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UNIVERSITÀ DEGLI STUDI DI MILANO

Preparing teachers for the AI Development in Education as an Innovative Asset

Project: 101132955 — PAIDEIA — ERASMUS-EDU-2023-PI-FORWARD

D2.1 REPORT ON THE STATE OF ART ABOUT AI IN COMPARATIVE PERSPECTIVE

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Abstract	This report maps of peer-reviewed academic literature and policy documentation related to AI in education. It highlights significant research activity, curriculum design, and AI's multifaceted applications in teaching, assessment, learning, and data analysis. Additionally, it underscores the need for developing AI-centric educational curricula and preparing educators to leverage AI effectively.
Key Words	Scoping review, policy analysis, AI education, AI in education, curriculum design, teaching and assessment, teacher preparation

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1. INTRODUCTION

This deliverable addresses the key objective of PAIDEIA project Work Package 2.1: to report on the state of the art with regard to Artificial Intelligence (AI) in education in PAIDEIA countries. The report is structured in two sections. The first section undertakes a scoping literature review regarding how AI is used in education, and how AI education takes place, in PAIDEIA countries. The second section undertakes an analysis of key policies relating to AI in a number of PAIDEIA countries, as well as consideration of selected European and International policies. For both sections, the methodology is explained, followed by the key findings from the research undertaken, and concluding with some observations and implications for the PAIDEIA project.

2. LITERATURE REVIEW

2.1 Introduction

At the time of writing, it feels like there is hardly any facet or walk of life that has not been influenced, inspired, or at least intrigued by Artificial Intelligence (AI) (Agrusti, 2023). Given this meteoric rise in interest and usage of AI in society more generally, it is unsurprising that this has become a topic of considerable attention with regard to teaching, learning, and assessment across the world (Incio Flores et al., 2021). The publication of recent systematic reviews on a subject may be seen as an indication of its popularity and scope, and it is clear that AI education and AI in education has many such reviews (Sanabria-Navarro et al., 2023). Some of these systematic reviews concentrate specifically on higher/university education (such as Bannister et al., 2023; Fajardo Aguilar et al., 2023), while others take a cross-sectoral approach and consider both higher education and schooling sectors (Delgado et al., 2024; García-Martínez et al., 2023). Of particular interest for this report, however, are those which focus specifically on primary and secondary/post-primary education, where such reviews are also in plentiful supply. Many of these adopt a generalist approach to considering AI usage at these levels (such as Crompton et al., 2022; S. J. Lee & Kwon, 2024; Martin et al., 2023; Rizvi et al., 2023). Others adopt a more focused approach on specific participants, topics, or issues. This includes, for instance, considering the opportunities and challenges of AI for teachers (Celik et al., 2022) and the dimensions of their data literacy (J. Lee et al., 2024), students' mental models and attitudes regarding AI (Marx et al., 2023), considerations of specific tools such as ChatGPT (Zhang & Tur, 2023) and chatbots more generally (Lucana Wehr & Roldan Baluis, 2023), focusing upon specific subjects such as school science (Heeg & Avraamidou,

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2023), consideration of the potential risks of AI integration into school education (Karan & Angadi, 2023), as well as approaches for the teaching AI at K-12 levels (Su et al., 2022) and pedagogical design of K-12 AI education (Yue et al., 2022).

Concurrent with this explosion of literature and interest with regard to AI in education is a heightened awareness for "AI Literacy" among both students and their teachers (Casal-Otero et al., 2023). Some authors have considered how AI may "fit" with existing competence frameworks and learning design models, or warrants expansion of some aspects of these existing frameworks (such as Celik, 2023; Mishra et al., 2023; Tiernan et al., 2023). Others have considered the role of separate AI frameworks (Mikeladze et al., 2024) or proposed new ones. This includes, for instance, the AI literacy framework proposed by Kong et al. (2024) which consists of four dimensions: cognitive (understanding of AI concepts), metacognitive (use of AI concepts for problem solving), affective (psychological readiness to use AI), and social (ethics of problem-solving using AI). The ED-AI Lit framework by Allen and Kendeou (2024) on the other hand, includes six components: Knowledge, Evaluation, Collaboration, Contextualization, Autonomy, and Ethics. An earlier (and well known) framework by Ng et al (2021) arises out of their exploratory review of academic literature with a view to conceptualising "AI literacy" and proposes four aspects based on the adaptation of classic literacies: know and understand, use and apply, evaluate and create, and ethical issues. Ng and other authors (2023) build upon this work to propose an AI Literacy Instructional Framework which underpins a 12-lesson AI learning course. And of particular interest at this time are the UNESCO draft AI competency frameworks (2024) for teachers and for school students (currently under development).

While there is therefore an enormous and rapidly growing body of published literature with regard to AI in schools and education from the world over, this report now turns to a more specific consideration of these issues with regard to the seven countries represented within the PAIDEIA project, in order to contribute to the key objective of PAIDEIA project work package 2.1. The methodology for this more focused literature review is now outlined.

2.2 Literature Review Methodology: Scoping Review

A scoping review is one of a family of literature reviews which adopt a systematic approach to finding, analysing, interpreting, and reporting on key literature with regard to a particular topic (Sutton et al., 2019). From within this family, scoping reviews are particularly relevant when the purpose of the review is to provide evidence to inform practice (Munn et al., 2018). This report utilises the well-established and widely recognised

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five-step framework for the undertaking of scoping reviews as proposed by Arksey and O'Malley (2005). These steps are now outlined.

Step 1: Identifying the Research Question(s)

The following research questions were adopted in undertaking this scoping review:

1. What is the extent, nature, and range of peer-reviewed published academic literature with regards to AI and education in PAIDEIA countries?
2. How is AI being used in education in PAIDEIA countries?
3. What is being taught about AI and how is this being approached in PAIDEIA countries?
4. How is ITE in PAIDEIA countries currently approaching and using AI?

Step 2: Identifying Relevant Studies

A detailed approach was taken to formulating the search criteria, which would be used to identify studies of potential relevance. The search focused on four criteria (and associated terms) for the study, which are outlined in Table 1.

Table 1: Search Criteria

Criteria Name	Criteria Terms
Criteria 1 AI Terms	"Artificial Intelligence" OR "AI" or "Generative Artificial Intelligence" OR "GenAI" OR "Chatbot" OR "conversational agent" OR "large language model" OR LLM OR "machine learning" OR "Intelligent Tutoring System"
Criteria 2 *Focus on Education*	Education OR Teaching OR Learning OR Training OR Instruction OR Assessment OR Teacher* OR Student* OR Pupil* OR Instructor*
Criteria 3 *Education Level*	K12 OR "primary school" OR "primary level" OR "primary education" OR "secondary school" or "secondary level" OR "second level" OR "secondary education" OR "post-primary" OR "elementary school" OR "middle school" OR "high school" OR "teacher education" OR "teacher training" OR "preservice teach*" OR "pre-service teach*" or "student teacher" OR "student-teacher" OR "teacher candid*" OR "candidate teach*"
Criteria 4 *Partner Countries*	Belgium OR Bulgaria OR Ireland OR Italy OR Malta OR Spain OR Türkiye

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The databases used for searching were Academic Search Complete, Education Source, Education Resources Information Centre (ERIC), and Web of Science (WoS). Search limiters were applied at the point of searching (data range, language, format of paper). These search limiters, along with the inclusion and exclusion criteria manually applied during Step 3, are summarised in Table 2.

Pilot searches were conducted in Week 4 of March 2024. The search combined all four criteria from Table 1 above, and searched at the level of Article Title, Abstract, and Keywords. The decision was then taken to expand the search to include published conference proceedings, and to search across full text of the papers. The search was rerun in Week 1 of April 2024.

Step 3: Study Selection

The 484 records returned were now screened manually using the criteria in Table 2.

Table 2: Search Limiters, Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Dates	Published since (or in) 2020	Pre-2020
Education Level	Education level focuses on Primary and/or Secondary/Post-Primary Levels; Teacher Education	Early Childhood, Further Education and Training, Higher Education, Adult Education, non-education settings
Language	Published in English Language	Non-English Language
Publication type	Peer-Reviewed Journal Articles; Published Conference Proceedings	Non-Peer-Reviewed Articles, Grey Literature, Book Chapters, Blog Posts, Reports, etc.
Access	Full text available	Full text not available
AI Focus	Sufficient focus within paper on AI/Machine Learning/Neural Networks/etc.	No or insufficient focus within paper on these terms.
PAIDEIA Partner Countries	Clear indication that research relates to one of the seven PAIDEIA countries.	Unclear that research relates to one of the seven PAIDEIA countries (e.g. no direct reference to this in the text).

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A rigorous screening process resulted in 79 studies being selected for full review.

Step 4: Charting the Data

A Data Extraction Template (DET) was created using Google Forms and used to extract key details on each study during the full-text review as this allowed easy export of the captured data to spreadsheet format for analysis (filtering, querying, etc.). During full-text review, a further four papers were removed.

Stage 5: Summarising and Reporting Findings

The final number of papers included in the review is 75. The core details of these papers are displayed in Table 3. Each paper has been assigned a Study ID (SID) in this table, and these SIDs will be used when reporting on paper findings. The full bibliographical details for each paper are available in the report bibliography.

SID	Author(s)	Paper Title	Year	PAIDEIA
S01	Akyuz & Erdemir	Preservice Science Teachers' Views of a Web-Based Intelligent Tutoring System	2022	Türkiye
S02	Alonso	Teaching Explainable Artificial Intelligence to High School Students	2020	Spain
S03	Aydın et al.	Investigation of the effects of computer-aided animations on conceptual understanding through metaphors: An example of artificial intelligence	2022	Türkiye
S04	Ballestar et al.	Effectiveness of tutoring at school: A machine learning evaluation	2024	Spain
S05	Barelli et al.	Epistemic Insights as Design Principles for a Teaching-Learning Module on Artificial Intelligence	2024	Italy
S06	Belda-Medina & Calvo-Ferrer	Using Chatbots as AI Conversational Partners in Language Learning	2022	Spain
S07	Belda-Medina & Kokošková	Integrating chatbots in education: insights from the ChatbotHuman Interaction Satisfaction Model (CHISM)	2023	Spain
S08	Bellas et al.	AI Curriculum for European High Schools: An Embedded Intelligence Approach	2023	Italy, Spain
S09	Bozak & Aybek	Comparison of artificial neural networks and logistic regression analysis in PISA science literacy success prediction	2020	Türkiye

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S10	Busra Eren & Caliskan	Classifying High School Students' Health-Related Physical Fitness Report Cards with Data Mining	2023	Türkiye
S11	Buyukatak & Anil	An investigation of data mining classification methods in classifying students according to 2018 PISA reading scores	2022	Türkiye
S12	Camacho et al.	Data Capture and Multimodal Learning Analytics Focused on Engagement with a New Wearable IoT Approach	2020	Spain
S13	Cebrián-Robles et al.	Impact of Digital Contexts in the Training of University Education Students	2023	Spain
S14	Çelik & Kartal	Modeling of reading problems experienced by primary school students through artificial neural networks	2023	Türkiye
S15	Çetin et al.	The Effect of Gamified Adaptive Intelligent Tutoring System Artibos on Problem-Solving Skills	2023	Türkiye
S16	Çetinkata et al.	Analysis of Machine Learning Classification Approaches for Predicting Students' Programming Aptitude	2023	Türkiye
S17	Çetinkaya & Baykan	Prediction of middle school students' programming talent using artificial neural networks	2020	Türkiye
S18	Çevik & Tabaru-Örnek	Comparison of Matlab and SPSS software in the predicition of academic achievement with artificial neutral networks: Modeling for elementary school students	2020	Türkiye
S19	Chocarro et al.	Teachers' attitudes towards chatbots in education: a technology acceptance model approach considering the effect of social language, bot proactiveness, and users' characteristics	2023	Spain
S20	Demir & Güraksin	Determining middle school students' perceptions of the concept of artificial intelligence: A metaphor analysis	2022	Türkiye
S21	Deveci Topal et al.	Chatbot application in a 5th grade science course	2021	Türkiye
S22	DomínguezGonzález et al..	Attention to Diversity from Artificial Intelligence	2023	Spain

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S23	Ekizce et al.	Pre-service science teachers' levels of awareness of industry 4.0 concepts.	2022	Türkiye
S24	Eyüp & Kayhan	Pre-Service Turkish Language Teachers' Anxiety and Attitudes toward Artificial Intelligence	2023	Türkiye
S25	Fernández-Martínez et al.	Early Introduction of AI in Spanish Middle Schools. A Motivational Study	2021	Spain
S26	Fidan & Gencel	Supporting the Instructional Videos With Chatbot and Peer Feedback Mechanisms in Online Learning: The Effects on Learning Performance and Intrinsic Motivation	2022	Türkiye
S27	Fissore et al.	Didactic activities on artificial intelligence: The perspective of STEM teachers	2022	Italy
S28	Gabrielli et al.	A Chatbot-Based Coaching Intervention for Adolescents to Promote Life Skills: Pilot Study	2020	Italy
S29	GalindoDomínguez et al.	An analysis of the use of artificial intelligence in education in Spain: The in-service teacher's perspective	2024	Spain
S30	García-Tudela et al.	The Spanish experience of future classrooms as a possibility of smart learning environments	2023	Spain
S31	Glushkova et al.	An approach to teaching artificial intelligence in school	2020	Bulgaria
S32	Guerreiro-Santalla et al.	Simulation-Based Adaptive Interface for Personalized Learning of AI Fundamentals in Secondary School	2023	Spain
S33	Guerreiro-Santalla et al.	Smartphone-Based Game Development to Introduce K12 Students in Applied Artificial Intelligence	2022	Italy, Spain
S34	Guerreiro-Santalla et al.	The School Path Guide: A Practical Introduction to Representation and Reasoning in AI for High School Students	2021	Spain
S35	Hastürk	Metaphorical Perceptions Prospective Teachers towards Socioscientific Issues	2021	Türkiye

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S36	Henry et al.	Teaching Artificial Intelligence to K-12 Through a Role-Playing Game Questioning the Intelligence Concept	2021	Belgium
S37	Hijón-Neira et al.	Prototype of a Recommendation Model with Artificial Intelligence for Computational Thinking Improvement of Secondary Education Students	2023	Ireland, Spain
S38	Holowka	Teaching robotics during Covid-19: Machine learning, simulation and AWS deepracer	2020	Türkiye
S39	Hopcan et al.	Exploring the artificial intelligence anxiety and machine learning attitudes of teacher candidates	2024	Türkiye
S40	Kahraman & Koc	Primary School Teachers' Views on the Technological Competencies of School Principles	2022	Türkiye
S41	Kapucu et al.	Predicting secondary school students' academic performance in science course by machine learning	2024	Türkiye
S42	Karahan	Using video-elicitation focus group interviews to explore preservice science teachers' views and reasoning on artificial intelligence	2023	Türkiye
S43	Karatas et al.	Predicting Academic Self-Efficacy Based on Self-Directed Learning and Future Time Perspective	2023	Türkiye
S44	Kazu & Kuvvetli	The influence of pronunciation education via artificial intelligence technology on vocabulary acquisition in learning English	2023	Türkiye
S45	Koç & Akin	Estimation of High School Entrance Examination Success Rates Using Machine Learning and Beta Regression Models	2022	Türkiye
S46	Körpeoglu & Yildiz	Using artificial intelligence to predict students' STEM attitudes: an adaptive neural-network-based fuzzy logic model	2023	Türkiye
S47	Lombart et al.	Tips and Tricks for Changing the Way Young People Conceive Computer Science	2020	Belgium

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S48	Lozano & Blanco Fontao	Is the Education System Prepared for the Irruption of Artificial Intelligence? A Study on the Perceptions of Students of Primary Education Degree from a Dual Perspective: Current Pupils and Future Teachers	2023	Spain
S49	Mahon et al.	A Novel Machine Learning and Artificial Intelligence Course for Secondary School Students	2022	Ireland
S50	Mahon et al.	No More Pencils No More Books: Capabilities of Generative AI on Irish and UK Computer Science School Leaving Examinations	2023	Ireland
S51	Martínez-Ramón et al.	Predicting teacher resilience by using artificial neural networks: influence of burnout and stress by COVID-19	2023	Spain
S52	Masneri et al.	cleAR: an interoperable architecture for multi-user AR-based school curricula	2023	Spain
S53	Mogas et al.	Smart schools on the way: How school principals from Catalonia approach the future of education within the fourth industrial revolution	2022	Spain
S54	Moral-Sánchez et al.	Analysis of artificial intelligence chatbots and satisfaction for learning in mathematics education	2023	Spain
S55	Murillo-Ligorred et al.	Knowledge, Integration and Scope of Deepfakes in Arts Education: The Development of Critical Thinking in Postgraduate Students in Primary Education and Master's Degree in Secondary Education	2023	Spain
S56	Naya-Varela et al.	Robobo SmartCity: An Autonomous Driving Model for Computational Intelligence Learning Through Educational Robotics	2023	Ireland, Spain
S57	Papa	Digital Device and Mathematics: Multilevel vs Machine Learning Models for Value-added Ranking in Italy	2022	Italy

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S58	Peña-Acuña & Crismán-Pérez	Research on Papua, a digital tool with artificial intelligence in favor of learning and linguistic attitudes towards the learning of the English language in students of Spanish language as L1	2022	Spain
S59	Perseghin & Foresti	A Shallow System Prototype for Violent Action Detection in Italian Public Schools	2023	Italy
S60	Polak et al.	Teachers' Perspective on Artificial Intelligence Education: an Initial Investigation	2022	Bulgaria, Italy
S61	Sahin & Erol	Prediction of Secondary School Students' Academic Achievements with Machine Learning Methods and a Sample System	2024	Türkiye
S62	Scaradozzi, Cesaretti, et al.	Identification and Assessment of Educational Experiences: Utilizing Data Mining With Robotics	2021	Italy
S63	Scaradozzi et al.	Identification of the Students Learning Process During Education Robotics Activities	2020	Italy
S64	Scaradozzi, Screpanti, et al.	Machine Learning for modelling and identification of Educational Robotics activities	2021	Italy
S65	Slavov et al.	Research on the Attitudes of High School Students for the Application of Artificial Intelligence in Education	2023	Bulgaria
S66	Szymanski et al.	Feedback, Control, or Explanations? Supporting Teachers With Steerable Distractor-Generating AI	2024	Belgium
S67	Tartuk	Metaphorical Perceptions of Middle School Students Regarding the Concept of Artificial Intelligence	2023	Türkiye
S68	Terzi	An adaption of artificial intelligence anxiety scale into Turkish: Reliability and validity study	2020	Türkiye
S69	Tirado-Olivares et al.	From Human to Machine: Investigating the Effectiveness of the Conversational AI ChatGPT in Historical Thinking	2023	Spain
S70	Uzumcu & Acilmis	Do Innovative Teachers use AI-powered Tools More Interactively? A Study in the Context of Difusion of Innovation	2023	Türkiye

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		Theory		
S71	Voulgari et al.	Learn to Machine Learn: Designing a Game Based Approach for Teaching Machine Learning to Primary and Secondary Education Students	2021	Malta
S72	Yildiz	Prediction of Pre-Service Teachers' Academic Self-Efficacy through Machine Learning Approaches	2023	Türkiye
S73	Zammit et al.	Learn to Machine Learn via Games in the Classroom	2022	Malta
S74	Zammit et al.	The road to AI literacy education: from pedagogical needs to tangible game design	2021	Malta
S75	Zanellati et al.	Student Low Achievement Prediction	2022	Italy

Table 3: PAIDEIA Scoping Review: Papers

3. FINDINGS

The Research Questions from Stage 1 are now used to structure the findings from this review.

RQ1: What is the extent, nature, and range of peer reviewed published academic literature with regards to AI and education in PAIDEIA countries?

The overwhelming majority of papers (68) are empirical in nature (i.e. capture or/and analyse data) with the remaining seven papers being conceptual in nature. Over three quarters of the papers are journal article publications (59) with the remaining 16 being papers published in conference proceedings. The highest proportion of papers was published in 2023 (30 papers) which is perhaps to be expected given the huge increase in interest in AI since the start of the decade. The details can be viewed in Figure 1[1].

The number of papers for each PAIDEIA country can be seen in Table 4. Five publications (S08, S33, S37, S56, S60) referred to more than one PAIDEIA country in the same paper, and ten publications also referred to countries outside the PAIDEIA partners.

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Figure 1: Year of Publication

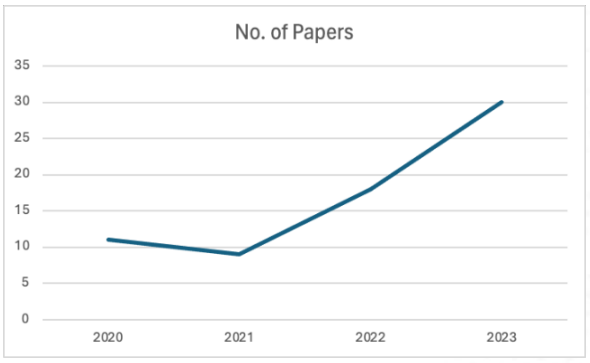

Table 4: No. of Papers per PAIDEIA Country

PAIDEIA Country	No. of Papers
Belgium	3
Bulgaria	3
Ireland	4
Italy	12
Malta	3
Spain	25
Türkiye	30

[1] 2024 data has not been plotted on this chart as extraction took place at the end of March 2024 and thus is not available for the full year; however we note that the number of papers already published in Q1 of 2024 (7 papers) is close to the total number published in 2021.

RQ2: How is AI being used in education in PAIDEIA countries?

The educational sector most commonly considered was that of post-primary/secondary education, with 35 papers focusing on this sector alone. 16 papers focused on both primary and post-primary/secondary together. Four papers focused on primary level alone. 20 papers related to Initial Teacher Education (ITE).

For half of the papers (38) data was collected from pupils/students. A quarter of the papers focused on teachers, and one paper [S53] captured the views of school principals. Eight papers considered the opinions of both pupils/students and teachers. The remaining papers drew upon data collected from ITE students (student-teachers/pre-service teachers).

Papers in this scoping review made reference to AI with regard to a wide range of academic subjects. Subjects relating to STEM/Science/Mathematics were most frequently cited (22 papers - examples include S73, S15, S57, S54, S21). This was followed by Linguistics/Languages/Language Learning (10 papers - examples include S07, S24, S06, S29, S04). Computer Science was referred to in nine papers (examples include S37, S50, S47, S49, S38), with programming/robotics referred to in four papers (S38, S16, S25,

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S31). Subjects that were mentioned three times or fewer include Social Studies, History, Technology, Instructional Technologies/Information Technologies, Art, PE, Geography, Music, Media Literacy, Economics, and Ethics/Religion. Thus it would appear that there is awareness of the implications of AI for a wide range of academic subjects in PAIDEIA partner countries, with a particular emphasis on STEM/Science/Mathematics, Linguistics/Languages/Language Learning, and Computer Science. Of particular note, one paper [S33] outlined a new subject, 'Introduction to AI'.

A variety of AI usage is reported in the papers. To explore this, we list the uses of AI in the included papers followed by examples of such use. Please note that the total figure below on AI usage is greater than the included number of papers as some papers had multiple AI usages.

30 papers considered **AI for teaching purposes** [S38, S74, S36, S60, S73, S71, S28, S30, S25, S56, S31, S66, S05, S49, S02, S08, S24, S33, S19, S37, S01, S50, S15, S44, S32, S06, S27, S21, S70, S29]. Galindo-Domínguez et al. [S29] found over twenty functionalities for which teachers used AI tools, with the most common functions being obtaining information and finding answers to queries, creating exercises, tasks or homework, and generating texts. Kazu and Kuvvetli [S44] explored vocabulary acquisition with the aid of AI for pronunciation, and found that AI-supported speech recognition pronunciation instruction methods considerably boosted students' word memory capacities. Several papers explored the use of chatbots [such as S19, S21, S69] and found that this form of AI can make a positive impact on students' learning; for example, students in Deveci Topal et al.'s [S21] research discussed how the chatbot allowed them to learn new information, gave immediate responses to questions, increased their interest, and was accessible outside of the classroom.

22 papers focused on **perceptions of AI** [S19, S20, S67, S40, S68, S55, S69, S42, S35, S39, S65, S53, S47, S03, S07, S48, S54, S24, S26, S27, S21, S70]. For example, several papers [S03, S20, S35, S67] used metaphors as a means of exploring and considering the perceptions of their participants with regard to AI; in the study by Demir and Güraksin [S20], for instance, students drew on positive (e.g., humans, brain) and negative (e.g., danger, evil) metaphors to explain AI which indicated their readiness for a future AI-supported education. Slavov et al. [S65] considered attitudes of high school students on the application of AI in education; they found that students correctly understood the essence of AI and were convinced of the usefulness of AI in their daily activities, but were not entirely clear about the utility of AI in learning and teaching, and did not show understanding of the ethical use of AI in education. Chocarro et al. [S19] considered teachers' attitudes towards chatbots in education through a Technology

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Acceptance Model (TAM) lens, and found that perceived easiness and perceived usefulness of chatbots leads to greater acceptance by teachers.

The use of AI / Machine Learning for data analysis was considered by 21 papers [S09, S04, S59, S64, S75, S46, S16, S43, S52, S12, S72, S57, S62, S63, S18, S10, S11, S14, S41, S17, S61]. For example, Bursa Eren and Caliskan [S10] used artificial neural network analysis and decision trees analysis in their data analysis to understand students' health-related physical fitness. Buyukatak and Anil [S11] considered the accuracy of data mining classification methods (such as Artificial Neural Networks, Decision Trees, and Naive Bayes) in analysis of PISA 2018 data.

Five papers considered the use of AI for **prediction of grades / behaviours / outcomes** [S51, S45, S61, S17, S41]. For example, Martínez-Ramón et al. [S51] used artificial neural networks to predict teacher resilience in schools. **Independent learning** was also considered by five papers [S58, S15, S44, S32, S06], including that of Çetin et al.'s [S15], whose research explored the use of AI in providing personalised education through intelligent tutoring systems to engage students in problem-creating and problem-solving activities, and found that students viewed this AI approach to independent learning more beneficial than traditional education environments.

Two papers [S29, S27] considered the use of **AI for planning purposes**. For example, Fissore et al. [S27] explored teachers' perceptions of AI and use of AI in teaching and planning; they concluded that while teachers used AI in their teaching through different pedagogical means, they needed further teacher professional development and learning on the planning of education activities related to AI in education. Two papers also considered **AI for support / assistance** [S22, S37], such as Hijón-Neira et al's. [S37] use of AI as an assistant to help with student learning of computational thinking. **Assessment** was also considered by two papers [S01, S50]. For example, Mahon et al. [S50] used ChatGPT to answer high-stakes examination questions and given its success in undertaking this task, the authors argue that examinations need to move to assessing processes rather than using traditional exam-style questions. Two papers also focused upon **establishing current levels of AI knowledge / understanding of AI** [S23, S48]. For example, Lozano and Blanco Fontao's [S48] research explored students use of ChatGPT in teacher education and found that 71% of PSTs will use this tool in their future teaching practice, and 96% of PSTs believe it is necessary to learn about AI tools to prepare them for teaching.

With regard to **academic integrity**, Cebrián-Robles et al. [S13] noted the need for more awareness on potential use of AI with regards to plagiarism amongst PSTs in ITE. Moral-Sánchez et al. [S54] undertook the **evaluation of a particular AI tool**: a chatbot which was designed for learning recurring definitions in the subject of geometry, and found it to be a useful tool for both students and teachers as a support mechanism. And finally, Fidan

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and Gencel's [S26] research considered the use of **AI for feedback** purposes, and found that chatbots can act as feedback mechanisms to improve the learning processes.

There were a number of recommendations and considerations for the use of AI in education across the included papers. First, there needs to be greater importance given to issues of AI in schools [S27]. Second, and connected to the first, if more awareness is needed on AI in schools, then teacher education needs to prepare teachers on AI issues; this also involves preparing teachers for the teaching and learning of AI [S27, S36, S69, S08]. Third, students need to develop the digital skills needed to understand and recognise AI (i.e., the risks and benefits of use); digital/AI literacy needs to be taught to students [S27, S55]. Fourth, it is encouraged to use AI to integrate interdisciplinary activities in learning experiences [S27]. Finally, there is a need to develop supporting materials for teachers on main AI concepts which consider educational activities and real-world implementations [S08, S71].

RQ3: What is being taught about AI and how is this being approached in PAIDEIA countries?

26 of the 75 papers centred around AI education (i.e. educating about AI and AI concepts). A number of papers explored why teachers were not addressing AI topics; reasons included lack of time and lack of confidence teaching AI which was perceived to be beyond their own knowledge [S27], low AI-related skills [S60], lacking prior experience of AI usage and digital competence [S29], and for PSTs, a gap between their teacher education and recent advances in AI usage [S06]. Despite this, there is clear teacher (and student) motivation to learn about AI and use digital tools in the classroom [S60, S25]. To bridge this lacking knowledge and experience of AI usage and a motivation for such usage, it has been advised for early involvement of stakeholders (i.e.: educators, researchers, students, policy makers, AI experts, etc.) in the development of AI education to meet teachers' and students' needs [S71]. This co-creation approach may "address the real educational requirements of students and teachers, and also consider situational factors of formal education settings and the classroom, such as the available infrastructure and the promotion of a culture of interdisciplinary collaboration among teachers of different subjects" (Zammit et al., 2021, p.7 [S74]).

Of the 75 included papers, 12 broadly focused on AI curriculum: five papers on a particular curriculum or course [S05, S31, S34, S33, S49], five papers on teachers teaching a particular curriculum or course [S27, S08, S36, S60, S74], and five papers on students learning a particular curriculum or course [S08, S21, S25, S36, S74] (again the total number here is greater than the included papers as some papers explored multiple

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perspectives). From these 12 papers on AI curriculum, a qualitative thematic analysis highlighted the core key features of curriculum design. With regards to curriculum design principles, four papers discussed principles or approaches for AI curriculum design. Bellas et al. [S08], whose paper presented a proposal for an AI curriculum in high school, alluded to the design of introducing AI content in a progressive manner and taught in a fully practical methodology informed by the concept of intelligent agent. Fernández-Martínez et al. [S25], whose research explored the operations of an AI workshop in high school, also suggested the need for a practical learning design in the teaching and learning of AI; the authors emphasised how the workshop should be less theoretical and more practical with a focus on application rather than explanation. Barelli et al. [S05] listed six design objectives for an AI module in secondary schooling: (i) to highlight the relationship between AI and society; (ii) to introduce a number of approaches to AI and programming paradigms; (iii) to scaffold reflections on learning; (iv) to minimise the technological language; (v) to exploit epistemic insights as a way to compare different approaches to AI; and (vi) to connect epistemic insights to operational vocabulary. Complementing this, Polak et al.'s [S60] research provides six design implications for AI education: (i) provide the required basics (start with Digital

Competence and AI literacy frameworks as AI and digital technologies are continually changing); (ii) authentic learning experiences should be at the forefront whereby explicit connections are made between AI and real-world materials; (iii) make the teaching and learning interactive and collaborative (group work, peer learning, interactive learning; (iv) keep everyone in the loop - address the needs of school management and students alongside the needs of teachers; (v) make the teaching and learning accessible (particularly if/when teaching about AI on an online platform, as was the case here); and (vi): motivate the user (the authors linked levels of motivation to levels of digital competencies – by increasing the latter, the former should increase too).

Teachers who taught about AI discussed pedagogical approaches which have potential in creating meaningful learning experiences. Teachers in Fissore et al.'s [S27] research argued for the need to: (i) be adaptable so that lower and higher performing students can be included in the learning processes; (ii) use peer collaboration as a teaching approach to allow for peer teaching and learning through group work and collaboration; (iii) integrate theory and practice so that students can apply theoretical concepts to practical learning experiences; (iv) use learning outcomes to have specific learning areas and objects to teach related to AI; (v) teach in a nonlinear approach whereby students are, for example, learning-by-doing; and (vi) use different pedagogical approaches and supporting resources and instruments following multimedia learning principles. Other papers suggested particular pedagogical approaches which can be adapted to best suit the teaching of AI. These included: authentic learning experiences with reallife problems [S08];

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cooperative project-based learning [S33] and project-based learning [S34]; problem-based learning [S05]; and the use of smartphones in the learning experiences [S08, S33].

There are therefore a number of papers exploring AI education / curriculum (i.e., the what) and the teaching of AI (i.e., the how). Research highlighted how AI curriculum design needs to focus on the applied aspect of AI content rather than the theoretical aspect [S25, S08] and emphasise the connection between AI and society to ensure an authentic learning experience [S05]. With regards to the teaching of AI, numerous student-centred approaches were advocated for in many of the included papers ranging from student collaborative approaches [S27] to project-based learning [S34].

RQ4: How is ITE in PAIDEIA countries currently approaching and using AI?

As current pre-service teachers will be the next generation of in-service teachers, consideration of initial teacher education (ITE) offers insights into possible future practices and potentials of AI in schools. Of the 75 included papers, 20 related to teacher education and were all explored from the viewpoint of the PSTs. With regards to AI usage in teacher education, 11 papers explored PSTs' perceptions of AI [S55, S69, S42, S35, S39, S07, S48, S54, S24, S26, S70], four papers used AI in teaching practice [S01, S06, S70, S37], two papers used AI for independent learning [S06, S58] and for data analysis [S43, S72], while one paper focused on AI-related support [S22], feedback [S26], assessment [S01], and academic integrity [S13].

Research which explored PST AI-related anxiety levels [S24, S39] shed light on a mixture of positive and negative attitudes towards AI. The PSTs had moderate anxiety levels with regards to AI when discussing job replacement, employment rates, social life, sociotechnical blindness and artificial intelligence configuration, but less anxiety with regards to AI in the learning dimension [S24]. There were lower anxiety levels amongst the PSTs if they had positive attitudes towards the importance, impact, and use of AI [S39]. These findings exemplify the need to educate PSTs on AI on its uses and impacts to enhance teacher confidence in AI. Supporting this, Karatas et al. [S43] noted the relevance of AI as a topic of study for PSTs as it can develop their thinking and reasoning, and in the long run, it can help their future school students in developing crucial skills needed in future society.

Over half of the papers in teacher education (11/20) explored PSTs' perceptions of AI [S55, S69, S42, S35, S39, S07, S48, S54, S24, S26, S70]. Chatbots were an AI tool explored by three papers in this context [S69, S48, S54]. For example, Lozano and Blanco

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Fontao's [S48] research explored 81 PSTs' level of knowledge of ChatGPT and its possibilities of use in education, and found that, on using this AI tool, 87% believed ChatGPT was easy to access and use. The authors questioned PSTs on their perception of ChatGPT as future teachers and found that 94% of them believed it crucial to have knowledge of the operations of AI to better understand their future students' use of it in learning tasks. Elsewhere Moral-Sánchez and colleagues [S54] first introduced student-teachers to chatbots before tasking them with the creation of a chatbot about content covered in a mathematics course. Their findings highlight PSTs' interest in the generation of their chatbot and a high degree of satisfaction with their AI creations, as well as overall improvement in student digital competence, and the suggestion that this type of experience can be transferred to other subjects and education contexts. While chatbot creation was preceded with an introduction to chatbots, it is worth noting that without such an introduction there appears to be a gap between PSTs preparation and recent advances in chatbots and AI more broadly [S07]. Teacher educators also used chatbots in their practice to improve teaching and learning processes; for example, Fidan and Gencel's [S26] use of a chatbot to provide peer feedback in combination with human feedback. They found that PSTs who received both forms of feedback had significantly higher intrinsic motivation than those who solely received human feedback.

While the above overviews what is currently happening in teacher education with regards to AI, we now look to some of the recommendations from such research. From the research papers which explored PSTs' perceptions and anxiety levels with regards to AI [S39, S24, S35], it was concluded that PSTs' positive attitudes to AI may give an insight to future use of AI in the school classroom, but the high levels of anxiety reported needs to be addressed; teacher education needs to educate PST on the benefits and limitations of AI. This latter point – the need to educate PSTs on AI – was raised by multiple papers as a clear recommendation [S48, S13, S69, S26]. These authors called for the need to improve PSTs' knowledge around the use of AI (i.e., increasing AI literacy) to better prepare and equip them with the skills to identify AI misuse by their future school students. There were also calls for further research [S06, S24, S26, S48, S69] to be conducted on in-service teachers' use of AI, the introduction of AI in education, on AI improvements in education, and PSTs' attitudes and concerns of AI for future use. Finally, research [S39] advocated for teacher educators to create projects and activities that promote innovation and collaboration through AI developments.

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3.1 Literature Review: Conclusions and Considerations

We conclude this section with some considerations from the included papers related to the teaching of AI and AI curriculum design principles. With regards to teaching approaches used in teaching AI, the following strategies were used: collaborative approaches (e.g., peer teaching and learning, group work) [S27]; experimental learning [S27]; practising use of AI [S27]; the use of digital technologies [S08]; authentic learning experiences [S08]; appropriate learning tasks to help understand theoretical knowledge [S31]; cooperative project based learning [S34]; project based learning [S33]; challenge-based learning [S08]; and interdisciplinary learning [S27]. With regards to content of AI teaching, three papers outlined the exact content knowledge taught. Guerreiro-Santalla et al. [S33] broadly stated how their research introduced students to the fundamentals of machine learning with a focus on application of such. Mahon et al.'s [S49] research presented an overview of a "Machine Learning and Artificial Intelligence" course for upper second level students and was structured around the following content areas: (i) Introduction to AI; (ii) Machine learning and data; (iii) Data analysis and pre-processing; (iv) Machine learning models – linear and logistic regression; (v) Machine learning models – decision trees and K-nearest neighbour; and (vi) Neural networks and deep learning. Glushkova et al. [S31] outline the content areas for an AI curriculum for secondary schools. The content involved: (i) acquiring the knowledge of the subject and tasks of AI; (ii) acquiring the knowledge of the agent-oriented paradigm and agent architectures; (iii) acquiring the knowledge and skills for solving problems through searching; (iv) semantic modelling; (v) modern trends in the development of AI (e.g., machine learning, cognitive robotics); and (vi) acquiring the skills for independent solving of specific tasks and problems. Finally, a number of papers included design implications for AI education; for instance, Polak et al.'s [S60] research outlines six design principles for AI education: (i) establish foundational digital and AI competencies, (ii) prioritise authentic learning experiences linked to real-world applications, (iii) foster interactive and collaborative learning, (iv) consider the needs of all stakeholders including school management and students, (v) ensure accessibility, especially in online formats, and (vi) boost motivation to enhance digital competencies.

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4. POLICY ANALYSIS

4.1 Introduction and Policy Analysis Framework

There is a growing demand for AI-specific policy guidelines to address issues such as the ethical integration of AI into education (Miao et al., 2021). International organisations like UNESCO and UNICEF, the European Union, and individual countries have formulated policies and strategies to tackle the potential benefits and risks associated with the increasing intersection of AI and education. However, Miao et al. (2021) and Schiff (2023) have indicated that policymakers are still navigating uncharted territory as they grapple with how learning, both now and in the future, will interact with AI. Therefore, this analysis examines policies in PAIDEIA countries and at European and international levels.

4.1.1 Methodology

PAIDEIA partners were invited to submit relevant policies relating to AI in their jurisdictions. As a number of these policies were written in the native language, it was necessary to translate these into English prior to analysis, which was conducted by one researcher in order to enhance consistency. This was achieved by uploading policies to ChatGPT 4 for translation and then applying the policy analysis framework (below) to the translation. Selected extracts from the submitted policies were then also cross-checked using Google Translate.

4.1.2 Policy Analysis Framework

This framework's methodological design facilitates a comprehensive policy analysis by addressing various dimensions, such as context, text, and potential implications/consequences (Gorman & Furlong, 2023). The framework employs a range of questions. The strength of using questions lies in their capacity to deconstruct policy and uncover underlying complexities, and to foster a systematic, critical, and reflective analysis.

Guiding Questions

1. What are the explicit goals, objectives, and targets outlined in the policy?
2. How are the policy's principles of transparency, accountability, and ethical use of AI technologies articulated?
3. What strategies and actions are proposed to support teachers' professional learning and capacity-building in AI?

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4. Does the policy guide curriculum design, instructional practices, and assessment methods tailored to incorporate AI?
5. How are resource allocations and funding mechanisms structured to support implementing AI?

4.2 PAIDEIA Countries - Individual and Cross-Country Policy Analysis

4.2.1 Individual Country Analysis

Table 5: PAIDEIA Country Policies submitted by PAIDEIA Partners

Country	*Policies for Analysis*
Belgium	*Verantwoorde AI in Het Vlaamse Onderwijs: Een Collaboratief Proces Van Ontwikkeling Tot Gebruik* (2024)
Bulgaria	*Bulgarian Ministry of Education guidelines for the use of AI in the education system* (2024) *National Development Program BULGARIA 2030* (2020) *Concept of Development of Artificial Intelligence in Bulgaria by 2030* (2020) *National Strategic Document with vision and goals of the policy for Digital Transformation 2020-2030* (2020) *Innovation Strategy for Smart Specialisation of the Republic of Bulgaria 20212027* (2021) *National Programme for increasing digital skills of teachers and students* (2021)
Ireland	*AI - Here for Good: A National Artificial Intelligence Strategy for Ireland* (2021) *Digital Strategy for Schools to 2027* (2022)
Italy	*Strategia Nazionale per l'Intelligenza Artificiale* (2020) *Programma Strategico Intelligenza Artificiale 2022-2024* (2021) *Piano Triennale per l'informatica nella Pubblica Amministrazione. Edizione 2024-* *2026* (2023) *Piano Scuola 4.0*

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	La Scuola A Prova Di Privacy (2023) *Progetto DIG4Future* (2021)
Malta	*Malta: The Ultimate AI Launchpad - A Strategy and Vision for Artificial Intelligence in Malta 2030* (2019) *National eSkills Strategy 2022 - 2025* (2022)
Spain	*Estrategia de Inteligencia Artificial 2024* (2024) *National Strategy for Artificial Intelligence* (2020) *La Intel·Ligència Artificial En L'educació: Orientacions i Recomanacions Per Al Seu Ús Als Centres* (2024)
Türkiye	*Turkish National Artificial Intelligence Strategy 2021-2025* (2021)

Belgium

The policy sets out four primary goals: defining responsible AI in education, providing foundational conditions for AI applications, laying a basis for responsible AI implementations, and creating a common language among stakeholders. The policy aims to define responsible AI, provide foundational conditions, establish a basis for AI implementation, and create a common language among stakeholders. Transparency and accountability are emphasised through traceability, explainability, and mechanisms for verifiability and reporting negative consequences. The policy mandates continuous professional development for teachers to keep pace with technological advancements, ensuring digital literacy and adaptability (although it does not consider individual educators' varying capacities). Guidance on curriculum design, instructional practices, and assessment methods is provided, emphasising collaboration and regular evaluation. Resource allocation and funding mechanisms highlight the government's role in providing necessary tools and training, fostering a culture of shared learning.

Bulgaria

A comparative analysis of these policies reveals several commonalities and differences in their goals, strategies, and approaches. The policies consistently emphasise the integration of AI to improve educational outcomes and teacher effectiveness. For instance, Policy 1 aims at "подобряване на качеството на образованието на учениците и ефективността в работата на учителите" (improving the quality of student education and

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the effectiveness of teachers' work). Similarly, Policy 2 focuses on "развиване на цифрови умения и компетенции" (developing digital skills and competencies) to align education with the digital transformation of the economy. However, the policies also have unique targets. Policy 3, for example, prioritises the creation of a robust infrastructure for AI and enhancing research capacities: "създаване на надеждна инфраструктура за развитие на ИИ" (creating a reliable infrastructure for AI development). Policy 4 emphasises updating university educational programmes to reflect the changing nature of teaching and integrating AI systems into school management.

Transparency, accountability, and ethical use of AI are critical across all policies. Policy 1 mandates that AI use in education adhere to existing privacy regulations: "Използването на ИИ в образованието трябва да се извършва в съответствие със съществуващите разпоредби за защита на неприкосновеността на личния живот" (The use of AI in education must be conducted in accordance with existing regulations for protecting students' privacy). Policy 2

reinforces this by linking digital skills with cybersecurity and digital ethics: "свързване на дигиталните умения с гражданската грамотност с киберсигурността с дигиталната етика"

(linking digital skills with civic literacy, cybersecurity, and digital ethics). Policy 3 flags the necessity for a legal and ethical framework to ensure AI technologies are secure and respect citizens' rights: "технологичният напредък да бъде съпроводен от правна и етична рамка" (a legal and ethical framework should accompany technological progress).

The policies propose various strategies to support teachers' professional learning. Policy 1 outlines mechanisms for continuous professional development: "МОН ще предложи механизми и подкрепа за постоянното професионално развитие на педагогическите специалисти" (The Ministry of Education will propose mechanisms and support for the continuous professional development of educational specialists). Policy 2 focuses on reforming educational processes to acquire comprehensive skills: "мерки насочени към реформиране на учебния процес" (measures aimed at reforming the educational process). Policy 4 proposes short-term training and internships to improve digital and AI competencies: "Предлагане на краткосрочни обучения и стажове" (Offering short-term trainings and internships). Policy 5 emphasises creating specialised retraining schemes in collaboration with businesses and higher education institutions.

Curriculum design and instructional practices are also a focus. Policy 1 encourages the use of AI tools for personalised learning and enhanced assessment methods: "Генеративните ИИ инструменти дават възможност за персонализирани учебни пътеки" (Generative AI tools enable personalised learning paths). Policy 2 stresses integrating AI

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into various subjects and grades: "Интегриране на ИИ в учебната програма" (Integration of AI into the curriculum). Policy 4 discusses applying AI tools to enhance the quality and attractiveness of education: "Прилагане на ИИ инструменти в образованието" (Applying AI tools in education). Policy 5 focuses on preparing students for future professions through AI-integrated education programmes.

Resource allocation and funding are considered with regard to supporting AI initiatives. Policy 1 mentions existing resources for continuous training: "Ресурси за продължаващо обучение и професионално развитие вече съществуват" (Resources for continuous training and professional development already exist). Policy 2 outlines various funding sources, including state and European funds: "Държавен бюджет - Европейски фондове и инструменти" (State budget - European funds and instruments). Policy 3 highlights the importance of public-private partnerships for funding: "Сътрудничеството между публичния и частния сектор е от решаващо значение" (Collaboration between the public and private sectors is crucial). Policy 6 refers to specific budget allocations for the digital qualification program, ensuring targeted investments in AI education.

Ireland

The policy “AI - Here for Good: A National Artificial Intelligence Strategy for Ireland” emphasises the importance of transparency and accountability in AI: "Transparency in the use of AI systems is critical for building public trust. The opaque nature of many AI algorithms may also obscure the reasoning behind AI-based decisions and can cause problems from the perspective of explainability and accountability". While the policy is pitched as a national strategy, it does flag the importance of ethics and transparency in the use of AI in education: “It is also important that teachers understand the strengths and limitations of AI as part of teaching methods - how AI can augment learning, but also the ethical considerations and risks involved”. The policy implies that its existing professional learning initiatives will play a role in supporting teachers to enact AI: "The Department of Education already assists schools to embed the effective use of digital technologies in teaching and learning practices and to develop digital literacy through the provision of a broad range of Continuous Professional Development initiatives". Regarding curriculum design, the policy states: "AI is a developing area so curricula must continue to evolve to ensure that children are being taught the skills they will need to engage confidently and effectively with AI in the future". The policy highlights the importance of teaching and learning using AI from the early years in schools: “Importantly, since our children will experience the greatest impact of AI, their use in schools can build familiarity and ease with AI solutions from an early age”. The policy also advocates for inclusion and supporting diverse learning using AI approaches: “AI-based educational tools may bring benefits such as the ability to provide customised learning and personalised feedback, as well as

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enabling distance education for children in remote regions and specialised products that can assist non-traditional learners and children with diverse needs". Some discussion is given to funding mechanisms: “School Excellence Funds for Digital and STEM provide some €1m funding to schools working in clusters on innovative projects using digital technologies in teaching and learning, some of which include the use of robotics and coding”.

One of the overarching goals of the “Digital Strategy for Schools to 2027” is to “consider how AI can be incorporated into future policy for digital learning”. Referencing the National Strategy on Artificial Intelligence (AI - Here for Good), this document aims to support the national strategy to build a “future-oriented workforce and population with the skills to drive the development, deployment and use of AI to increase productivity and benefit society”. The strategy also highlights that “it is important that teachers and school leaders understand the strengths and limitations of AI as part of their teaching methods – taking advantage of how AI can augment learning, but also addressing the ethical considerations and risks involved”. Participation in European AI pilot projects and the dissemination of high-quality resources developed through these initiatives are seen as critical to achieving the strategy's goals. The strategy outlines several approaches and actions to support professional learning on “the effective use of digital technologies in all teaching, learning and assessment activities and supporting schools to further embed effective digital capacity planning and development”. The focus is on creating a sustainable model of professional learning that is "well-funded, coherent, flexible and sustainable”. Teacher professional learning programmes across the continuum are emphasised: “Embedding digital technologies across the continuum of teacher education ensures a system wide structured approach to digital education”. The strategy also guides curriculum design: “It is important that children are given the opportunity to build familiarity and ease with AI solutions from an early age”. While resources and funding streams are not exclusively identified for AI, resource allocation and funding mechanisms for digital infrastructure in schools are addressed.

Italy

The explicit goals and objectives across the policies consistently emphasise modernising education and enhancing Italy’s technological competitiveness. The National AI Strategy, for instance, aims "to enable Italy to maximise the benefits and minimise the costs of the most significant technological paradigm shift of our time" ("Obiettivo della Strategia Nazionale è delineare un piano coerente per consentire all’Italia di massimizzare i benefici e minimizzare i costi derivanti dal più importante cambio di paradigma tecnologico dei nostri tempi"). Similarly, the Strategic Policy on AI targets comprehensive skill development to keep the country at the technological forefront and prepare the workforce for future opportunities ("Investire nella formazione e creazione di competenze

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sull'IA a 360 gradi al fine di mantenere il paese sulla frontiera tecnologica e preparare la forza lavoro alle opportunità di domani"). These objectives highlight a forward-looking approach to AI integration, aiming for a robust digital transformation within the educational sector.

The principles of transparency, accountability, and ethical use of AI technologies are articulated with a strong emphasis on ensuring that AI development and deployment serve societal needs responsibly. The National AI Strategy highlights that AI must serve people, ensure human supervision, and prevent social inequalities ("L'IA deve essere al servizio delle persone garantendo una supervisione umana prevenendo i rischi di inasprimento degli squilibri sociali e territoriali potenzialmente derivanti da un suo utilizzo inconsapevole o inappropriato"). Similarly, the Strategic Policy on AI stresses anthropocentric, reliable, and sustainable AI development ("L'intelligenza artificiale italiana sarà antropocentrica affidabile e sostenibile... L'IA deve essere progettata e implementata in modo responsabile e trasparente"). These principles are crucial for building public trust and ensuring ethical considerations are at the forefront of AI integration in education.

Strategies and actions to support teachers' professional learning and capacity-building in AI competencies are varied and comprehensive. The policies propose continuous professional development, integration of AI into STEM education, and specific training initiatives. For instance, the National AI Strategy advocates for foundational digital knowledge coupled with critical thinking skills ("La scuola soprattutto dovrà porre le basi per sviluppare le conoscenze digitali di base accompagnate da un adeguato pensiero critico dei cittadini di domani"). Additionally, the Strategic Policy on AI promotes integrating AI content into school curricula and expanding applied AI courses and internships in technical institutes ("Espandere i corsi di programmazione e includere corsi e stage di IA applicata in tutti i curricula ITS").

Another area addressed is guidance on curriculum design, instructional practices, and assessment methods tailored to incorporate AI education. The policies advocate integrating AIrelated topics into degree courses and curricula at various educational levels. For instance, the

National AI Strategy calls for the redesign of national degree courses to include AI topics ("Riprogettazione dei corsi di laurea nazionali prevedendo l'inserimento di crediti formativi riconducibili a temi propri dell'IA") so that students receive a comprehensive education that includes both theoretical and practical AI knowledge.

Resource allocations and funding mechanisms are clearly outlined to support implementing AI initiatives in teacher education. Significant public and private investments are planned to enhance digital infrastructures and support continuous teacher training.

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The National AI Strategy, for example, plans a public investment of €2.5 billion over five years to promote AI technologies and applications ("L'obiettivo per il quinquennio 2021-2025 è di un investimento pubblico di 25 miliardi di euro con fondi per interventi volti a favorire lo sviluppo delle tecnologie e delle applicazioni di IA").

Malta

The "National AI Policy of Malta"' and the "National eSkills Strategy 2022-2025" both emphasise the integration of AI into various sectors, particularly education, while promoting principles of transparency, accountability, and ethical use. Both policies are grounded in the Malta Ethical AI Framework, which aligns with the European Commission's AI HLEG Ethics Guidelines for Trustworthy AI, underscoring the importance of ethical considerations in AI deployment. Both policies outline several strategies to support teacher professional development and capacitybuilding in AI competencies. The "National AI Policy of Malta" proposes annual conferences on AI in education, introductory AI training for educators at all levels, and AI modules for university students. Similarly, the National eSkills Strategy includes formal upskilling programmes, continuous professional development (CPD), and the integration of AI professional learning into existing teacher education programs. Both policies stress the importance of establishing standard digital competence frameworks, such as the EU DigComp standard, to ensure consistent and comprehensive digital literacy.

Both policies address curriculum design, instructional practices, and assessment methods, aiming to incorporate AI education across all educational levels. The National AI Policy of Malta specifies actions such as offering AI elective modules at the University of Malta, while the National eSkills Strategy advocates for curricula that reflect the needs of the evolving digital transformation from primary to post-tertiary education.

Funding mechanisms are also a common theme, with policies detailing resource allocations and strategies to support AI initiatives in education. The National AI Policy of Malta mentions scholarships for post-graduate studies in AI and pilot projects, though it highlights the need for scalability initiatives to ensure sustainable innovation. The National eSkills Strategy discusses investments in digital infrastructure, including devices and networks, and explores funding through government, EU schemes, and employer sponsorships for specialised ICT education in areas such as AI, Data Science, Cloud Computing, and IoT.

Spain

The "Estrategia de Inteligencia Artificial 2024," the "National Strategy for Artificial Intelligence," and the "La intel·ligència artificial en l'educació Orientacions I recomanacions

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per al seu ús als centres" all address the integration of artificial intelligence (AI) into the Spanish education system. These policies collectively emphasise the importance of enhancing digital competencies and fostering AI talent through specialised training and curriculum integration. The "Estrategia de Inteligencia Artificial 2024" outlines explicit goals such as modernising vocational training and improving the skills of digital professionals by incorporating AI into teacher preparation programmes. Similarly, the "National Strategy for Artificial Intelligence" aims to enhance professional capacities and skills in AI across various sectors, including education. Both policies recognise the need for long-term teacher professional learning and for integrating AI into the curriculum from early childhood education to ensure educators are well-equipped to teach and utilise AI effectively.

Transparency, accountability, and ethical use of AI technologies are recurring principles in all three policies. The "Estrategia de Inteligencia Artificial 2024" stresses the importance of developing and implementing AI systems that adhere to high ethical standards and transparency. The policy mentions evaluation and review processes to ensure the reliability of AI models and systems. The "National Strategy for Artificial Intelligence" also highlights the significance of using transparent, explainable algorithms to improve public trust and strengthen citizen-government relationships. The Catalonia-specific policy, "La intel·ligència artificial en l'educació Orientacions I recomanacions per al seu ús als centres," robustly articulates these principles, ensuring that AI decisions are traceable and explainable. It includes the transparency of relevant elements for an AI system, such as data, the system, and business models.

Supporting teachers' professional learning and capacity-building in AI competencies is a key focus across the policies. The "Estrategia de Inteligencia Artificial 2024" proposes several strategies, including specialised training programmes, scholarships, and professional development initiatives. For example, it mentions the launch of training scholarships in AI and enabling digital technologies valued at €120m. The "National Strategy for Artificial Intelligence" also underscores the necessity of long-term training for teachers and proposes the creation of master's programmes in AI. The Catalonia policy stresses continuous professional development

and provides resources for teachers to engage with AI tools, particularly generative AI, highlighting the need for educators to be supported through professional learning.

Curriculum integration is another significant theme. The "Estrategia de Inteligencia Artificial 2024" guides curriculum design, instructional practices, and assessment methods tailored to incorporate AI education. It emphasises integrating AI into the curriculum by developing computational thinking and digital competence among students. The "National Strategy for Artificial Intelligence" supports integrating computational thinking and AI across various educational levels, laying the foundations for understanding computational,

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critical, and creative thought regarding AI fundamentals. The Catalonia policy advocates for a competencebased curriculum that leverages real-world contexts and challenges for students, promoting learning situations that enhance students' engagement with AI.

Resource allocation and funding mechanisms are well-articulated within these policies to support the implementation of AI initiatives in education. The "Estrategia de Inteligencia Artificial 2024" outlines significant investments in AI education and training programmes, aiming to position Spain as a leader in AI research and education. The "National Strategy for Artificial Intelligence" mentions establishing the NextTech public-private venture capital fund to promote digital entrepreneurship and create AI-based companies. The Catalonia policy highlights the need for sustainable funding and resource management to ensure the successful integration of AI technologies in education. However, it also acknowledges the challenge of maintaining equitable access to AI resources due to potential cost barriers, noting that most AI applications initially free may later become paid services.

The three policies exhibit a coherent and comprehensive approach to integrating AI into the Spanish education system. They share common themes of enhancing digital competencies, fostering AI talent, ensuring ethical and transparent AI use, supporting teacher professional development, integrating AI into the curriculum, and securing necessary resources and funding. While the "Estrategia de Inteligencia Artificial 2024" and the "National Strategy for Artificial Intelligence" have a national focus, the Catalonia-specific policy aims to position the region as a leader in AI innovation. These policies aim to prepare educators and students for a future where AI plays a significant role in various sectors.

Turkey

Within this policy, the goals of increasing employment in AI to 50,000 and raising the number of AI specialists in public institutions to 1,000 reflect an imperative and ambitious stance on human capital development: "YZ alanında istihdam 50.000 kişiye çıkarılacaktır" and "Kamu kurum ve kuruluşlarında YZ uzmanı istihdamı 1.000 kişiye çıkarılacaktır". This approach shows a strategic commitment to cultivating a proficient AI workforce, further supported by targets to enhance university capacities and increase the number of postgraduate AI graduates to 10,000. The policy emphasises transparency and accountability through mechanisms like algorithmic accountability and ethical governance, indicating a proactive stance on ethical AI use:

"algoritmik hesap verebilirliği kolaylaştıracak yönetişim mekanizması hayata geçirilecektir".

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Strategies for professional learning and capacity-building in AI competencies are discussed. Current teachers will receive “in-service training”, and “new educational personnel will be recruited as necessary”: "Mevcut öğretmenlerden nitelikleri uygun olanlar... hizmet içi eğitimden geçirilecek" and "kısmi veya tam zamanlı yeni eğitim personeli temin edilecektir". Curriculum design and instructional practices are geared towards creating immersive AI learning experiences. The encouragement of educational models that emphasise interaction and deep learning: "YZ alanında deneyimlemeyi etkileşimi ve derinleşmeyi sağlayacak eğitim modelleri" suggests a comprehensive approach, while the creation of an ecosystem for developing digital education content indicates a systemic and integrated method: "Dijital eğitim ve öğretim içeriği geliştirme ekosistemi oluşturulması". Resource allocations and funding mechanisms are structured to support AI initiatives, with a focus on increasing venture capital funds and supporting specialised educational programmes: "YZ odaklı girişim sermayesi fonları etkinleştirilecek ve hacmi büyütülecektir".

4.3 Cross-Country Comparative Analysis

A primary goal across the policies in all seven countries is enhancing education through AI. Bulgaria focuses on improving student learning outcomes and teacher effectiveness with AI learning tools. Italy aims to modernise education by incorporating AI to foster technological competitiveness, leading Italy to place a stronger emphasis on technological skills over pedagogy, curriculum, and professional learning. Ireland’s policies aim to equip future generations with AI skills. Belgium and Türkiye also seek to enhance educational outcomes through AI. Spain aims to position itself as a leader in AI research and education by promoting new AI-related degrees and master's programmes, emphasising the development of high ethical standards and transparency in AI systems. Malta outlines specific goals and targets for integrating AI into education, including principles of transparency, accountability, ethical use, and strategies for teacher professional development and curriculum design.

All countries stress the importance of developing digital skills among students and teachers. Bulgaria and Italy emphasise integrating AI into curricula to build digital competencies. Ireland’s strategies include reviewing AI skill implications, expanding upskilling initiatives, focusing on workplace-related training programmes, and expanding sustainable professional programmes across the continuum. Spain aims to integrate AI into the curriculum by developing computational thinking and digital competence among students and provides significant investments in AI education and training programmes.

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Malta's policies advocate for integrating AI and digital skills across all educational levels, with actions such as providing AI elective modules for university students. Belgium promotes innovative instructional practices to enhance digital skills. Türkiye focuses on increasing AI employment and the number of AI specialists through educational programmes.

Ensuring ethical AI use and maintaining transparency are central themes. Ireland aligns its AI strategy with the EU's Ethics Guidelines for Trustworthy AI. Italy stresses the need for AI to serve people, prevent social inequalities, and be developed responsibly and transparently. Bulgaria emphasises ethical AI use and privacy protection. Belgium's policy focuses on creating a shared understanding of responsible AI. Türkiye proposes algorithmic accountability mechanisms. Spain emphasises developing and implementing AI systems that adhere to high ethical standards and transparency through evaluation and review processes. Malta's strategy is built on the European Commission's AI HLEG Ethics Guidelines for Trustworthy AI, ensuring transparency and accountability.

Bulgaria proposes mechanisms and support for ongoing professional learning to ensure teachers can adapt to AI technologies. Both of Ireland's policies features workplace-focused training programmes and imply that its existing professional learning initiatives will support teachers in enacting AI. Italy advocates for continuous professional learning to enhance digital knowledge and critical thinking. Spain's policy includes specialised training programmes and scholarships to support teachers' professional learning and AI competencies. Malta outlines strategies such as annual AI conferences for teachers and introductory AI training at all levels to support professional learning and capacity-building. Belgium emphasises the necessity of ongoing professional learning to keep pace with technological advancements. Türkiye outlines measures for professional learning (in-service training) and recruiting new educational personnel to improve AI competencies among teachers.

Effective resource allocation and funding mechanisms are crucial for successful AI initiatives. Bulgaria and Italy detail specific funding sources, including state and European funds, to support AI integration in education. Spain outlines significant investments in AI education, such as €160m for talent and training programmes. Ireland's strategies signal that it will draw on establishing funding mechanisms and mention the School Excellence Funds for Digital and STEM, which provide funding to schools for innovative projects, including AI technologies. Italy's strategy emphasises public-private partnerships. Malta's policy includes funding strategies like scholarships for postgraduate studies in AI and

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investments in digital infrastructure within educational institutions. Belgium acknowledges the role of government and educational networks in providing necessary tools and training. Türkiye refers to increasing venture capital funds and supporting specialised educational programs.

4.4 European and International Policy Analysis

Table 6: Selected European and International Policies

Policy No.	Policy Details
European Policy 1	*Guidelines for teachers and educators on tackling disinformation and promoting digital literacy through education and training*. European Commission (2022).
European Policy 2	*Artificial intelligence and education: A critical view through the lens of human rights, democracy and the rule of law*. Council of Europe (2022).
European Policy 3	*AI report by the European Digital Education Hub's Squad on artificial intelligence in educatio*n. European Commission (2024).
International Policy 1	*Guidance for generative AI in education and research.* UNESCO (2023).
International Policy 2	*AI and education: A guidance for policymake*rs. UNESCO (2021).
International Policy 3	*Policy guidance on AI for children*. UNICEF (2021).

The policies consistently highlight the necessity of equipping teachers with the skills to enact AI in teaching and learning. For instance, the European Commission's "Guidelines for Teachers and Educators on Tackling Disinformation and Promoting Digital Literacy through Education and Training" (European Policy 1) focuses on promoting digital literacy among teachers and students as a foundation for building AI competencies. This is echoed in UNESCO's "Guidance for Generative AI in Education and Research" (International Policy 1), which aims to ensure that teachers and students develop the necessary skills to benefit from and contribute to an AIdriven world.

AI's ethical and responsible use is another central theme that permeates these policies. The Council of Europe's policy on "Artificial Intelligence and Education: A Critical View through the Lens of Human Rights, Democracy, and the Rule of Law" (European Policy 2) addresses the need for ethical AI use, highlighting data protection and privacy measures. UNICEF's "Policy Guidance on AI for Children" (International Policy 3) stresses the

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importance of designing AI systems that respect children's rights and promote their well-being. Transparency and accountability are principles emphasised across all six policies. The policies emphasise the importance of transparent AI systems so that teachers and students need to understand and trust these technologies. The European Digital Education Hub's "AI Report by the European Digital Education Hub's Squad on Artificial Intelligence in Education" (European Policy 3) advocates for transparency in AI systems, aligning with the guidelines provided by UNICEF, which also call for transparency and accountability in AI applications used in educational contexts.

Professional learning and capacity building for educators are recurring themes, and all policies recognise their importance. The European Commission's guidelines (European Policy 1) and UNESCO's guidance (International Policy 1) stress the need for ongoing professional learning programmes to help teachers integrate AI into their teaching practices. These programmes should provide educators with the knowledge and skills required to use AI tools effectively. They should also foster a continuous/lifelong learning culture to deal effectively with technological advancement and adaptation.

Curriculum integration and the adoption of innovative instructional practices are highlighted as essential strategies for preparing students for an AI-driven future. The policies advocate incorporating AI-related content into curricula and using AI tools to enhance learning experiences. For example, the Council of Europe's policy (European Policy 2) suggests integrating AI across various subjects to promote interdisciplinary learning. This approach is also evident in UNESCO's "AI and Education: Guidance for Policymakers" (International Policy 2), which calls for reviewing and adjusting curricula to incorporate AI and transform learning methodologies. These policies emphasise the need for flexible and forward-thinking curricula capable of adapting to the rapid advancements in AI technology.

The European Commission's guidelines (European Policy 1) and UNESCO's guidance (International Policy 2) highlight the importance of substantial investments in infrastructure and professional learning. These policies propose various funding mechanisms, such as European funding programmes like Erasmus+ and encouraging partnerships between educational institutions, businesses, and AI providers.

The approaches to resource allocation and funding also vary among the policies. While the European Commission's guidelines (European Policy 1) and UNESCO's Guidance for Policymakers (International Policy 2) stress the need for substantial investment, they differ in their approaches to sustainable funding. The European Digital Education Hub's report (European Policy 3) discusses the role of European programmes like Erasmus+ in providing financial support. At the same time, UNICEF's guidance (International Policy 3)

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suggests incentives for private and public sector collaboration to develop ethical AI systems.

4.5 Policy Analysis: Conclusions and Considerations

We conclude this section with some considerations from the policy analysis related to the teaching of AI and AI curriculum design principles.

The policy analysis clearly confirms the value of developing an AI curriculum and the need for AI education more generally. The necessity for development of teacher digital competence with regard to AI is highlighted repeatedly, as are suggestions that this should occur across the continuum of teacher education (i.e. practising in-service teachers, pre-service (ITE)). There is also a need to take account of teachers' varying levels of awareness and understanding of AI and its usage in education. In addition, curricular design should be mindful of teachers' constraints with regard to accessing and engaging with resources in a flexible and accessible manner.

Policies highlight a number of potential aspects regarding AI that might be included in a curriculum. For instance: (i) incorporating AI-related content within and across subjects to promote interdisciplinary learning, (ii) provision of instructional strategies and tools which enable teachers to leverage AI to enhance the learning experience, (iii) the use of AI tools for personalised learning and assessment, (iv) the application of AI for contexts beyond education (i.e. societal impact and relevance, work-related considerations, etc.), (iv) ethical implications with regard to AI, such as responsible AI usage, transparency with regard to AI, issues relating to privacy and AI, and so on.

5. REPORT SUMMARY

This report has addressed the main objective of PAIDEIA project work package 2.1: to report on the state of the art with regard to Artificial Intelligence (AI) in PAIDEIA countries.

It began with a scoping review to map the extent, nature, and range of peer-reviewed published academic literature with regards to AI and education in PAIDEIA countries. This review illustrates the vast amount of research being conducted on AI and its role in education, highlights the importance of the design of curriculum for AI education, and revealed how AI is being used for teaching, assessment, learning, and data analysis. It also gave an insight into learning about AI and the pedagogical approaches which are advocated for this, as well as exploring how teacher education is currently incorporating AI.

The report then moved to a review of policy pertaining to AI education/AI in education in PAIDEIA countries, as well as a consideration of a number of European and

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international policies. The policies highlight the need for development of AI curricula and education, and the need to prepare teachers to incorporate AI as an innovative asset. A number of key considerations and implications for curricular development and enactment also emerge from these policies.

Overall, this report has provided a number of insights, findings, observations, and recommendations with regard to AI education, and AI in education, which can be drawn on for the purposes of curriculum design and development for the PAIDEIA project.

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