson plans and assessment strategies	Octavio, M. M., Argüello, M. V. G., & Pujolà, J. (2024). ChatGPT as an AI L2 teaching support: A case study of an EFL teacher. *Technology in Language Teaching & Learning*, *6*(1), 1–25. https://doi.org/10.29140/tltl.v6n1.1142 Link to materials
18	**Generation AI**	Finland	Curriculum modules + teachable machines	www.generation-ai-stn.fi/en/ Link to social media machine on GitHub
19	**AI4edu**	Greece	Study Buddy & Teacher Mate AI assistants	www.ai4edu.eu
20	**AI4Ed**	Spain	AI toolkit, training modules, implementation guidelines	www.ai4ed-project.eu/ Link to training programme
21	**Bootcamp AI/XR**	Belgium, Uganda	An immersive bootcamp for AI/XR	britt.adams@vives.be(contact person) LinkedIn post of Enabel Link to learning materials/presentations

Appendix 2 – List of questions for best practice analysis

1. What educational challenges or needs does the AI address?
2. What motivated the choice of this specific AI approach?
3. Which of Holmes' three domains does the case align with: *learning about AI*, *learning with AI*, or *use AI to learn about learning*?
4. What AI technologies are used, and how are they integrated into the teacher education programme?
5. Who are the key stakeholders involved?
6. What outcomes have been observed or are anticipated?
7. What challenges were encountered and how were they addressed?
8. What lessons and recommendations emerge from the case?

Appendix 3 – Stakeholder groups/Holmes' AI domains in the best practices

Stakeholder groups targeted

Stakeholder group	Best practices (Appendix 1)
Pre-service teachers	1, 2, 5, 6, 8, 10, 12, 13
In-service teachers	3, 4, 7, 14, 15, 19, 20
Mixed (Pre-service + In-service)	9, 11, 16, 17, 18

Holmes' AI domains covered

AI domain	Best practices (Appendix 1)
Learning about AI	1, 2, 3, 4, 8, 10, 12, 13, 15, 18, 19, 20
Learning with AI	1, 2, 3, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17, 18, 19, 20
Using AI to learn about learning	6, 9, 18, 19, 20

Appendix 4 – List of European curriculum screenings

#	Country	Institution	Level	Study field
1	Austria	Private University College for teacher education Augustinum (PPH Augustinum)	Bachelor	Primary school teacher education
2	Austria	Private University College for teacher education Augustinum (PPH Augustinum)	Bachelor	Secondary school teacher education
3	Austria	Private University College for teacher education Augustinum (PPH Augustinum)	Master	Primary school teacher education
4	Austria	Private University College for teacher education Augustinum (PPH Augustinum)	Master	Secondary school teacher education
5	Belgium	VIVES University of applied sciences	Bachelor	Primary and secondary education
6	Belgium	KU Leuven University teachers' academy	Master	Primary education
7	The Netherlands	HAN University of applied sciences	Bachelor, Master, In-service	Teacher education across levels
8	The Netherlands	Radboud University teachers' academy	Minor, Master, In-service	Academic teacher education across levels
9	Norway	National framework (PfDK)	Master	Framework for teachers' digital competence

10	Poland	University of Rzeszów teachers' academy	Bachelor, Master, Postgraduate	Teacher education in early childhood, primary, and language education.
11	Turkey	METU Middle East Technical University (CEIT Department)	Undergraduate (Minor)	Minor in Data and AI in Education

Appendix 5 – List of questions for curriculum screenings

Part 1: curriculum overview

- What is the name and level of the teacher education programme?
- Is AI currently included in the curriculum?
- If yes or to some extent, where is it located? (e.g., standalone course, integrated in existing modules, project-based, practicum)

This section established the basic parameters of each programme, including its structure, scope and whether AI was explicitly or implicitly present.

Part 2: mapping AI content using Holmes' framework

This section applied **Holmes' framework**, which categorises AI integration into three pedagogical domains:

1. **Learning about AI**
    - Is this domain covered in your curriculum?
    - In which courses or activities?
    - Short description of content (e.g., ethics, terminology, societal impact)

- Depth of coverage: Introductory / Intermediate / Advanced

2. **Learning with AI**
    - Is this domain covered in your curriculum?
    - In which courses or activities?
    - Short description of content (e.g., AI tools for teaching, chatbots, adaptive platforms)
    - Depth of coverage: Introductory / Intermediate / Advanced
3. **Use AI to learn about Learning**
    - Is this domain covered in your curriculum?
    - In which courses or activities?
    - Short description of content (e.g., personalisation, learning analytics)
    - Depth of coverage: Introductory / Intermediate / Advanced

This framework enabled a comparative analysis of how deeply and broadly AI is addressed across pedagogical dimensions.

Part 3: cross-curricular and practical integration

- Are there cross-curricular projects or internships involving AI?
- Do student teachers use AI tools in teaching practice or assignments?
- Are there written guidelines for AI use?
- Is AI used in relation to inclusion, assessment, feedback or personalisation?

This section explored the practical application of AI in teacher training, including experiential learning, institutional support and ethical considerations.

Part 4: gaps, strengths, and planned reforms

- What are the strengths of your current curriculum regarding AI integration?

- What gaps or areas for development do you see?
- Are there any planned curriculum reforms related to AI in the near future?

This final section allowed institutions to reflect critically on their current position and future ambitions regarding AI in education.

Appendix 6 – List of questions for focus group interviews

PART 1: introductory questions

- Can you briefly introduce yourself and your role within the educational field (if you teach, what subject(s) do you teach?).
- Try to estimate your current level of experience with AI in education (*Novice: You're fairly new to AI and haven't used it much yet - Intermediate: You've used AI a few times and have some familiarity - Expert: You use AI regularly and feel confident applying it in educational settings*).

PART 2: professional development, support and barriers

- What makes you feel confident, or what might hold you back in using AI tools?
- In your view, how can schools (through leadership, ICT support, or colleagues) best support teachers in working with AI? What kind of help or collaboration would make a difference?
- What kind of support or direction could come from a higher level (such as policy, government, or teacher education programmes) to

  a) better support the meaningful integration of AI in education and

b) help educators use AI meaningfully and feel more confident/prepared?

- If teachers were to explore AI in education further, what kind of professional learning, resources, or guidance would you think of as most useful?

- Are there any barriers that prevent teachers from participating in such initiatives, and how could these be addressed?

PART 3: AI integration in education (using Holmes' Framework)

A. Learning about AI

- What kind of knowledge do you think teachers should have about AI in general?
    - What technical aspects of AI should teachers be familiar with?
    - How are the technical aspects of AI (e.g., content knowledge about algorithms, programming…) integrated into lessons and taught to students?
    - What ethical or data-related considerations should teachers be aware of?
    - How is AI literacy currently embedded in the teacher education curriculum?

B. Learning with AI (ease of use/usefulness)

- What possibilities do you see for AI tools to help students in their learning process?
- Have you come across or used any AI-based tools in education - either yourself or through others? Feel free to share examples, what the tools were used for, in which context or subject, and what stood out to you.
- Based on your experience or what you've seen, how do these tools support teaching or learning? You can think about their added value, where they work well, and where they might fall short.

- What about ease of use and usefulness of these tools?

C. Use AI to learn about learning

- Have you ever worked with tools that use AI to give you insights into how students are learning? If so, what kind of information did these tools offer, and how was it presented to you (e.g., via dashboards, reports, visualisations)?
- How comfortable do you feel interpreting this kind of data about student learning? What helps - or makes it harder - to use these insights effectively in your teaching?
- How do you connect insights from such tools to your teaching decisions or classroom strategies? Can you give an example of a moment where learner data influenced your approach?
- To what extent do you think students should have access to data about their own learning? What could be the benefits or challenges of this in your context?

PART 4: closing questions

- Have we missed anything important from your perspective, or is there something else you would like to add?

Appendix 7 – List of focus group participant profiles

Profile	Belgium	Austria	Norway	Poland	The Netherlands	Turkey
Pre-service teacher	1	0	0	0	2	0
In-service teacher	2	3	4	2	2	3
Researcher	1	1	0	0	1	0
Teacher educator	2	0	1	0	2	2

Academic/University lecturer	0	3	0	3	0	0
Advisor/Expert	1	0	0	2	1	1
ICT coordinator/ICT-related job	1	0	0	0	0	0
Headmaster	0	0	1	0	1	1
Policy advisor	0	0	1	0	0	0
Others	1	0	1	0	0	1

Appendix 8 – AI integration overview based on focus group interviews

Country	AI experience of participants	Main confidence factor	Main Barriers	Main professional development needs	Main ethical concerns
Belgium	High	Policy-driven	Time & Ethics	Mandatory AI literacy	GDPR emphasis
Austria	Mixed	Peer-driven	Time & Ethics	Hands-on workshops	Bias & Equity
Norway	Mixed	Policy-driven	Time & Ethics	Hands-on workshops	GDPR emphasis
Poland	Mixed	Peer-driven	Infrastructure	Hands-on workshops	Bias & Equity
The Netherlands	High	Peer-driven	Time & Ethics	Mandatory AI literacy	Bias & Equity
Turkey	High	Peer-driven	Infrastructure	Hands-on workshops	Bias & Equity

Appendix 9 – Gap analysis matrix

Dimension	Strengths identified	Gaps identified	Recommendations
Curriculum design	AI embedded in some pilot programmes (Austria, Turkey); Holmes' framework referenced (VIVES, METU).	AI literacy absent in most teacher education; AI often limited to ICT/electives; Fragmented progression across Holmes' domains; Lack of compulsory, coherent pathways and integration.	Mandate AI integration/AI literacy across subjects and levels; Establish structured AI learning pathways across all years and domains; Embed ethics and critical thinking.
Pedagogical, practical integration	AI used for lesson planning, didactis and creative projects (e.g.,VIVES, METU); Pedagogy-first approach in case studies.	Teachers lack confidence; AI content often isolated in (ICT) modules; Lack of subject-specific integration; Fear of misuse; Overreliance risk.	Embed AI in existing courses; Provide subject-specific examples; Promote AI as a cognitive partner; Prioritize pedagogy over technology.
Use AI to learn about learning	Initial dashboard use in some cases (Austria, Turkey, VIVES, HAN).	Limited adoption; Teachers lack data literacy; Weak personalisation practices; Concerns about relational learning; Over-monitoring risks causing stress.	Add modules on data analytics and ethical personalisation and dashboard interpretation; Maintain social learning focus; Flag over-monitoring when real-time analytics are used.
Assessment & evaluation	AI used in thesis work (VIVES, METU) and pilots (HAN – AI	AI rarely assessed formally;	Ensure AI is assessed as part of final competencies;

	assessment framework).	No clear criteria for evaluating AI-generated work; Fairness and explainability concerns; Plagiarism risk.	Develop transparent and explainable assessment standards/criteria; Ensure human oversight.
Professional development	Bootcamps and co-design formats effective in best practices; Internal training is offered (e.g., VIVES, KULEUVEN).	Training often optional or superficial; Teachers prefer hands-on, collaborative formats; Low teacher confidence in AI use; Uneven adoption across institutions; Time constraints.	Make PD mandatory and adaptive; ensure sufficient time is provided; Offer flexible, practice-based formats; Build networks/communities of practice for peer support; Start small.
Institutional alignment	Policy frameworks emerging in some institutions (HAN, VIVES, METU); Co-design approach in case studies (MOVEL, BRIDGE-ELT).	Lack of governance structures for consistency; Reliance on individual champions; Absence of national standards.	Collaborate with policymakers; Create institutional governance structures; Align with EU AI Act; Ensure legal clarity; Ensure infrastructure and access to responsible AI tools.
Ethics & inclusion/equity	Ethical use highlighted in best practices; AI used for personalization and inclusion (Austria, Turkey).	GDPR compliance unclear; Ownership issues; Risk of emotional attachment; Conceptual mention (of inclusion/equity)	Provide clear ethical protocols (beyond GDPR to ownership, cognitive well-being, bias/fairness, relational learning...); Train teachers on data privacy and bias;

		only in most curricula; Limited operationalization (inclusion/equity).	Use AI to foster inclusion, differentiation, and equity (e.g., adaptive learning, accessibility features).
Sustainability & resources	Use of OERs and open-source tools (ChatLearn, AI4Ed); Modular, reusable formats tested.	Focus groups stress funding gaps and tool overload; Proprietary tools risk becoming outdated; Few long-term strategies for updating and maintaining resources.	Secure funding for quality-assured tools; Prioritise sustainable, open solutions/resources and avoid tool overload; Establish long-term update and maintenance strategies.
Collaboration & scalability	Erasmus+ best practices emphasize peer feedback and cross-institutional collaboration.	Limited cross-institutional pilots; Lack of shared standards; Limited cross-curricular AI projects in existing curricula.	Introduce cross-curricular AI projects and pilots; Scale collaboration across institutions and countries; Create shared repositories and guidelines.