Open Classroom Conference

Empowering Educators and Learners for the Age of AI

7-8 November 2025 | Ellinogermaniki Agogi, Greece

Organised by

In cooperation with

FRIDAY
07.11.2025

16:00-17:00	**Registrations**

Introductory Session
Chairs: Dimitra Dimitrakopoulou – Dr. Dimitris Koulentianos, *Ellinogermaniki Agogi*

CONFERENCE HALL

17:00-17:30	**Greetings** Dr. Andreas Marinos, *Director of the Secondary Education Directorate of East Attica, Greece* Panagiotis Angelopoulos, *Member of the Hellenic National Support Organization for eTwinning* Prof. Iraklis Varlamis, *Harokopio University of Athens, GFOSS*
17:30-18:30	**Supporting the student journey with AI Tools** Prof. Denise Whitelock, *The Open University, Vice-President of EDEN* **Discovery Space: An AI-enhanced Classroom for Deeper Learning in STEM** Prof. F. X. Bogner, *University of Bayreuth* **How do machines "understand"? Large Language Models and their potential in education** Dr. Vassilis Katsouros, *Director of the Institute for Language and Speech Processing, Athena Research Center*
18:30-18:40	**Discovery Space Competition: Teachers' awards Ceremony**
18:40-19:00	**Coffee Break**
19:00-20:40	**Trustworthy Artificial Intelligence and the Future of STEM Educations** Prof. G. Mentzas, *Institute of Communication & Computer Systems, National Technical University of Athens* **From Theory to Practice: Integrating AI into eTwinning Projects and Online Classrooms** Panagiotis Angelopoulos, *Member of the Hellenic National Support Organization for eTwinning* **Information Technology: the clever, fast, and naughty, brain grandchild of humanity: From Artificial Intelligence to Fake News** Prof. Costas Tsolakidis, *University of the Aegean* **Technology is here: What is education doing?** Prof. Iraklis Varlamis, *Harokopio University of Athens*
21:00	**Dinner** **Observation night at the school Observatory**

SATURDAY
08.11.2025

9:30-10:00	**Registrations**

Teach for AI
Chair: Dr. Kati Clements, *University of Jyvaskyla*

CONFERENCE HALL

10:00-10:20	**Beyond Borders: AI, Psychological Safety, and the Future of Learning in the Age of Disruption** Dr. Daithí Ó Murchú, *Drumcondra Education Support Centre, Ireland*
10:20-10:35	**Co-design in action: Developing Teacher Mate and Study Buddy through iterative prototyping** Spyridoula Stamouli, *Institute for Language and Speech Processing, Athena Research Center*
10:35-10:50	**Building Resilient AI-Powered Learning Environments** Dr. Dimitra Pappa, *NCSR Demokritos*
10:50-11:05	**Generative AI Frameworks for Education: Roadmaps towards integrating AI technologies in K-12 schools** A. Dimitrakopoulou, Prof. A. Jimoyiannis, *University of Peloponnese*, Prof. S. Retalis, *University of Pireaus*
11:05-11:20	**Towards Trustworthy AI in STEM Education: Challenges and Strategies from the Trust-AI platform** Dr. E. Anagnostopoulou, *Institute of Communication & Computer Systems, National Technical University of Athens*
11:20-11:30	**Discussion**
11:30-12:00	**Coffee Break**

SATURDAY
08.11.2025

	Teach with AI **Chair:** Dr. Anne Pawsey, *European Physical Society*	**Teach about AI** **Chair:** Spyridoula Stamouli, *Institute for Language and Speech Processing, Athena Research Center*
	CONFERENCE HALL	**ROOM B126**
12:00-12:15	**Teaching "Helen" by Euripides using AI tools** Theodora Lymperi, *Secondary School Director, Ambassador eTwinning North Aegean*	**From needs to design: A Human-Centered framework for AI in education** Hamam Mokayed, *Luleå University of Technology*
12:15-12:30	**i-Private Project: A student-led, AI-and-robotics intervention for reimagining the public beach changing room** Charoula Leontari, *Primary school of Vasiliko, Evia*	**Usability and technology acceptance: Evaluating AI4EDU tools in real classrooms** Dimitra Dimitrakopoulou, *Ellinogermaniki Agogi*
12:30-12:45	**Chatbots as Virtual Tutoring Assistants in Secondary Education** George Gribilakos, *Lesvos Directorate of Secondary Education*	**Beyond usability: Assessing the educational impact of AI4EDU applications** Marios Papaevripidou – Theodoros Karafyllidis, *University of Cyprus*
12:45-13:00	**AI: The Means for Inclusive Education – Pedagogical Applications, Teacher Collaboration and Dissemination within the Framework of Erasmus+ KA122 Mobility** Alexandra Efthymiou, *Directorate of Primary Education of Eastern Attica* Konstantia Georgiou, *4th Primary School of Gerakas*	**Evidence into action: Implementation guidelines and policy recommendations for responsible AI in education** Dr. Daithí Ó Murchú – Peter Coakley, *Drumcondra Education Support Centre, Ireland*
13:00-13:15	**A Case Study on NUCLIO's Implementation of AI-Supported Inquiry Scenarios in DSPACE** Almeida, M. L., *Núcleo Interativo de Astronomia e Inovação em Educação*	**Ethics and AI policy in schools: Cyprus Ministry of Education, Sport and Youth policy and guidelines for the responsible and ethical utilization of Artificial Intelligence in primary and secondary education** Theodora Kakouri – Panayiota Ioannou, *Cyprus Pedagogical Institute*
13:15-13:30	**Artificial Intelligence and Distance Education as Catalysts for Inclusive Teaching in STEM** Argeroula Petrou, *Special education consultant, Athens* Chara Bouta, *Education Advisor for Primary Education, Athens*	**Bright Minds AI Summer Camp: A Model for AI Integration and Curriculum Innovation in Secondary Education** Cosmina Stalidi, *Aurel Vlaicu Secondary School Fetesti, Romania*
13:30-14:00	Discussion	
14:00-15:00	**Lunch Break**	
15:00-17:00	**Workshops**	

Workshops

ROOM B126

Conversational AI Assistants for Teaching and Learning

Participants will explore, among other things, how the AI4Edu tool can be used in the creation of educational materials, lesson planning, assessment management, and personalized student support. Through hands-on activities, participants will have the opportunity to interact with the tool, experiment with its use, and design educational scenarios for its application in teaching practice.

Workshop Coordinators: Dimitra Dimitrakopoulou, *Ellinogermaniki Agogi*, Spyridoula Stamouli – Anna Vacalopoulou, *Institute for Language and Speech Processing, Athena Research Center*, Marios Papaevripidou – Theodoros Karafyllidis, *University of Cyprus*

COMPUTER LAB

AI-Enhanced Formative Assessment for Students' Problem-Solving Competence

Participants will explore ready-to-use, AI-supported classroom scenarios that promote problem-solving and inquiry-based learning. The session focuses on how these scenarios are structured and how educators can implement them effectively to enhance student engagement and competence development.

Workshop Coordinators: Dr. Dimitris Koulentianos, *Ellinogermaniki Agogi*, Mr. Nikolaos Antonios Grammatikos, *Institute of Communication & Computer Science, National Technical University of Athens*

ROOM B134

The Artificial Intelligence-Aware Classroom

Participants will explore a range of AI tools and engage with best practices for applying AI across different school subjects. The workshop aims to equip educators with essential skills and insights by addressing multiple dimensions of AI, ranging from technical competencies such as data literacy and machine learning to critical topics like ethics, bias, and responsible use in educational contexts.

Workshop Coordinators: Dr. Agapi Vavouraki, Olga Ioannou, Dimitra Dimitrakopoulou, *Ellinogermaniki Agogi*, Dr. Kati Clements, *University of Jyvaskyla*

ROOM B117

Designing and Enacting a Teacher Academy on AI in School Education

Participants will be introduced to such an Academy's scope and philosophy, which seeks to equip teachers, school leaders, and education professionals with the knowledge, skills, and ethical grounding needed to integrate AI meaningfully into teaching and learning. Beyond presentation, the workshop will actively engage stakeholders (teachers, school leaders, education consultants, and policymakers) in collaborative activities to share experiences, raise challenges, and provide recommendations concerning AI in school education.

Workshop Coordinators: Nikos Zygouritsas, *Ellinogermaniki Agogi*, Menelaos Sotiriou-Dimitrios Sotiropoulos, *Science View*

Manuscript Title
A Teacher-in-the-Loop Approach to AI-powered Learning Design
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Abstract

The contemporary educational landscape demands that teachers move beyond content delivery to become designers of engaging, technology-enhanced learning experiences. This shift, however, has intensified teacher workload, creating a profound need for innovative solutions. In response, a new generation of generative AI (GenAI) lesson planning tools has emerged, offering unprecedented efficiency and support for school teachers (Gallup, 2025; Jambunathan & Jayaraman, 2025). Recent studies highlight a significant trend, with a growing number of educators using AI for lesson planning to save time, allowing more focus on direct student engagement (Hoare & Smith-Ferguson, 2025).

While the rapid adoption of these tools signals their immediate value, a critical gap exists between the efficiency they provide and the pedagogical rigor required for high-quality instruction (Huntington Research School, 2025; Trust & Whalen, 2020). Most AI tools prioritize speed and automation, generating plans that often lack grounding in established learning theories and do not support the structured, reflective processes common in traditional learning design (LD). This presents a core R&D challenge: *how to reconcile the efficiency of AI with the intentional design required for effective teaching*?

Our work addresses this challenge by investigating the philosophy and design of AI-powered lesson planning tools. We argue that the key trend in the field is a shift from purely automated generation to human-in-the-loop co-creation. This approach leverages AI as an intelligent assistant that enhances, rather than replaces, a teacher's expertise. It is through this lens that we present a case study of the AI-enhanced CADMOS LD tool.

Our analysis shows how AI capabilities can be seamlessly integrated into a structured, layered design framework to provide a powerful, hybrid solution. The AI-powered CADMOS LD tool guides teachers through a systematic design process, from defining course metadata and goals to generating aligned activities, resources, and durations. This approach goes beyond simple planning, enabling teachers to construct a coherent conceptual model and learning flow model of their lesson. At every stage, the teacher retains full agency, able to accept, refine, or reject AI suggestions, transforming them into a powerful co-designer.

This structured co-creation model not only ensures pedagogical rigor but also provides a robust, standardized design that can be directly translated and enacted. Our closing remarks highlight a key future trend: moving beyond mere document generation, next-generation tools will focus on creating structured designs that are ready for seamless enactment on Learning Management Systems (LMS) like Moodle. This bridges the gap between design and practice, promising a future where innovative, technology-enhanced lessons can be implemented with a few clicks, offering substantial productivity gains without compromising instructional quality.

Keywords: Learning Design, AI-powered lesson planning, Co-creation, Teacher Agency

Relevant conference themes: AI Tools for Personalized and Adaptive Learning

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Manuscript Title
Beyond usability: Assessing the educational impact of AI4EDU applications

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Abstract

This study examines the impact of two generative AI applications on students' performance, motivation, and engagement, as well as on teachers' practices, across two school-based case studies in Cyprus and Ireland. A quasi-experimental design was used, with control and experimental student groups following the same curriculum, while only the experimental groups used SB for independent or inquiry-based learning. Teachers in both groups employed TM to prepare lessons, assessments, and instructional materials. Academic performance tests and the Motivation and Engagement Survey (MES) were administered before and after implementation, complemented by teacher interviews and student feedback. In the Cyprus case, both groups showed clear learning gains, with the experimental group achieving notably higher improvement, while motivation and engagement remained relatively stable. In the Irish case, minimal learning gains were observed due to ceiling effects and the short intervention, yet qualitative data indicated that SB supported students' autonomy, inquiry, and confidence in completing project tasks. Overall, the findings suggest that generative AI can enhance teaching and learning when integrated with appropriate guidance, with effectiveness shaped by context, duration, and baseline student performance.

Keywords: Artificial Intelligence in Education, Academic performance, Student engagement

1. Introduction

Artificial intelligence (AI) is rapidly reshaping educational landscapes by offering new ways to personalise learning, support instructional design, and enhance the overall efficiency of teaching and learning processes (Ayeni et al., 2024). Over the past decade, AI-powered applications have evolved from simple adaptive quiz systems to sophisticated conversational tutors and teacher-support tools capable of generating explanations, practice tasks, lesson materials, and real-time feedback (Adiguzel et al., 2023). These developments have generated substantial optimism regarding AI's potential to support differentiation, strengthen learner engagement, and reduce the growing administrative burden on teachers.

Although students and teachers are increasingly experimenting with AI tools, mainstream adoption in schools remains limited. This can be attributed to several factors, including insufficient teacher preparation, limited professional development opportunities, and a lack of established pedagogical frameworks for integrating AI into everyday practice. While a substantial body of research explores the technical accuracy, usability, or engagement features of AI tools, far fewer studies investigate how these tools influence core educational processes, such as students' study behaviours, teachers' planning and assessment practices, or classroom interactions within authentic school environments. Consequently, a gap persists between the technological capabilities of AI systems and the pedagogical understanding required for their effective and sustainable integration in schools.

Three key gaps in the current literature remain underexplored:

1. **Limited empirical evidence on AI's impact under everyday classroom conditions.** Much existing research is conducted in controlled settings, with limited consideration of real-world school constraints, teacher mediation, or variations in curriculum structures.

2. **Insufficient attention to teacher-facing AI tools.** While student-facing AI tutors are relatively well studied, there is considerably less evidence on how AI systems designed to support teachers' planning, assessment design, differentiation, or classroom management influence instructional practice.
3. **A lack of comparative, cross-national evidence.** Educational systems across Europe differ in curriculum design, instructional norms, teacher roles, and digital readiness. Few studies examine whether AI tools function consistently across such diverse contexts or how system-level differences shape their educational value.

To address these gaps, this study examines the educational impact of two AI applications: Study Buddy (SB), a student-facing AI study companion, and Teacher Mate (TM), a teacher-support platform designed to streamline planning, assessment, teaching delivery, and student monitoring tasks. Implemented across Cyprus, Greece, Ireland, and Sweden, the study provides a cross-national perspective on how AI tools integrate into classrooms that vary significantly in curriculum demands and technological infrastructure.

The objectives of the study are threefold:

1. To evaluate how SB influences students' learning outcomes, motivation, and engagement.
2. To examine how TM supports or transforms everyday teaching practices.
3. To identify the key conditions that enable or hinder the effective integration of AI tools across different national and educational contexts.

By addressing both student-facing and teacher-facing AI applications, this study offers a holistic perspective on AI's educational impact and provides practical recommendations for implementing AI tools in ways that enhance rather than replace pedagogical practices.

2. Methodology

This study was carried out within the framework of the "AI4EDU: Conversational AI Assistant for Teaching and Learning" project (AI4EDU – ERASMUS-EDU-2022-PI-FORWARD), which aims to develop and evaluate two AI-powered applications designed to enhance teaching and learning practices: SB, a student-facing AI study assistant supporting personalised and self-directed learning, and TM, a teacher-facing AI platform providing assistance in lesson planning, content differentiation, assessment creation, and classroom organisation.

The broader project involved four participating countries (Cyprus, Greece, Ireland, Sweden), approximately 15 teachers, and nearly 500 students. However, to provide a more focused and contextually grounded analysis, the present paper reports in detail on two illustrative case studies, one conducted in Cyprus and one in Ireland, each offering rich, multi-source data on the classroom integration and educational effects of SB and TM.

2.1 Evaluation Design

To examine the educational impact of these applications, a quasi-experimental design was employed. In each participating school, intact class groups were assigned either to an experimental condition, where students used SB to support independent study, or to a control condition, where teaching and study routines followed traditional practices. TM was made available to teachers in both conditions, enabling the research team to explore its influence on lesson preparation, assessment design, and instructional organisation independently of SB use.

The study adopted a convergent mixed-methods approach, collecting quantitative and qualitative data before, during, and after implementation. Quantitative data consisted primarily of curriculum-aligned pre- and post-academic tests, developed by participating teachers based on national curriculum standards to measure changes in content knowledge. Many test items were created or refined using TM, allowing evaluation of its practical utility in supporting teacher assessment practices. In addition, students completed the Motivation and Engagement Survey (MES), adapted from Lee and Reeve (2012), at both pre- and post-test stages. The MES includes 38 items rated on a 5-point Likert scale and assesses behavioural, emotional, cognitive, and agentic engagement alongside motivational constructs such as psychological need satisfaction and self-efficacy. Responses were aggregated at class level to capture general motivational trends over time. Qualitative data were collected through classroom observations, semi-structured teacher interviews, and student questionnaires. Classroom observations provided insights into how SB and TM were integrated into instructional routines, how students interacted with the applications, and how teachers mediated their use. Teacher interviews explored educators' experiences with TM, their perceptions of SB's impact on students, and the practical challenges encountered during implementation. Student questionnaires further illuminated learners' perceptions of SB's usability, usefulness, and influence on study habits. Together, these qualitative sources allowed for triangulation of findings and strengthened the validity of the analysis.

2.2 Implementation Procedures

Implementation followed a structured, three-phase process that was consistent across all participating countries. During the pre-implementation phase, schools were recruited and teachers received training on both SB and TM. Baseline academic tests and the MES were administered to both control and experimental groups before any use of the applications began.

During the implementation phase, teachers used TM to design lesson materials, generate assessment items, and organise class activities for both groups. Students in the experimental groups used SB to support independent learning, either during designated classroom periods or as part of home study, depending on local school routines. Control groups continued with conventional study practices without access to SB. Classroom observations and usage analytics were collected to document the fidelity and variability of implementation.

In the post-implementation phase, all students completed the academic post-tests and repeated the MES. Teachers participated in follow-up interviews, and students completed open-ended questionnaires reflecting on their experience. These data helped contextualise the academic findings and provided a deeper understanding of how the AI tools shaped teaching and learning.

2.3 Case studies

Although the AI4EDU project implemented SB and TM across four countries with a large sample of students, this paper focuses exclusively on two case studies selected for their contrasting educational contexts, completeness of datasets, and capacity to illustrate how AI applications function in authentic classroom environments.

2.3.1 Case Study 1: Cyprus – Physics (Grade 10)

The first case study was conducted in a public upper-secondary school in Cyprus and involved two Grade 10 Physics classes (N = 47) studying the topic of gravitational force over a three-week period. The control group (n = 24) followed traditional learning routines, while the experimental group (n = 23) incorporated SB into their independent study. In both groups, the teacher used TM to prepare lesson plans, generate and refine pre- and post-test items, and organise instructional resources. Evaluation instruments included academic performance tests and the MES, administered to both groups before and after implementation.

2.3.2 Case Study 2: Ireland – Sustainability Citizenship (Grade 6)

The second case study took place in a primary school in Ireland and involved two Grade 6 classrooms (N = 48) studying the theme of Sustainability Citizenship, specifically focusing on Green Schools and Learning Ecologies, over a one-week period. Each class consisted of 24 students and was supported by three teachers. The control group followed established instructional practices, whereas the experimental group used SB to support individual inquiry and concept exploration. TM was used by all teachers for lesson planning and organisational tasks. Evaluation instruments included curriculum-aligned pre- and post-tests and qualitative data from classroom observations and teacher–student discussions.

3. Results

3.1. Student Learning and Engagement in Cyprus (Physics, Grade 10)

The first case investigated the impact of SB on students' understanding of gravitational force over a three-week intervention. Analysis of the curriculum-aligned academic tests scores revealed learning gains in both the control and experimental groups, with the latter demonstrating notably higher improvement (Table 0.1). The control group improved from a mean pre-test score of 37.00/100 to a post-test mean of 59.17/100, yielding a mean gain of 22.17 points. In contrast, the experimental group, which used SB to support independent study, increased from a mean pre-test score of 40.87/100 to 71.83/100, corresponding to a mean gain of 30.96 points. These results indicate that although both groups progressed in their understanding of gravitational force, students who used SB achieved substantially greater learning gains.

Table 0.1 Academic performance scores in Case Study 1 (Cyprus)

Group	Group size	Pre-test mean score /100	Post-test mean score /100	Mean gain score /100
Control	24	37.00	59.17	22.17
Experimental	23	40.87	71.83	30.96

Motivation and engagement levels, assessed through the MES, provide further context. As shown in Table 0.2, both groups exhibited small changes in motivational indicators, but no substantial divergence emerged between conditions. For the control group, mean motivation shifted slightly from 3.60 to 3.53 and engagement from 3.34 to 3.40. The experimental group showed similarly modest changes, with motivation decreasing from 3.48 to 3.47 and engagement rising from 3.15 to 3.31. These stable motivational patterns suggest that the stronger academic gains observed among SB users cannot be attributed to differences in motivation or engagement during the intervention period.

Table 0.2 Motivation and engagement scores in Case Study 1 (Cyprus)

Group	Group size	Motivation pre	Motivation Post	Engagement pre	Engagement post
Control	24	3.60	3.53	3.34	3.40
Experimental	21	3.48	3.47	3.15	3.31

Qualitative data further illuminate patterns in student and teacher experience. The teacher reported that TM was particularly valuable for generating assessment items and structuring lesson materials, contributing to a more coherent instructional sequence. Students generally viewed SB as a helpful study resource, though several noted that they required initial guidance to navigate the application effectively.

3.2 Student Learning and Engagement in Ireland (Sustainability Citizenship, Grade 6)

The second case study explored the use of SB and TM within a one-week Sustainability Citizenship unit. Because students in both groups began with very high pre-test scores, opportunities for measurable improvement were limited. As shown in Table 0.3, the control group decreased slightly from 8.36/10 to 8.30/10 (mean gain = –0.06), while the experimental group increased marginally from 8.33/10 to 8.36/10 (mean gain = 0.03). These minimal changes reflect ceiling effects combined with the short duration of the implementation.

Table 0.3 Academic performance scores in Case Study 2 (Ireland)

Group	Group size	Pre-test mean score /10	Post-test mean score /10	Mean gain score /10
Control	21	8.36	8.30	-0.06
Experimental	19	8.33	8.36	0.03

Despite the minimal quantitative change, qualitative data revealed important differences in how students engaged with sustainability concepts. Teachers reported that SB was particularly useful as a supportive resource for individual inquiry, enabling students to explore topics such as recycling systems and ecological citizenship with greater autonomy. Observations indicated that experimental-group students consulted SB frequently during project tasks to clarify terminology, check facts, and explore examples from other environmental initiatives. Teachers described TM as helpful for structuring the project materials and facilitating the organisation of activities across the three teacher teams supporting the classes.
Classroom discussions and student feedback indicated that learners appreciated SB's ability to provide quick explanations and fact-checking support, although more complex concepts were still preferentially discussed with teachers. The combination of high baseline performance and the brief intervention period likely constrained the potential for measurable learning gains, but the qualitative data suggest that SB contributed positively to students' inquiry processes, independence, and confidence in seeking information.

4. Discussion

The findings from the two case studies offer important insights into how AI-supported applications can influence teaching and learning processes in authentic school environments. The results from the Cyprus Physics case demonstrate that students who used SB achieved substantially greater learning gains than those relying on traditional study methods, despite modest differences in motivational indicators. This pattern aligns with existing research suggesting that AI-powered study companions can enhance conceptual (Lee et al., 2022). The stronger gains observed in the experimental group suggest that when students use such tools consistently and with clear study goals, AI can effectively support content mastery even within short instructional periods.
SB appears to have functioned primarily as a cognitive scaffold rather than a motivational enhancer.
At the same time, the limited changes in motivation and engagement for both groups indicate that short-term exposure to AI tools may not be sufficient to alter underlying motivational states. This contrasts with studies arguing that AI can facilitate motivational shifts (Moybeka et al.; 2023; Parhanuddin et al., 2025). In this sense, SB appears to have functioned primarily as a cognitive scaffold rather than as a motivational enhancer.
The Ireland case study provides a complementary perspective by illustrating a contrasting curricular and temporal context. Here, both groups began with very high pre-test performance, leaving little room for quantifiable improvement. Nonetheless, qualitative data revealed meaningful differences in how students approached inquiry-based tasks. Students in the experimental group used SB to clarify concepts, verify information, and explore examples independently, suggesting that AI tools can support knowledge exploration and autonomy even when measurable learning gains are constrained by ceiling effects. The case also underscores that the educational value of AI cannot be assessed solely through test scores.
Across both cases, TM emerged as an enabling factor in the instructional process. Teachers consistently reported that TM streamlined lesson preparation, supported differentiated resource creation, and offered organisational coherence. These experiences align with research showing that teacher-facing AI tools can reduce administrative burdens, assist with routine planning tasks, and help teachers respond more effectively to diverse student needs (Celik et al., 2023). Importantly, TM's influence was present in both control and experimental conditions, highlighting the applications's role in supporting teacher workflows independently of student-facing AI use.
Taken together, these findings reinforce three key insights for the integration of AI in education. First, the effectiveness of AI tools depends heavily on the broader instructional ecosystem. SB contributed most effectively when supported by clear teacher guidance, structured study expectations, and alignment with curricular goals. Second, AI tools appear able to support different forms of learning depending on context: SB enhanced conceptual mastery in Physics but primarily facilitated inquiry processes in an interdisciplinary Sustainability Citizenship setting. Third, the role of teacher-facing tools like TM should not be

underestimated. By improving the efficiency and structure of instructional preparation, such tools create the conditions for more meaningful and targeted student-facing AI use.

5. Conclusions and Future Work

This study examined the educational impact of two AI-powered applications across two contrasting European classroom contexts. The findings strengthen emerging evidence that AI tools can meaningfully support both teaching and learning when integrated within coherent pedagogical structures. In the Cyprus Physics case, SB contributed to substantially greater learning gains, highlighting its potential to enhance conceptual understanding in content-heavy subjects. In the Ireland Sustainability Citizenship case, although academic gains were minimal due to ceiling effects and a short implementation period, qualitative findings revealed that SB supported students' inquiry processes, enabling more autonomous exploration and clarification of complex ideas. Across both cases, TM played an important role in improving teachers' planning efficiency, supporting differentiation, and fostering more organised instructional sequences.

Several overarching conclusions can be drawn. First, AI applications yield the greatest educational value when embedded within teacher-led structures that provide students with clear goals, scaffolding, and opportunities for guided practice. Second, student-facing and teacher-facing AI tools can complement one another: SB supports personalised learning processes, while TM enhances the instructional conditions that enable effective use of such applications. Third, the impact of AI is context-dependent, shaped by curriculum demands, instructional time, and baseline student knowledge.

Despite these contributions, the study has limitations. Only two case studies were examined, with short implementation periods limiting the scope for observing longer-term changes in motivation, engagement, or study habits. Additionally, academic assessments focused primarily on content acquisition, leaving other learning dimensions such as critical thinking, collaboration, and self-regulation less directly measured. Future work should address these limitations through larger-scale, longitudinal studies that capture more sustained patterns of AI use and learning.

Future research should also examine how AI tools interact with broader classroom ecologies, including peer collaboration, teacher feedback practices, and school-level digital policies. As AI systems become increasingly multimodal and adaptive, there is a need to investigate how students develop the skills required to use AI effectively, critically, and responsibly. Finally, design-oriented research could explore how applications such as SB and TM can better support visual explanations, multimodal representations, and differentiated pathways to meet diverse learners' needs.

In sum, the findings demonstrate that AI tools like SB and TM can serve as valuable components of contemporary pedagogical ecosystems, particularly when educators integrate them deliberately and in alignment with established learning goals. With continued research and thoughtful implementation, AI-powered applications hold substantial potential to support more personalised, efficient, and engaging learning experiences across diverse educational settings.

Acknowledgements

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Manuscript Title
Title **AI: The Means for Inclusive Education – Pedagogical Applications, Teacher Collaboration and Dissemination within the Framework of Erasmus+ KA122 Mobility**
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Abstract

The profile of our school community — students with linguistic, learning, and social particularities, such as Roma students, multilingual learners, and students with learning difficulties — served as the starting point for our transformative journey into the integration of Artificial Intelligence (AI) in the classroom. The Erasmus+ KA122 mobility, titled **"AI: The Means for Inclusive Education,"** at the 4th Primary School of Gerakas, aimed to empower students through a structured, inclusive, and supportive learning environment that incorporated digital tools such as ChatGPT, NotebookLM, Chalkie, Suno, and Canva. These tools enabled the design and implementation of learning activities tailored to the learners' needs for self-expression and active engagement in their learning process.
AI was utilized as a digital assistant in the co-creation of **multimodal educational content** by the students themselves, across all subject areas of the national curriculum – from History and Language to Environmental Studies, Religious Education, and Citizenship Education. Through the development of **21st-century soft skills**, students became creators, listeners, and presenters, acting as **active digital citizens** of the future.
This presentation shows **good practices and student-generated projects** such as podcasts, posters, songs, comics, videos, quizzes, animations, QR codes, along with various forms of dissemination (press releases, events, teacher training, educational networks, and public sharing). The final **digital repository (Padlet)** illustrates the implementation process, professional reflection, and outreach to the broader educational and local community.

Keywords: Artificial Intelligence in Education, Digital Tools & Multimodal Learning, Inclusive Pedagogy, Erasmus+, Professional Reflection

1. Introduction

The rapid advancement of technology, exemplified by the emergence of Artificial Intelligence (AI), opens up new perspectives for meaningful integration in the educational process, while simultaneously presenting challenges for educators (UNESCO, 2021; European Commission, 2020). AI is increasingly being recognized as a powerful digital tool not only for enhancing teaching practices but also for shaping inclusive learning environments in which all students—regardless of linguistic, social, or learning backgrounds—have equal opportunities to pursue personalized learning, overcoming barriers (McNulty, 2025).

Guided by these developments and the growing demand for pedagogical upskilling, the **4th Primary School of Gerakas** participated in an approved Erasmus+ KA122 mobility project entitled **"AI: The Means for**

Inclusive Education," implemented in Prague with a six-member teaching team and the support of the broader school community (see Figure 1). The program aimed to:

1. Strengthen teachers' competencies in the pedagogical use of AI to promote the equitable participation of all learners (UNESCO, 2021; European Commission, 2023), regardless of linguistic or cultural background or learning needs;
2. Foster international networks and collaboration with educational institutions across Europe; and
3. Enable the authentic and active engagement of our students in **digital, experience-based learning environments** (European Commission, 2023).

This presentation highlights the educational pathway, the innovative classroom practices based on AI, and the outcomes of the mobility experience as implemented by two participating educators: **Alexandra Efthymiou (Grade 4)** and **Konstantia Georgiou (Grade 6)**. Inspired by their Erasmus+ experience, the two teachers designed and implemented AI-enhanced learning activities both within and beyond their classrooms.
More specifically, they collaborated for a second consecutive year within the **pilot program "Learning Community Organization" (OKM)** coordinated by the National and Kapodistrian University of Athens (EKPA), producing shared educational content and involving all students from both grades in two key areas:
(a) **active citizenship in practice**, and
(b) **reading comprehension and written expression**.

The personal and collaborative work of the teachers is documented in their individual padlets as well as in the final collective padlet and further evidenced through multiple dissemination activities conducted at both local and national levels.

2. Methodology

ARTIFICIAL INTELLIGENCE IN EDUCATION – PEDAGOGICAL APPROACH AND FOCUS

Artificial Intelligence, as an innovative digital tool, is gaining a significant role in the educational process by redefining teaching and learning practices and transforming the relationship between teacher and student (Tsaliki, 2021). Its potential to be applied in diverse learning environments and across all educational levels, combined with its multimodal nature, aims at creating more accessible, personalized, and inclusive learning experiences.

Starting from the need to support student diversity and offer opportunities for personal expression, the two educators transformed digital innovation into pedagogical practice by integrating it into their daily instructional approaches. This implementation operated inclusively, addressing the wide range of learner profiles. The active participation of all students—including those from Roma backgrounds, with ADHD, or with low self-esteem—in AI-supported learning activities empowered them, fostered self-confidence, and made it possible for every voice, visible or marginalized, to be heard in the classroom.

The production of multimodal content through the use of AI allowed for:

1. the emergence and development of oral and written communication skills.
2. the transformation of non-functional behaviors and the cultivation of more effective ones for personal growth.
3. the reinforcement of learning models adapted to linguistic and cultural contexts.
4. the provision of alternative modes of comprehension, expression, and communication.
5. the activation of motivational and feedback tools within a safe and supportive environment (Holmes et al., 2019; McNulty, 2025); and
6. the enhancement of teachers' professional confidence and reflective practice.

In this context, the pedagogical approach was based on the principles of:

- **inclusive pedagogy and the pedagogy of diversity and personal empowerment**.
- **digital and AI literacy development** (European Commission, 2020);
- **active learning and collaborative approaches**, including **differentiated instruction** (Matsaggouras, 2000);
- **task- and project-based learning** (Ellis, 2000; Bell, 2010).

AI was applied in the educational process as a **digital assistant and a medium for creative expression** (both oral and written), fostering student agency and strengthening individual identity (Holmes, Bialik & Fadel, 2019). All core subjects of the national curriculum were addressed through activities designed to promote active participation, supported by AI tools such as: **ChatGPT, NotebookLM, Chalkie, Canva AI, Genially, Suno AI**, and **Copilot**.

CASE STUDY A: IMPLEMANTING AI IN A 4th GRADE INCLUSIVE CLASSROOM – ALEXANDRA EFTHYMIOU

The rationale for implementing AI in the 4th grade of our school was based on the specific educational conditions and the diverse learning backgrounds of the students, including Roma children enrolled in Priority Education Zones, as well as students with learning difficulties and ADHD. The interventions were designed to engage all students in meaningful learning activities across curriculum subjects through AI-based digital tools, while respecting each learner's pace, personal development, and individual learning needs. The use of AI in the educational process became an opportunity to create an inclusive learning environment that supported and empowered every student, enabling them to attain an equal role, voice, and presence in the classroom (Psacharopoulos, 2022).

Complementary learning material was also developed for 6th grade students around themes such as Europe, sustainability, humanism, and active citizenship. This content was further utilized in the 4th grade, demonstrating the project's scalability and the unified pedagogical vision.

1. AI TOOLS & PLATFORMS

A variety of tools were integrated into the instructional design and classroom implementation:

- ChatGPT & Gemini: for editing dialogues, generating comprehension questions, and supporting vocabulary building (See figure 2).
- NotebookLM: for summarizing, analyzing, interpreting, and understanding language texts.
- Canva AI & Genially: for producing posters, infographics, comics, QR codes, podcasts, interactive quizzes, and multimedia presentations including student voice recordings.
- Suno AI: for creating educational songs in a range of genres and topics.
- Chalkie: for designing interactive lessons with customized worksheets across multiple subjects in real-time.
- Copilot: for generating adaptive educational material based on different learning contexts and student needs.
- Kahoot & Genially: for collaborative quiz development, tested and revised by students.
- Google Docs & Word (Review tool): for speech-to-text input and read-aloud features to assist students with decoding and phonological awareness difficulties.

2. SAMPLE SCENARIOS & THEMATIC APPLICATIONS

The activities aligned with the official National Curriculum (N.C.) and were developed with a strong emphasis on experiential, personalized, and creative learning opportunities.

- **Language (General):**
    - Redesign of texts to support reading comprehension and writing.
    - Production of digital comics based on existing textbook content (Greek Pedagogical Institute, 2001).

- Use of NotebookLM to support deeper understanding of informational texts (e.g., the invention of the telephone).
- **Language Program within Designated Priority Education Area/ in Priority Education Zones:**
  - Use of voice recording and audio synthesis tools to support the oral language development of Roma students.
- **History:**
  - Integration of AI-generated images, comics, quizzes, and infographics into historical narratives.
- **Environmental Studies & Religious Education:**
  - Interdisciplinary lesson scenarios created with Chalkie, connecting environmental content with Visual Arts, Geography, and Chemistry (including student-led experiments).
- **Mathematics:**
  - Design and implementation of original quizzes for content reinforcement.
- **Skills Labs (linked with Social & Civic Education and Anti-Bullying):**
  - AI-assisted projects aimed at promoting active citizenship, with student creations published on the Greek School Network, blogs, and shared digital repositories.

3. OUTCOMES & STUDENT-CREATED CONTENT

Students, driven by a sense of responsibility, motivation, and personal interest, produced diverse and original multimodal digital content: podcasts, posters, comics, quizzes, songs, and musical compositions. The process empowered them to explore and showcase talents they were previously unaware of.

All outputs were transformed into QR codes and shared on the educator's personal padlet and the school's official blog. They were also archived within a collective digital dissemination repository, which included content developed by the Erasmus+ team, collaborative projects with other staff, and evidence from the school's wider involvement in the mobility and its impact.

CASE STUDY B: IMPLEMENTATION OF AI IN GRADE 6 – KONSTANTIA GEORGIOU

The need to strengthen students' creative expression, multimodal literacy, and emotional empowerment, especially at the final stage of primary education—served as the motivation and rationale for the implementation of Artificial Intelligence (AI) in Grade 6. Both international and Greek literature highlight that the use of AI tools, such as large language models (e.g., ChatGPT, DALL·E), actively contributes to fostering creative writing, multimodal storytelling, and the enhancement of students' self-expression (Chloptsioudis, 2024; Chatzichristofis, 2024; SaferInternet4Kids, 2024).

Aiming to create an active and inclusive learning environment, learning activities were designed and implemented based on personal narratives, collaborative creation, and the use of innovative AI tools. These practices addressed the diverse learning needs of students by applying personalized and multimodal learning pathways (Amanatidis et al., 2021; IEP, 2024).

At the same time, the use of AI tools—such as creative chatbots, digital assistants, and platforms for multimodal text production—highlighted the importance of developing students' critical thinking, digital literacy, and emotional intelligence through engagement with emerging technologies that are reshaping education (EEBT, 2025; IEP, 2024; Filippakos, 2024). AI promotes new forms of active participation, enhances learner autonomy, and provides opportunities for students to express their thoughts, feelings, and ideas in ways that reflect their individual learning profiles (Chatzichristofis, 2024).

1. AI TOOLS AND PLATFORMS

The following tools were utilized:

- ChatGPT: for enhancing written language production, generating dialogues, ideas, and narrative prompts.
- StoryboardThat & FlipaClip: for creating comics and animations based on students' own or interdisciplinary texts.
- TokkingHeads: for animating characters and presenting oral speech visually.
- Canva & MyQRCode: for designing posters, producing visual material, and disseminating content.
- Quizizz: for developing interactive self-assessment quizzes.

2. SAMPLE SCENARIOS AND THEMES

The activities were organized around multiple thematic axes:

- Language: writing essays, descriptive and narrative texts, illustrated and digitally adapted.
- Active Citizenship: creation of podcasts, posters, and projects on inclusion, care, and social responsibility.
- Interdisciplinary connections: integration with Religious Education, Visual Arts, Environmental Studies, and History.
- Student voice cultivation: students were encouraged to create and share personal or social messages using AI in a meaningful and inclusive context.

3. Results

OUTCOMES AND STUDENT-GENERATED MATERIAL

Students actively contributed to the development of diverse multimodal materials (comics, videos, posters, podcasts, quizzes), which were shared via QR codes, padlet, and the school's website with the wider school community, parents, and neighboring educators. These products reflect the students' progressive empowerment and engagement, with respect for each learner's individual profile.

The class project served as an example of how AI can be used as a tool for inclusion, supporting the development of soft skills, personal expression, and identity for all students. The learning process was further enhanced through collaborative activities between Grade 6 and Grade 4 students in the context of the Active Citizenship project. By exchanging roles, experiences, and content, the students demonstrated the power of peer collaboration and the continuity of the school community.

Teacher reflection that followed offered a valuable foundation for refining instructional practices, strengthening differentiation strategies, and systematically integrating AI into everyday teaching. All materials were integrated into the shared padlet and final dissemination repository, reinforcing the project's outreach, sustainability, and alignment with the contemporary reality of school education under Erasmus+.

4. Discussion

COLLABORATIVE PROJECT – PILOT PROGRAM: LEARNING COMMUNITY ORGANIZATION (NATIONAL & KAPODISTRIAN UNIVERSITY OF ATHENS) & DISSEMINATION ACTIONS

The scientific expertise, pedagogical consistency, shared vision, and mutual respect for innovation demonstrated by the two Erasmus+ educators laid the foundation for their second consecutive participation in the **pilot program "Learning Community Organization** coordinated by the National and Kapodistrian University of Athens. The innovative framework of this program served as a fertile ground for experimentation, advancement, and deeper reflection upon the experiences gained through Erasmus+ mobility, enabling a second-level pedagogical interpretation and intervention.

Their collaboration was grounded in **task-based and project-based learning approaches**, aiming to elicit authentic student expression beyond subject boundaries, supported by multimedia AI tools (Ellis, 2000; Bell, 2010). This methodology fostered the development of essential soft skills such as in-depth communication, active listening, collaboration, and equitable participation in all phases of the learning process. Roles between teachers and students were intentionally alternated to respond to diverse learning paces, surface individual needs, and draw upon the unique talents of each learner. All this took place in a climate of acceptance and trust, reinforcing inclusive education and a sense of belonging (Luckin et al., 2016; Selwyn, 2019; European Digital Education Hub, 2024; Bell, 2010; Thomas, 2000; Trilling & Fadel, 2009).
The collaborative activities carried out between the 4th and 6th grades were interdisciplinary, AI-enhanced, and centered on two main pillars:

- **(a)** Reading comprehension and written expression, aimed at strengthening students' language abilities,
- **(b)** Active citizenship in action, with topics chosen by students to foster argumentation and express personal concerns related to environmental crises and social challenges (See figure 3).

Despite differences in age, cognitive level, and learning styles, the students managed to collaborate to the best of their ability and produced remarkable digital outcomes, such as:
• Posters on active citizenship
• Texts, audio recordings, and songs
• Video presentations
• Podcasts, creative slogans, and QR codes
The shared content was uploaded to:

1. The final Erasmus+ project padlet
2. The teachers' personal padlets
3. The school's official blog
4. The Erasmus+ project website, accessible to the broader educational community.

In parallel, dissemination actions included:
✓ Internal presentations and teacher training sessions,
✓ Posts on the Panhellenic School Network, the Ministry of Education portal, and the local press
✓ Participation in public awareness events and conferences organized by the Directorate of Primary Education of Eastern Attica, featuring experiential material,
✓ Creation of podcasts, posters, and QR-linked resources (see figure 4),
✓ Development of a final collective padlet containing student projects, dissemination evidence, and press releases published online (see figure 5).

5. Conclusions and Future Work

CONCLUSION – IMPACT – FUTURE PROSPERT

The knowledge and experiences gained through the Erasmus+ mobility, combined with the implementation of the Learning Community Organization (OKM) program by the National and Kapodistrian University of Athens, have brought a renewed spirit of innovation and pedagogical transformation to the educational process. The integration of Artificial Intelligence tools into the school classroom can serve as a catalyst for promoting digital literacy and active citizenship, preparing students to navigate an increasingly fast-paced, uncertain, and evolving digital environment (European Commission, 2020; Chatzigeorgiadou, 2024).
As future citizens, students can be supported and empowered to engage in experiential, personalized, and differentiated learning within an inclusive and open school that actively prevents dropout and disengagement (Holmes, Bialik & Fadel, 2019; Council of Europe, 2024). At the same time, AI can contribute to the pedagogical development and professional growth of teachers (UNESCO, 2021; Erasmus+ Training Course, 2024).
The creation of multimedia content, the development of 21st-century soft skills, and the reinforcement of student self-expression through digital tools play a vital role in shaping learning environments where diversity

is embraced, creativity is expressed, and trust-based relationships are cultivated among all members of the educational community (Kippels, 2023).
Furthermore, the two educators, working with a strong sense of responsibility toward their students and with awareness of the ethical considerations that AI raises in relation to creativity, imagination, and cognitive development, never felt threatened by the presence of AI (Tsaliki, 2021). Instead, AI was positioned as a tool for **professional empowerment and instructional renewal**, offering new opportunities to create more engaging learning environments that respond to today's societal challenges.
A central objective going forward is the continuation and advancement of this work at the level of everyday teaching practices, along with the development of collaborative partnerships with European educators through the implementation of a joint **eTwinning project**.

Figure 1: The program's logo

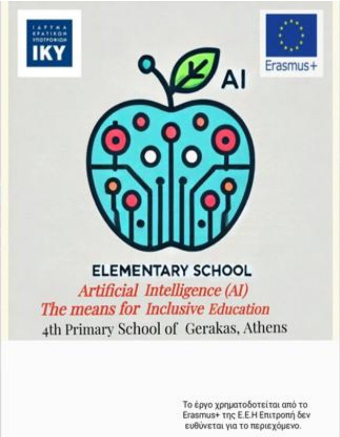

Figure 2: AI-assisted student comics

Figure 3: Writing & Citizenship Projects

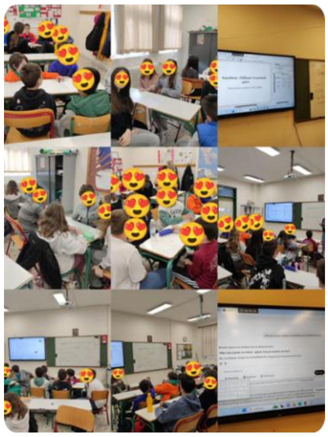

Figure 4: QR codes from students' work

Figure 5: Our padlet

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Appendix

Below are sample links and examples of student-created content and project dissemination:

1. Project Padlet with all student products

➤ Collective Padlet featuring student creations from all participating classes, published on the https://blogs.sch.gr/4dimger/2025/06/05/i-techniti-noimosyni-stin-ekpaideysi-to-scholeio-mas-sto-erasmus-ka122-2/

2. Active Citizenship Activities

➤ *Our students' message*
https://youtu.be/wEXneZD7XMU?si=5qEdobD72j-oyXqX

➤ *Active Citizen Podcast*
https://youtu.be/qpZ58QEsgbc?si=0q-veZg25nsdHHUR

➤ *Joint classroom project on writing and dramatization*
https://youtu.be/xGRS1FNxb3Y?si=GA-xNYbKSXEIQ7qi

➤ *Active Citizenship Song*
https://youtu.be/-wuhwAtUseY?si=RKSjaHhl4fA41SXm

3. Personal Padlets of the two educators (hosted on the school blog)

➤ Alexandra Efthymiou – Erasmus+ KA122:
https://blogs.sch.gr/4dimger/2025/06/06/eythymioy-alexandra-erasmus-ka122/

➤ Konstantia Georgiou – Erasmus+ KA122:
https://blogs.sch.gr/4dimger/2025/06/06/georgioy-konstantia-erasmus-ka122/

4. Digital and school bullying awareness activities

➤https://blogs.sch.gr/4dimger/2025/05/20/1878/

➤ https://blogs.sch.gr/4dimger/2025/06/01/1998/

5. QR codes showcasing examples of multimodal student projects—such as podcasts, songs, slogans, and collaborative digital creations—developed through the inclusive implementation of Artificial Intelligence in the classroom.

Manuscript Title
From Chalk to ChatGPT: Validating AI Readiness Framework Through Early Adopters' Insights
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Abstract

The rapid emergence of large language models (LLMs) and generative AI tools in education demands systematic approaches to institutional AI readiness. This study validates an initial AI readiness framework through qualitative analysis involving 15 education professionals from Finland, Germany, Greece, and Lithuania. Using thematic interviews and focus groups, the research examines early AI integration experiences to refine institutional readiness frameworks. The analysis identifies four main themes: institutional integration and policies, educational practice transformation, learning experience evolution, and ethical considerations. These findings empirically validate core framework categories while underscoring the complex interplay between technological capabilities and pedagogical adaptation. Cross-cultural insights reveal how institutional support structures and teacher preparation influence AI integration success. This study contributes to the development of AI readiness assessment tools by validating framework elements and identifying areas for refinement, particularly professional development pathways and context-sensitive implementation strategies. It highlights the need for balanced approaches that align technological innovation with educational values.

Keywords: Artificial Intelligence in education, AI Readiness Framework Digital Transformation, Maturity Model, Change Management in Leadership

1. Introduction

The rapid emergence of generative AI, exemplified by models like ChatGPT, presents both opportunities and challenges for educational institutions. While existing digital readiness frameworks like SELFIE (European Commission, 2021) and DigiCompEdu (European Schoolnet, 2018) provide valuable guidance on general digital transformation, they lack specific elements crucial for navigating the unique complexities of AI integration. These missing elements include targeted guidance on ethical AI implementation (e.g., addressing bias in algorithms, ensuring data privacy), the development of AI-specific competencies for educators and students, and strategies for integrating AI into specific subject areas. This research addresses this critical need by focusing on institutional AI readiness. This paper investigates the assessment and development of AI readiness in schools by addressing the research question:

"How can educational institutes such as schools assess and develop their AI readiness?"

To answer this, we propose the AIWARE AI readiness framework, designed to assist schools in assessing current state and developing strategic AI integration plans. This framework is informed by a comprehensive literature review and, crucially, by insights from early adopter interviews. This paper presents the initial high-level categories of the AIWARE framework and validates them through thematic analysis of data collected via interviews and focus groups with education professionals across four European countries (Finland, Germany, Greece, and Lithuania). Our research explores the dual perspectives of *teaching about AI and teaching with AI*, examining the opportunities and challenges presented by LLMs and their impact on pedagogy, curriculum, and student engagement. This study focuses specifically on the European context, aligning with EU educational policies and leveraging existing EU assessment tools such as SELFIE.

Background

AI in Education: Evolution and Current Landscape Artificial intelligence (AI) is rapidly evolving within education, moving from early adaptive learning systems, such as the algorithms used in Khan Academy, to sophisticated2 generative AI applications like ChatGPT (Holmes et al., 2023). This evolution has opened new possibilities for personalized learning, automated feedback, and dynamic content creation (Luckin et al., 2022). Generative AI., for instance, can offer automated essay feedback, tailored curriculum recommendations, and personalized tutoring experiences. Recent research has begun to explore the potential of LLMs in diverse educational contexts, highlighting their efficacy in providing tailored support to both students and teachers (Liu et al., 2023). However, the integration of LLMs and other AI tools is still nascent, requiring further investigation to optimize their impact and address potential challenges.

Opportunities and Challenges of AI Integration The integration of AI in education presents both significant opportunities and challenges. AI offers the potential for personalized learning experiences, automation of administrative tasks, and enhanced accessibility for students with diverse learning needs. However, several challenges must be addressed for successful and responsible implementation. These include the need for robust technical infrastructure (Zawacki-Richter et al., 2023), effective teacher training and professional development focused on AI pedagogy (DigiCompEdu), and careful consideration of ethical implications such as bias, privacy, and transparency (Holmes et al., 2019). These challenges are further complicated by the varying levels of digital maturity across institutions and the need for continuous adaptation to the rapidly evolving AI landscape. Trust in these technologies can only be built through proactive strategies addressing concerns about bias, transparency, and responsible AI use (SELFIE, SELFIE Reports, 2023-2024).

Theoretical Framework: Framework builds upon established digital readiness models, including SELFIE, DigiCompEdu, FDMS, and OSOS, drawing on their strengths while addressing their limitations *specifically in the context of AI integration.* It also incorporates principles of change management (Kotter, 1996) and insights from maturity models (Mettler, 2011; Berghaus & Back, 2016). While the DTHEAC framework offered initial conceptual perspectives, AIW ARE readiness framework prioritizes alignment with widely recognized and peer-reviewed models like SELFIE, DigiCompEdu, FDMS, and OSOS for robust theoretical grounding. Further theoretical grounding is provided by literature on organizational change in educational settings (Pawlowski, 2025; Carreno, 2024).

Limitations of Existing Digital Readiness Frameworks for AI Integration: Several frameworks provide valuable guidance for general digital transformation. However, they do not adequately address the *specific* challenges and opportunities of AI integration. For example, while SELFIE acknowledges “emerging technologies,” it only briefly mentions AI alongside other technologies without specific guidance: “I have tried emerging technologies... (e.g., virtual and augmented reality, robots, AI).‘” (Economou, 2023). This superficial treatment fails to address AI's unique implications. Similarly, OSOS, while promoting broad pedagogical principles like “creative learning... student-led activity...” (Sotiriou et. al, 2022) lacks concrete guidance on AI integration. *Even the recent WP3 supplement to DigiCompEdu, while addressing AI competencies, does not provide a comprehensive institutional readiness framework*. This highlights the need for a framework that moves beyond general digital competence to address the unique ethical, pedagogical, and practical challenges of AI in education.

Table 4: A comparative framework analysis coverage

Categories	Element	FDMS	DigiCompEdu	DTHEAC	OSOS Self - Assesment	Ethical Readiness
Management and Culture	Strategic planning, School policies, Change readiness	x	x	x	x	x
ICT Infrastructure and Support	Infrastructure, ICT support, Security and privacy	x		x	x	x
AI Supported Teaching and Learning	Resources, Personalization, Empowerment, Assessment	x	x	x	x	x
AI Competencies	Training, Pedagogy	x	x	x	x	
AI Regulations and Ethics	Guidelines, Ethics, Communication			x	x	x

Comparative Analysis of Existing Frameworks reveals gaps in their coverage of key elements crucial for AI readiness. As Table 1 demonstrates, existing frameworks do not comprehensively cover all elements crucial for effective AI integration. *This lack of comprehensive coverage at the institutional level, particularly concerning ethical readiness, AI-supported teaching and learning strategies, and specific AI competencies within a school context, justifies the development of the AIWARE AI Readiness framework.* Framework builds upon established models, including SELFIE, DigiCompEdu, FDMS, and OSOS, while addressing their specific limitations regarding AI. It also incorporates principles of change management (Kotter, 1996) to facilitate institutional adaptation. *Critically, this paper focuses on validating the high-level categories of the framework through empirical data, laying the foundation for future development of a practical assessment tool based on these validated categories.*

Development of the AIWARE AI Readiness Framework

The initial AIWARE AI Readiness Framework was developed through a multi-phased process designed to address the question: "How can institutional AI-readiness framework development be informed by early AI integration experiences across different EU educational contexts?" This process comprised three key stages:

- *Gap Analysis:* A systematic review of existing digital readiness frameworks (SELFIE, DigiCompEdu, FDMS, OSOS, THEAC) identified AI-specific gaps (Table 1), revealing the need for comprehensive coverage of key areas: Management and Culture, ICT Infrastructure and Support, AI-Supported Teaching and Learning, AI Competencies, and AI Regulations and Ethics. These areas became the core categories of the AIWARE AI readiness framework.
- *Expert Consultation:* An expert panel of six learning technology experts with experience in AI in education, curriculum development, and educational technology implementation (including backgrounds in teaching, research, and faculty management) provided valuable input. A focus workshop held in Vilnius in April 2024, utilizing thematic discussion sessions and guided interactive ideation within a collaborative online tool, contributed to the initial design and refinement of the framework.
- *Empirical Data Collection:* Thematic analysis of data collected through interviews and focus groups with education professionals across four European countries (Finland, Germany, Greece, and Lithuania) further informed the refinement and *validation* of the framework's categories.

This multi-faceted approach ensured that the framework is grounded in both theory and practice, addressing the specific needs of educational institutions in the context of AI integration within the EU. While considering research from other contexts (e.g., Zheng et al., 2021, on AIED paradigms), AIWARE AI Readiness framework maintains its focus on the European context due to variations in educational systems and policies. This broader perspective, however, informed the framework's comprehensiveness, particularly regarding subject-specific variations in AI integration identified in our empirical data.

Key Categories, Maturity Levels, and Importance Scale

Through the development process, it became apparent that the categories and elements of AI readiness are interconnected, creating a complex system with various stakeholder perspectives. Recognizing the importance of assessment accessibility for implementation impact, particularly given the time constraints of educators, a multi-step process of ideation, iteration, and refinement within a collaborative online environment led to the five core categories presented in Table 2. While initial elements within these categories were sketched, detailed scoping will be addressed in future research.

To provide a granular assessment, the framework utilizes a five-level “Readiness Level” maturity scale. However, recognizing that a single maturity score is insufficient to capture institutional nuances, it incorporates an "Importance" scale (1-5 Likert scale) for each element within the categories. This allows stakeholders to prioritize development areas based on their specific context and goals. The progressive maturity levels and the Importance scale are described in Table 2. This dual approach provides a more nuanced and actionable understanding of AI readiness. Specific elements within each category and their detailed mapping to maturity levels will be explored in future research.

The initial AIWARE AI Readiness Framework lays the groundwork for a future, highly accessible AI readiness assessment and guidance tool. This paper focuses on the crucial first step of validating the proposed high-level categories through thematic analysis of expert interviews, ensuring their relevance and comprehensiveness within the diverse contexts of European secondary education.

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Table 5: The AIWARE Readiness Framework

		Readiness level 1	Readiness level 2	Readiness level 3	Readiness level 4	Readiness level 5	Importance
Categories	Elements	minimal awareness unplanned Integration organic adaptation	some awareness, lacking implementation, initial plans	active ongoing development, partial Integration, included in strategic planning	comprehensive ongoing Implementation, in daily use, established experience and expertise	implemented in all activities, strategic continuous improvement, systematic competency development	Likert scale 1-5
Management and Culture	Strategic planning, School policies, Change readiness						1-5
ICT Infrastructure and Support	Infrastructure, ICT support, Security & privacy						1-5
AI-Supported Teaching and Learning	Resources, Personalization, Empowerment, Assessment						1-5
AI Competencies	Training, Pedagogy						1-5
AI Regulations and Ethics	Guidelines, Ethics, Communication						1-5

2. Methodology

This study employed a qualitative research design to explore the perspectives of education professionals and experts on *teaching about and with artificial intelligence* in educational settings. Data were gathered through thematic structured interviews and focus groups with participants selected based on predefined criteria to ensure diversity and representativeness across key roles: teachers, school leaders/policymakers, and technology experts, from four European countries: Finland, Germany, Greece, and Lithuania. This cross-national approach allowed for the exploration of diverse educational contexts and policy landscapes. The structured interview and focus group protocols were adapted from previous research on technology integration in education (Pirkkalainen & Pawlowski, 2014), ensuring alignment with established methodological practices. Thematic analysis, following the framework outlined by Braun and Clarke (2006), was employed to identify key themes and patterns within the collected data. This analysis focused on discerning significant insights that offered unique perspectives, demonstrated novelty or successful approaches to AI integration, or highlighted broader relevance to the existing literature and policy discussions. Due to space constraints, detailed information on participant demographics, interview and focus group details and protocols are provided in the appendix (Table 5., Table 6.).

3. Results

The qualitative data collected through thematic interviews and focus groups were analysed using thematic analysis (Braun & Clarke, 2006). This analysis revealed four key themes related to AI integration in educational institutions, directly informing the validation of the AIWARE framework's categories (Table 3.).

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Table 6: Themes and subthemes

Main Theme	Sub Theme	Description
1. Institutional Integration and Policies *Integration at systemic level depends on strategic alignment, robust infrastructure and effective change management.*	**1.1. Strategic Planning and Policy Alignment**	Readiness is contingent on coherent policies, curricula, and resource allocation aligned with institutional goals.
	1.2 Technical Infrastructure and Resource Development	Adequate resource allocation, availability and support are essential enablers of AI integration.
	1.3. Change Management and Digital Transformation	Organizational adaptability requires leadership and support systems to address resistance and professional identity shifts.
2. Educational Practice Transformation *Teaching is reshaped through tailored pedagogy, skill-building, and operational support.*	**2.1 Subject-Specific Integration**	Pedagogical strategies must adapt for discipline specific variations in requirements and implementation.
	2.2 Professional Development and Support	Training and experiential learning are crucial to building educators' digital competencies.
	2.3 Implementation Challenges and Solutions	Pedagogical support is key to overcoming classroom-level challenges in AI integration.
3. Learning Experience Evolution *Transformation of engagement, assessment and requirements on classroom level.*	**3.1 Student Engagement and adaptation**	Initial enthusiasm calls for guided support to deepen understanding.
	3.2 Assessment transformation	New frameworks are required to uphold academic integrity, learning authenticity and fairness.
	3.3 Competency development	Critical thinking and digital literacy are crucial for AI-driven learning environments.
4. Ethical and Future Considerations *Balancing innovation and integrity is central to ethical and future-oriented AI integration.*	**4.1 Ethical Implementation Considerations**	Responsible AI use obligates safeguards against dependency and threats to integrity, in balance with learning opportunities.
	4.2 Personal and Professional Impact	Educators must adapt to evolving roles through skill-building and identity transformation.
	4.3 Future Readiness Development	Sustained adaptation demands interdisciplinary planning and curriculum evolution.

Theme 1: Institutional Integration and Policy Context theme directly validates the AIWARE framework's "Management and Culture" and "ICT Infrastructure and Support" categories. The subthemes highlight the interplay between strategic planning, infrastructure development, and change management, all crucial aspects of institutional readiness for AI.

- *Strategic Planning and Policy Alignment:* Analysis confirms the importance of coherent policies and curricula aligned with institutional goals (Ferrari & Punie, 2013; Bekiaridis, 2023), supporting the "Management and Culture" category. Findings echo the emphasis on leadership, policy, and resource allocation in frameworks like SELFIE and DigiCompEdu (European Commission, 2021; European Schoolnet, 2018).
- *Technical Infrastructure and Resource Development:* Data reveals persistent infrastructure challenges, from basic equipment ("lack of equipment," LT1) to specific technical requirements ("stable internet," GER3; "student devices," GER3), directly validating the "ICT Infrastructure and Support" category. This aligns with research emphasizing infrastructure as a critical enabler (Wang et al., 2021) and reinforces the need for comprehensive resource planning (DigiCompEdu; European Commission, 2021).
- *Change Management and Digital Transformation:* The need for effective change management to address resistance and foster professional identity transformation, as evidenced by concerns about teacher autonomy (GER1), further supports the "Management and Culture" category. This aligns with DTHEAC management elements (UNESCO, 2021) and Kotter's Change Management Theory (Kotter, 1996).

Theme 2: Educational Practice Transformation validates the "AI-Supported Teaching and Learning" and "AI Competencies" categories, focusing on the practical implications of AI integration for educators.

- *Subject-Specific Integration:* The varying levels of AI integration across disciplines (Wang et al., 2021), with some subjects readily adopting AI tools (LT2, FIN1) while others lack readily applicable tools, highlights the need for discipline-specific pedagogical strategies (DigiCompEdu; European Schoolnet, 2018), directly supporting the "AI-Supported Teaching and Learning" category.
- *Professional Development and Support:* The identified need for professional development to build educator competencies, particularly given time constraints (GER1) and varying digital skills (GR03), strongly validates the "AI Competencies" category. This aligns with DigiCompEdu's emphasis on targeted training (European Schoolnet, 2018).
- *Implementation Support Requirements:* The interplay between technical capability and pedagogical adaptation, evidenced by technical barriers (GER1) and calls for pedagogical redesign (FIN1, FIN2), further reinforces the need for both "AI-Supported Teaching and Learning" and "AI Competencies." The emphasis on balanced integration ("technology...cannot replace everything," GR01) and expert support ("IT experts who could help…," GR03) highlights practical implementation needs.

Theme 3: Learning Experience Evolution theme further validates the AI-Supported Teaching and Learning and AI Competencies categories by focusing on the impact of AI on student learning.

- *Student Engagement and Adaptation:* Observations of initial student enthusiasm (GR01, LT01) coupled with the need for deeper understanding (GR02) reinforce the importance of scaffolded support within the "AI-Supported Teaching and Learning" category.
- *Assessment Transformation:* Challenges in ensuring academic integrity with AI-generated work (GER2) validate the need for new assessment frameworks and AI literacy within the "AI-Supported Teaching and Learning" and "AI Competencies" categories.
- *Competency Development: T*he emphasis on experimental learning ("Students should be able to try it out…," GER2), critical thinking ("Recognition of what is true and false," FIN1), and verification skills ("Everything should be checked carefully," LT3) strongly supports the "AI Competencies" category.

Theme 4: Ethical and Future Considerations directly validates AI Regulations and Ethic" category.

- *Ethical Implementation Considerations:* The tension between innovation and educational integrity, evidenced by varying approaches to AI use (GER2) and concerns about learning authenticity and cognitive development (FIN2, GER3), directly validates the "AI Regulations and Ethics" category. The need for transparent usage guidelines and balanced integration (GR01) aligns with ethical AI frameworks (UNESCO, 2021; Holmes et al., 2023).
- *Professional Evolution Patterns:* The reshaping of professional identities and the need for balanced approaches to AI dependency (FIN1, GR03) further supports the "AI Regulations and Ethics" category, particularly regarding the ethical implications for educators.
- *Future Readiness Development:* The varying perspectives on future timelines and the recognition of fundamental transitions (GR02, GER3, FIN3, GER1) highlight the ongoing need for ethical considerations and strategic planning within the "AI Regulations and Ethics" category.

4. Discussion

This study explored AI readiness in educational institutions across four European countries, revealing key themes related to institutional integration, practice transformation, learning experience evolution, and ethical considerations. The findings strongly validate the core categories of the AIWARE framework, demonstrating their relevance and comprehensiveness in addressing the complexities of AI integration.

Pattern Recognition and Motivational Drivers: A key pattern was the importance of motivation in driving AI adoption. Participants emphasized the need for experiential learning and positive initial encounters: "Let them 'play' with AI…show nice sides of AI" (GER1). This resonates with DigiCompEdu's focus on educators' ability to select and use digital tools effectively, further supported by the insight: "teacher needs to know when using AI is a good idea…when use traditional tools" (FIN3). This highlights the interplay between individual motivation (micro) and competency development (meso), which the AIWARE framework addresses through its "AI Competencies" category. This progression from institutional planning (macro) to individual motivation (micro) and classroom implementation (meso) underscores the need for a framework that addresses all levels, a key strength of AIWARE.

Framework Validation and Theoretical Resonance: The findings directly validate the AIWARE framework's categories. The observed need for strategic planning, policy alignment, and resource allocation directly supports the "Management and Culture" and "ICT Infrastructure and Support" categories. The participant statement, "Technology should be used for educational innovation…but cannot replace everything" (GR01), demonstrates the need for a balanced approach aligned with institutional goals, precisely what AIWARE's "Management and Culture" category aims to facilitate. This connects the micro-level observation to the meso-level institutional need and the macro-level theoretical perspective of balanced technology integration.

Furthermore, the challenges related to professional development and subject-specific integration validate the "AI-Supported Teaching and Learning" and "AI Competencies" categories. These findings directly address the research questions regarding the interaction between technological affordances and pedagogical adaptation and the role of institutional support. This resonates with Kotter's (1996) change management theory, particularly his emphasis on "creating a guiding coalition" and "empowering broad-based action." The observed resistance to change (e.g., GER1) and the need for targeted support align with Kotter's focus on overcoming resistance and creating short-term wins. This links the micro-level observations of teacher concerns to the macro-level theory of organizational change. The challenges in assessment, such as "How to evaluate assignments where AI has been used…?" (FIN2), strongly validate the "AI-Supported Teaching and Learning" category, particularly concerning assessment strategies and maintaining academic integrity.

Implementation Challenges and Framework Validation: The empirical findings from this study provide strong evidence for the practical relevance of the AIWARE categories in addressing real-world challenges. The need for ethical guidelines and clear communication, as highlighted by concerns about AI misuse and dependency (e.g., GR03, FIN1), directly validates the "AI Regulations and Ethics" category. This addresses the ethical dimensions of AI integration; a critical gap identified in existing frameworks.

Future Development and Practical Implications: As one participant noted, we are "At the brink of explosive disruptions…exciting" (FIN3), highlighting the dynamic nature of AI. The expert panel emphasized the need for practical tools to assess both maturity and importance, directly informing the future development of an AI readiness assessment tool based on the validated AIWARE categories. This future work will focus on developing specific elements within each category, mapping them to maturity levels, and creating a quantitative instrument incorporating both maturity and importance metrics. This aligns with the broader need for AI-specific assessment tools, as highlighted by advancements in SELFIE and DigiCompEdu.

5. Conclusions and Future Work

This study provides valuable insights into the challenges and opportunities of AI integration in education across
diverse European contexts. The findings strongly validate the AIWARE framework's core categories, demonstrating their comprehensiveness and relevance. By focusing on key areas such as Management and Culture, ICT Infrastructure and Support, AI-Supported Teaching and Learning, AI Competencies, and AI Regulations and Ethics, AIWARE offers a holistic approach to assessing and developing AI readiness. The framework's dual focus on maturity and importance provides a nuanced understanding of institutional needs. This research offers practical contributions for institutions and policymakers by providing a validated framework for navigating AI integration.

This study's limitations include its qualitative nature and the specific context of the participating European countries. Future research will explore the framework's generalizability and develop context-sensitive implementation strategies. Crucially, future work will focus on developing and validating specific elements within the AIWARE categories and creating a quantitative assessment instrument based on the validated structure. This will enable more precise and actionable assessments of AI readiness in diverse educational contexts and explore the long-term impact of AI integration on teaching and learning. This work lays the groundwork for a more informed and strategic approach to AI integration, fostering responsible and effective use of these technologies.

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Appendix

Table 4: Participant demographics

ID	Age	Gender	Work experience in education, years	Field of education	Role in School / Organisation	Student levels that you teach (if teacher)	Experience of technology use in classrooms, years	Experience teaching AI, years	Experience teaching other topics, years
Fin1	44	M	18	Finnish language, literature	teacher	Grades 7-9	20	Few months with new tools	10
Fin2	28	M	3	History	teacher	Grades 1-9	3	-	-
Fin3	48	M	20	Ph.D. in Education	lecturer, AI Expert	University	32	4	8
Fin4	44	M	10	Biotech, Computer science	not currently, previously teacher	Previously 1-12	10	-	-
Ger1	39	F	17	Physics, Computer Science	AI Expert,Professor	University (K16)	-	2	15
Ger2	27	F	1	English, Geography	Trainee Teacher	5-12	1	-	-
Ger3	51	F	20	German, Spanish, French	Teacher	5-12	2	-	-
Ger4	34	M	9	History, Religion	Teacher	5-12	2	-	-
Ger5	54	F	25	English, Arts	Senior Teacher	5-12	-	-	-
Gr1	57	F	30+	Masters in mathematics, statistics, and computing education. Ph.D. on computing education as an educational innovation.	Head of EA Primary School	University	Taught in university before 2004. Web tools, synchronous and asynchronous communication	Experience in projects of early AI implementation in education	-
Gr2	24	F	1	Primary school teacher, Ms. STEM Education and Educational Robotics Systems	ICT teacher	Primary school Grades 1-4	Computer Science and robotics, primary school.	Robotic course AI (machine learning)	-
Gr3	29	F	2	IT & Telecommunications	ICT teacher	Primary school Grades 1-4	Computer science	Some AI courses	-
Gr4	46	F	10	Phd: Massive online games and learning	Professor at EKPA University, collab.with the Institute of Digital Games, University of Malta	University	Education and Technology	Courses with AI (machine learning) and teacher workshops of using AI in class.	-

Lt1	45	F	20	Environment safety, management	Head of the school	Grades 9-12	10 years	-	-
Lt2	40	M	17	Master, Information technologies	IT Teacher	Grades 5-12	17 years	-	-
Lt3	36	F	12	Ph.D., computer science	AI Expert, Professor	University	12 years	5	-

Table 5: Thematic Interview Structure

Schedule	**Topic**
15 mins	Welcome, Introduction to project and interview process
15-20 mins	Introduction AI in Classrooms, some examples of 2023 • **ChatGPT** Tool? • **Personalized education** (AI driven learning analytics & recommendations in learning environments) • **Example: How China is using AI:** https://www.youtube.com/watch?v=JMLsHI8aV0g
1 hour	**Experience** 1. Describe your personal experience in AI in secondary education/teaching? Can you describe a good AI experience? Have you experienced AI in schools? What technology? What happened? **Benefits/Opportunities** 2. What were the benefits of using AI? **Barriers/Challenges** 3. What were the problems in using AI in classrooms? 4. What are your biggest worries about using AI? **Students response / insights** 5. How did the students respond to using AI in classrooms? **Curriculum** 6. AI in the curriculum: *Is there a school, regional, or national level curriculum for Artificial Intelligence?* How is it implemented? Is it compulsory? In which topics of the curriculum could you see AI skills fit/to be learned? **Future of AI** 7. AI in the future of classrooms. What do you think will happen in the next 5 years? What about 10 years? **Needs / Requirements** 8. What kind of extra resources (technology, training/support, materials) would you need/like to have for teaching AI/with AI? Which skills can you imagine needing now or in the future for using AI in classrooms (Teachers, students)?
5mins	Conclusions and farewell

Manuscript Title
Beyond Borders: AI, Psychological Safety, and the Future of Learning in the Age of Disruption

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Abstract

This manuscript synthesises an OCC 2025 keynote deck and an ISDDE 2025 paper to argue that the decisive variable in AI-enabled education is culture, not tooling. Psychological safety, leadership style and collaborative professionalism mediate learning impact more than technical capability. We outline a staged adoption pathway (teacher-assistant → syllabus-grounded student use), with disclosure, verification and authentic assessment. Governance and equity guardrails (EU AI Act, GDPR, UDL/WCAG) anchor responsible scale. We propose a light assurance pack (AI charter, DPIA triggers, logging, incident response) and shared KPIs for monitoring learning, workload, inclusion and incidents.

Keywords: Psychological safety; AI in education; organisational culture; EU AI Act; human-in-theloop; inclusive design

Glossary of Terms

AI (Artificial Intelligence): Computer systems that perform tasks requiring human intelligence.

Psychological Safety: Shared belief that the team is safe for interpersonal risk-taking; vital for experimentation and learning.

Teacher Mate: AI assistant for teachers used for planning, feedback and formative assessment orchestration.

Study Buddy: AI assistant for students used for practice, explanation and metacognition, embedded in curriculum tasks.

Human-in-the-Loop: Design where human judgment supervises and can override AI outputs, especially for high-stakes decisions.

EU AI Act: EU regulation establishing risk-based requirements for AI systems, including transparency and oversight duties.

DPIA (Data Protection Impact Assessment): GDPR mechanism to assess and mitigate risks to individuals' rights when processing personal data.

RAG (Retrieval-Augmented Generation): Technique where models retrieve relevant documents to ground and cite responses.

Model Card: Transparency artefact summarising an AI model's purpose, data, performance, limits and risks.

UDL (Universal Design for Learning): Accessibility framework to design for multiple means of engagement, representation and action/expression.

WCAG: Web Content Accessibility Guidelines; standards for accessible digital content.

Post-market Monitoring: Ongoing monitoring of AI performance and incidents after deployment, per EU AI Act risk management.

Disclosure: Informing users when AI is used in instruction, feedback or assessment contexts.

Assurance Pack: Lightweight set of governance artefacts: AI charter, role mapping, DPIA triggers, logs, incident response.

Authentic Assessment: Tasks mirroring real-world performance, reducing over-reliance on AI outputs and promoting integrity.

1. Introduction

Across five Dublin schools serving migrant, refugee and minority learners, AI4EDU piloted two assistants—**Teacher Mate** (teachers) and **Study Buddy** (students)—to support planning, feedback, language acquisition and metacognition. The OCC keynote ("Beyond Borders") and ISDDE manuscript converge on a core claim: AI succeeds where cultures are safe to risk, fail and innovate; it stalls where fear and compliance dominate. We frame psychological safety as the foundation for human-centred AI use and situate practice within international guidance (UNESCO), EU regulation (AI Act) and accessibility standards (UDL/WCAG).

2. Methodology

Targeted synthesis of: (a) the OCC 2025 keynote on AI, psychological safety and culture-first adoption; and (b) an ISDDE 2025 manuscript on expansive design, leadership and organisational psychology in AI4EDU. Convergent findings on classroom orchestration, leadership, integrity, inclusion and governance were mapped to a staged adoption pathway and a light, school-ready governance pack. Directional pilot metrics (e.g., gains in language acquisition, engagement, and teacher-perceived student agency) are used illustratively.

3. Results

What worked in practice

- Teacher-mediated, curriculum-first use produced the clearest gains (planning time saved; clearer explanations; quick formative checks).
- Disclosure of AI use and routine verification sustained integrity; authentic tasks reduced over-reliance on AI outputs.
- Psychological safety predicted adoption: high-safety schools iterated faster and reported stronger gains; low-safety schools stalled despite equal access.

Constraints to address

- Timetable pressure; variable device/connectivity access; short pilot windows.
- Usability and accessibility gaps raised orchestration load; PD maturity varied across departments.

Equity & inclusion enablers

- Multilingual supports; UDL/WCAG-aligned modes (reader/TTS/simplified views); offline-first options where needed.
- Community communication to build trust; culturally responsive prompts and datasets (syllabusgrounded RAG).

4. Discussion

Culture, not tooling, differentiates impact. Transformational/democratic leadership, collaborative professionalism and growth-mindset cultures amplify AI benefits. A risk-based governance approach aligned to the EU AI Act operationalises accountability without constraining teacher agency: define roles (provider/deployer), classify risk, document data flows, trigger DPIAs where needed, and enable transparent logging and incident response. Equity is non-negotiable: fund baseline access; normalise accessibility and multilingual design; protect PD time and communities of practice.

5. Conclusions and Future Work

Adopt in two stages over 4–8 weeks

1. **Teacher-assistant phase:** establish disclosure, verification and workload-aware routines in planning/feedback.
2. **Syllabus-grounded student use:** embed Study Buddy with quick checks and authentic assessment.

Run a light governance pack

• School AI charter; role mapping; DPIA triggers; model cards/transparency; logging and incident response.

Build capacity & community

• Short, focused PD; prompt/assessment libraries; cross-school communities of practice; leadership training.

Monitor & iterate

• Quarterly dashboards on learning, workload, inclusion and incidents; share cases; iterate with partners.

Table 1: Monitoring indicators and evidence loops

Domain	Example KPI	Evidence Collection (Quarterly)
Learning	Mastery vs. curricular targets; gains on quick checks	Quiz analytics; teacher annotations; student self-reports
Teacher Workload	Time saved in planning/feedback	Time-use logs; teacher surveys; exemplar artefacts
Inclusion & Access	% learners supported incl. assistive needs	Device/connectivity inventory; accessibility checks
Integrity & Safety	Disclosure rate; incident frequency	Classroom audits; incident log; corrective actions

Figure 1: Culture-first, staged adoption pathway with light governance and shared KPIs (schematic).

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Manuscript Title
Title *From theory to practice: Integrating AI into eTwinning projects and Online Classrooms*
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Abstract

Artificial Intelligence has rapidly entered educational discourse, accompanied by equal measures of excitement and anxiety. Yet educators continue to search for its true pedagogical value beyond technological novelty. This paper presents the Greek eTwinning community as a case study of how AI literacy can be developed through a human-centered, community-based professional learning model. Rather than focusing on tools alone, the approach emphasizes pedagogy, ethics, creativity, and teacher agency. Drawing on participatory observation of teacher training programs, MOOCs, project documentation, and qualitative feedback, the study examines how educators engaged in structured reflection, collaborative experimentation, and ethical discussion while exploring AI use in classrooms. Results indicate that teachers developed stronger critical literacy about AI, increased confidence in purposeful classroom integration, and enhanced collaboration across subject areas and schools. The discussion highlights the importance of safe, non-commercial learning environments and communities of practice as mechanisms linking classroom innovation to policy discourse. Through alignment with frameworks such as DigCompEdu and engagement with the European School Education Platform (ESEP), local experimentation has contributed to broader strategic discussions on teacher professional development. The findings suggest that sustainable AI integration depends not on accelerating adoption, but on building reflective ecosystems where technology amplifies pedagogy rather than replacing it.

Keywords: *AI literacy, teacher professional development, eTwinning, communities of practice, human-centered AI*

1. Introduction

Artificial Intelligence increasingly permeates education, public debate, and everyday digital tools. However, amidst enthusiasm and concern, educators still struggle to identify what truly constitutes meaningful AI integration for learning. The essential challenge is not the sophistication of technology itself, but whether its use responds to genuine pedagogical needs. Many AI tools promise efficiency or engagement, yet some risk narrowing creativity, encouraging superficial responses, or reproducing algorithmic biases. Consequently, the central question for educators becomes: does a particular technology support critical thinking, meaningful dialogue, and human connection in the classroom?

European frameworks such as DigCompEdu and the Digital Education Action Plan consistently emphasize that pedagogy must guide technology, not follow it. Within this perspective, teacher professional judgment remains irreplaceable, and AI should be designed to enhance—not automate—educational practice. The Greek eTwinning network represents a trusted, non-commercial ecosystem that provides precisely this reflective context. Through collaborative projects, training initiatives, and peer learning communities, teachers critically explore AI tools while maintaining human-centered pedagogical priorities.

This paper examines how eTwinning enables educators to integrate AI responsibly by combining practical classroom experimentation with structured reflection and ethical discourse. The study aims to demonstrate how community-based professional learning can transform localized innovation into policy-relevant insight, creating a bridge from classroom practice to national and European strategies for AI literacy development.

2. Methodology

This study employs a qualitative case-study methodology situated within the activities of the Greek eTwinning National Support Organisation. Data collection spanned 2023 to 2025 and included participatory observation during national training events, online seminars, and European networking activities focused on AI integration.

Primary sources also consisted of documentation and learning artifacts from eTwinning projects, Moodle courses, and Open edX MOOCs devoted to AI pedagogy. These training initiatives introduced teachers to ethical foundations of AI, educational chatbots, creative content generation tools, and reflective dissemination practices aligned with collaborative project work. Additional data were drawn from qualitative questionnaires, reflective logs, and feedback discussions conducted within training communities.

Data were analysed thematically to identify patterns related to teacher learning outcomes, ethical reasoning development, collaborative processes, and perceived connections between classroom practice and policy frameworks. Methodological triangulation was applied by cross-validating findings across observational data, course analytics, and qualitative narratives, strengthening interpretative reliability while maintaining ecological validity grounded in authentic professional practice.

3. Results

Three core findings emerged from the analysis.

First, teachers developed increased critical AI literacy. Participants reported improved understanding of algorithmic bias, data protection concerns, and limitations of automated tools, which informed more cautious and pedagogically grounded classroom experimentation. AI ceased to be viewed as a novelty and was instead approached as one didactic resource among many—chosen only when educational value could be clearly articulated.

Second, collaboration proved essential to meaningful integration. Teachers from diverse disciplines co-designed project-based learning scenarios using AI-supported creative tools and formative feedback applications. Peer mentoring, ethical dialogues, and community reflection sessions promoted confidence and mutual support, reducing isolation and lowering the anxiety often associated with rapidly changing technologies.

Third, community outcomes began informing broader systemic discussions. Insights generated through practice-based experimentation and MOOC evaluations were communicated through national coordination channels and European networks. These contributions aligned with DigCompEdu priorities and fed into *dialogues associated with the European School Education Platform (ESEP), illustrating how classroom evidence can inform evolving teacher professional development frameworks.*

4. Discussion

The findings affirm existing research on communities of practice, demonstrating that sustained collaborative networks foster deeper professional learning than short-term technical training initiatives. eTwinning functions not merely as a digital platform but as a reflective learning ecosystem that embeds innovation within ethical dialogue, pedagogical design, and peer validation.

A significant element of success lies in the use of open and non-commercial educational infrastructures, reducing dependency on proprietary agendas and enabling focus on pedagogical intent. Educators' awareness of policy frameworks further enhanced professional agency, positioning practitioners as contributors to systemic educational discourse rather than passive recipients of technological change.

Limitations include the national scope of the case study and its qualitative emphasis. Future comparative studies across multiple eTwinning countries and inclusion of quantitative classroom outcome data would strengthen generalizability and impact assessment.

5. Conclusions and Future Work

This study concludes that sustainable AI integration in education depends on human-centered communities of practice rather than accelerated tool adoption. eTwinning provides an effective scaling mechanism whereby classroom experimentation informs policy through reflective professional ecosystems. AI proves most valuable when it operates quietly—supporting teacher judgment, creativity, and empathy without overshadowing pedagogy.

Future work will focus on developing blended professional learning pathways combining MOOCs, mentoring networks, and potential micro-credentialing frameworks for verified AI literacy competence. Strengthening teacher participation in policy co-design processes is also recommended to preserve the human purposes of education amid continuing technological transformation.

Acknowledgements

This work draws upon the activities of the Hellenic eTwinning National Support Organisation and Erasmus+–supported initiatives promoting teacher professional development in digital and AI literacies. The author would also like to acknowledge Ellinogermaniki Agogi for hosting and organizing the Open Classroom Conference 2025 – "Empowering Educators and Learners for the Age of AI", providing a valuable forum for dialogue between educational practice and policy.

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Manuscript Title
i-Private Project: A student-led, AI-and-robotics intervention for reimagining the public beach changing room.
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Abstract

The i-Private Project represents a student-led, project-based learning (PBL) initiative that merges robotics, generative artificial intelligence (AI), and civic engagement within a primary education context. Implemented during the 2024–2025 school year by sixth-grade students at the 3rd Primary School of Vasiliko, the project reimagines the public changing room at Lefkanti Beach as a site for social innovation and digital empathy. Through interdisciplinary STEAM activities, learners explored how technology can serve community needs while fostering active citizenship and creativity.

The project integrated AI tools across all phases of learning: ideation and planning with ChatGPT; 2D and 3D design using DALL·E, Microsoft Image Creator, and Meshy; audio production through Suno AI; and multimodal storytelling with Gamma and Canva. These applications supported inquiry, collaboration, and reflection, allowing students to design functional, inclusive prototypes while engaging critically with the ethical and creative dimensions of AI.

Grounded in the "Teaching About, With, and For AI" framework, i-Private positioned learners as both technology users and ethical designers. Outcomes included increased student agency, digital literacy, and empathy, as well as the development of scalable pedagogical models for AI-enhanced civic projects. The

paper discusses methodology, implementation, and implications for empowering teachers and students to integrate AI meaningfully and responsibly in the classroom.

Keywords: *AI in Primary Education*, *Digital Empathy*, *Project-Based Learning*

1. Introduction

Artificial Intelligence (AI) is rapidly transforming education, challenging schools to cultivate new forms of digital literacy, ethical awareness, and creative problem-solving. As AI tools become increasingly accessible to young learners, primary education must support children not only in using intelligent technologies, but also in understanding how these systems shape communication, behaviour, and community life. This creates an urgent need for practical models that demonstrate how AI can be integrated meaningfully, responsibly, and creatively in everyday classroom practice.

Although international frameworks emphasize the importance of teaching about, with, and for AI, there is still limited research on how primary students can actively engage with AI within authentic, real-world contexts. Many existing approaches remain abstract or tool-focused, lacking opportunities for civic engagement, interdisciplinary design, and student agency. Teachers therefore need concrete, replicable examples that combine AI literacy with social purpose and hands-on creation.

The i-Private Project responds to this gap by presenting a student-led, project-based learning intervention that merges generative AI, robotics, and civic awareness. Implemented with sixth-grade students at the 3rd Primary School of Vasiliko (Greece), the project used the redesign of the public beach changing room at Lefkanti as a meaningful anchor for exploring accessibility, empathy, and community well-being. Through a structured STEAM approach, learners used AI tools for ideation, prototyping, storytelling, and reflection—while engaging critically with the ethical and human dimensions of technology.

This paper contributes a practice-based model for integrating AI into primary education in a way that is creative, socially grounded, and developmentally appropriate. It highlights how young learners can become active designers and responsible users of AI through authentic problem-solving and community-oriented innovation.

2. Methodology

Research Design

The study followed a qualitative, design-based research (DBR) approach embedded within an interdisciplinary Project-Based Learning (PBL) framework. The intervention was designed to explore how primary students engage with generative AI and robotics while addressing a real community challenge. The learning cycle followed an Inquiry–Design–Create–Reflect model, informed by the "Teaching About, With, and For AI" framework.

Participants

The project was implemented during the 2024–2025 school year with 22 sixth-grade students (ages 11–12) at the 3rd Primary School of Vasiliko, Greece. Participation was integrated into the Skills Workshop and Active Citizenship curriculum structures. All students worked in mixed-ability teams and adopted rotating roles (researchers, designers, coders, artists, storytellers).

Instruments and Tools

Digital instruments included:

– ChatGPT for ideation and refinement
– DALL·E**,** Microsoft Image Creator**,** Meshy **f**or 2D/3D prototyping
– Suno AI for music generation
– Gamma**,** Canva Docs**,** Lumen for multimodal storytelling
– Mural AI for organizing brainstorming data
– Echo3D for AR visualization

Physical instruments included sketching materials, cardboard prototyping supplies, and robotics kits (Micro:bit, Tp-bot, S1 robot programmed in Arduino). A full set of classroom artefacts, prompts, and student outputs is openly available for reproducibility via the project repository.

Procedures / Implementation

The implementation took place across six phases:

1. Social Inquiry – field study of the Lefkanti Beach public changing room, measurements, user-needs analysis.
2. Ideation – guided AI-assisted brainstorming using ChatGPT and Mural AI.
3. Design and Prototyping – creation of 2D/3D models using generative tools; parallel hands-on modelling and robotics experimentation.
4. Cultural Storytelling – development of a digital persona (Centaur Lefkantios), scriptwriting, Suno music composition, and AR elements.
5. Construction & Coding – integration of robotics functions, QR-linked media, and physical prototypes.
6. Presentation & Reflection – schoolwide exhibition, digital portfolios, student self-assessment, teacher observations.

Reproducibility

All lesson plans, prompts, student artefacts, 3D files, and code used in the intervention are publicly available in the project's GitHub repository, enabling replication and adaptation by other educators: https://github.com/chleontari/Evia-Robowaves

3. Results

The implementation of the i-Private Project resulted in measurable gains across cognitive, creative, social, and ethical domains. **Table 1** summarizes student self-assessment data collected through a post-project questionnaire (n = 22). Students reported increases in:

(a) confidence in using AI tools (82%),

(b) ability to work collaboratively (91%),

(c) understanding of accessibility and community needs (86%), and

(d) creativity in design tasks (95%).

Qualitative observations confirmed these trends. Students demonstrated the ability to compare, critique, and refine AI-generated outputs, identify ethical considerations (privacy, bias, user inclusion), and justify design decisions. Classroom artefacts showed progression from simple sketches to functional prototypes enriched with robotics functions and multimodal digital assets.

The final exhibition brought strong engagement from the school community. Visitors interacted with the redesigned changing-room prototype, QR-linked Welcome Song, and augmented reality guide (**Figure 1**). Audience feedback highlighted the clarity of student explanations, the originality of the cultural storytelling components, and the project's relevance to local needs.

Overall, the results indicate that combining generative AI, robotics, and civic design enabled students to adopt active roles as creators, problem-solvers, and ethical thinkers. Evidence supports that this blended approach fostered AI literacy, empathy, and agency in a developmentally appropriate way.

4. Discussion

The findings align with international research showing that young learners benefit from pedagogical models that integrate design, creativity, and ethical reflection when engaging with AI (Holmes et al., 2023; UNESCO, 2024). In line with Bers (2018) and Vygotsky (1978), the i-Private Project demonstrated how hands-on making and social collaboration can coexist productively with digital tools, amplifying rather than replacing human-driven creativity.

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A key implication for teaching is that **AI can enhance primary education when embedded in a structured, inquiry-based framework** rather than used as an isolated digital add-on. The project showed that even young students can meaningfully evaluate AI outputs, question algorithmic choices, and consider accessibility and empathy in design. This aligns with current policy directions emphasising human-centered AI and digital citizenship.

For practice, the project offers a replicable model for integrating generative AI and robotics within sustainability-related and civic-oriented challenges. The redesign of the public changing room encouraged children to view technology as a tool for community improvement—not entertainment—supporting the shift toward socially responsive education.

Limitations include the small sample size, technical constraints of school infrastructure, and the need for ongoing teacher training in AI tools.

5. Conclusions and Future Work

The I-Private Project demonstrates that AI, robotics, and civic education can be successfully integrated into primary schooling through a structured, human-centered PBL model. Students developed confidence, digital literacy, creativity, and empathy while addressing a real community challenge. The intervention provides a practical, replicable model for educators seeking to embed AI meaningfully in the curriculum.

Future work may explore **scaling the project across multiple schools**, conducting **longitudinal studies** to measure the lasting impacts on AI literacy, and developing **standardized assessment rubrics** for AI-enhanced PBL activities. Additional directions include refining teacher-support materials, adapting the project for different age groups, and collaborating with policy stakeholders to pilot AI-infused Skills Workshops in diverse educational settings.

By empowering young learners to design with empathy and purpose, the project contributes to preparing future citizens who can shape technological innovation responsibly and creatively.

Table 7: Post project questionnaire results

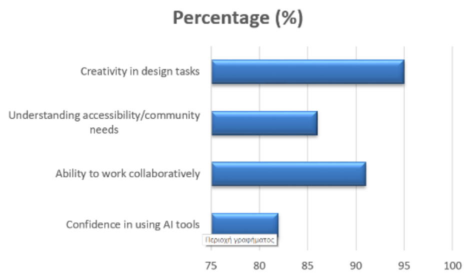

Figure 2: Centaur Lefkantios in front of the public changing room

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Manuscript Title
Title [**Artificial Intelligence and Distance Education as Catalysts for Inclusive Teaching in STEM"**]
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Abstract

The increasing integration of artificial intelligence (AI) with distance education (DE) offers a promising pathway to advance inclusive teaching in STEM (science, technology, engineering, mathematics). By combining AI-driven personalization, adaptive feedback, intelligent tutoring and the flexibility and reach of DE platforms, educators can better meet the diverse needs of learners—especially those underrepresented in STEM, from remote or underserved contexts, or with disabilities. Yet, achieving inclusive teaching through these technologies is not automatic: issues of digital access, algorithmic bias, teacher readiness, and ethical design must be addressed. This paper reviews the state of research, examines how AI and DE can act as catalysts for inclusive STEM instruction, presents illustrative applications, identifies key enablers and barriers, and offers recommendations for practice and policy

Keywords: *AI,* **Distance Education, Inclusive Teaching, STEM**

1. Introduction

Inclusive education is a fundamental human right and a goal of international agreements (United Nations, 2006). In the field of science, the variety of learning needs requires the adoption of innovative technologies that promote the participation and learning of all students ((Santos, 2023); (Upadhyay, 2023)). Artificial intelligence and distance learning have significant potential to transform teaching practices and promote inclusion. A systematic literature review with specific inclusion criteria is presented, use of multiple sources, and thematic analysis, providing a comprehensive picture of the research of the last three years on inclusive STEM teaching in remote education conditions using Artificial Intelligence. Key question was: How are Artificial Intelligence and remote education utilized in inclusive STEM teaching during the period 2022–2025? Secondary questions were also examined, which concerned (a) the methods of incorporating interactive elements in remote learning environments, (b) the role of teacher-student interaction in a digital framework, and (c) the challenges and opportunities that arise for students with special educational needs. The selection criteria were related to teaching in the sciences or STEM subjects, the dimension of inclusion (students with special needs, learning difficulties, disability or heterogeneity), and the application of artificial intelligence or/and distance education.

STEM education has long been recognized as pivotal for economic development, innovation, and preparing students for 21st-century careers. Yet, inequities persist women, students from low-income or rural backgrounds, students with disabilities and other under-represented groups remain less likely to access or

succeed in STEM pathways. Inclusive teaching—where all learners feel welcomed, supported and able to succeed—is therefore both morally and practically imperative.
Concurrently, two major pedagogical and technological shifts are underway: the growth of distance education (DE) and the rapid advance of artificial intelligence (AI). Distance education—through online learning platforms, virtual classrooms, and remote laboratories—extends the reach of STEM instruction beyond the confines of the classroom. AI offers the potential to personalize learning, provide adaptive scaffolding, and free up teacher time through automation.
When combined, AI + DE can act as a catalyst for inclusive STEM teaching: reaching learners where they are, tailoring instruction to their needs, and reducing barriers of time, place, and prior preparation. This paper explores how, and under what conditions, this synergy can be leveraged effectively, and what must be done to avoid reinforcing existing inequalities.

2. Methodology

Through a Systematic Literature Review (SLR), the AI and Distance Education were identified, and both their benefits and challenges were evaluated in inclusive STEM. All aspects of the issue will be presented below.

2.1 Distance Education and STEM Inclusion

Distance education has matured significantly, especially accelerated by the pandemic. In STEM domains, DE has enabled remote laboratories, virtual simulations and asynchronous instructions helping learners in geographically isolated or resource-constrained settings. For example, literature on educational robotics in distance settings highlights the opportunity for remote participation in STEM activities (Foti M., 2025). DE offers flexibility (temporal, spatial), and when designed for accessibility, it can widen access to STEM.
However, the mere availability of DE does not guarantee inclusion. Learners from low-income backgrounds may suffer from limited connectivity, device access, or lack of digital literacy. Teacher supports and design for accessibility matters. The digital divide remains a salient barrier.

2.2 Artificial Intelligence in Education: Personalization and Inclusion

AI has emerged in educational settings through intelligent tutoring systems (ITS), adaptive learning platforms, chatbots, predictive analytics, and more. These tools can personalize instruction, adjust pacing, identify misconceptions, provide real-time feedback, and monitor engagement.
Creating educational content can be more efficient with the use of AI tools. Teachers can create dynamic and customized educational materials that meet the needs of students. This flexibility can be particularly useful in remote learning environments, where students can access material that is appropriate for their level and progress (Filiz, 2025). Multiple research efforts have focused on using AI to predict student performance in STEM courses. For example, in a study analyzing data from digital learning platforms, machine learning algorithms improved the accuracy of predicting academic performance by 15%-20% compared to traditional models (Tahir, 2024).Furthermore, the use of these predictive tools allows for early understanding of learning difficulties and the implementation of targeted interventions that support improved outcomes (Almasri, 2024). Such technologies introduce dynamic feedback and support tools that enhance personalized learning.
In terms of inclusion, AI holds promise. A systematic review found that AI and virtual reality (VR) technologies support students with disabilities by enabling personalized (Watters, 2021), immersive, accessible learning experiences (Chalkiadakis, 2024). Greek studies from 2022–2025(Rizos, 2024), (Tsiomi, 2023), (Ionian University, 2024), etc. show that there is considerable involvement of researchers/educators in the use of AI and remote education technologies to achieve inclusion in the sciences. However, the data often comes from small interventions, and it is considered that scaling up is required with the appropriate support and policies.Moreover, AI in higher education is being studied for its inclusive potential—for supporting minorities, first-generation students and learners with diverse needs (Chalkiadakis, 2024).
Yet, many authors caution that without deliberate design for equity, AI may simply reproduce or exacerbate existing inequalities: bias in data, algorithmic opacity, unequal access to infrastructure. For example, a rapid

review observed that AI in higher education more often serves institutional efficiency than supports equitable outcomes (Chalkiadakis, 2024).

2.3 Synergy of AI and DE for Inclusive STEM

The intersection of AI and DE in STEM teaching is promising AI can enhance DE by adding personalization, scaffolding, analytics, and tailoring to individual learner profiles; DE can extend the reach of AI tools beyond traditional classrooms. A recent conceptual article on AI in open distance e-learning in STEM emphasizes this potential—AI-driven platform providing personalized learning experiences, real-time feedback, adaptive assessments and immersive simulations (Shabalala, 2024). In STEM contexts, examples include generative-AI support for robotics curricula to bridge gender gaps (Voutyrakou, 2025). Thus, the literature suggests a dual mechanism: (1) increasing accessibility (through DE) especially for people in remote and hard-to-reach areas with limited access to learning resources ; (2) enhancing responsiveness to diversity (via AI).

Key Challenges and Gaps

Despite the promise, three major challenge clusters emerge:

1. **Access & infrastructure**: Learners in remote/underserved contexts may lack devices, connectivity or support for DE and AI-rich environments.
2. **Algorithmic & design bias**: AI systems trained on non-diverse datasets may disadvantage under-represented groups; inclusive pedagogy must underpin tool design (Chalkiadakis, 2024)
3. **Teacher readiness & pedagogy**: Teachers' knowledge of content, pedagogy and technology influences how AI/DE tools are used. A recent case study of STEM teachers in Qatar found moderate technological knowledge but a need for deeper understanding of ethical, inclusive concerns (Alkubaisi, 2025).
4. **Evaluation and evidence**: Empirical evidence of inclusive impact of AI+DE in STEM remains limited; many studies are conceptual or small-scale (Buzzi, 2025).

In sum, the literature supports the argument that AI + DE can act as catalysts for inclusive STEM teaching—but only if thoughtfully implemented.

2.4 Framework: How AI and DE Catalyze Inclusive STEM Teaching

In this section a conceptual framework is proposed to illustrate how AI and DE can serve as catalysts for inclusive STEM teaching.

2.4.1 Dimensions of Inclusion in STEM Teaching

Inclusive teaching in STEM can be characterized along multiple dimensions:

- **Access**: Learners from diverse geographies, socio-economic statuses, disabilities, gender/gender-identity groups can access learning.
- **Engagement**: Learners feel valued, motivated, and able to participate meaningfully.
- **Personalization**: The instruction adapts to diverse prior knowledge, learning style, pace, and supports remediation and extension.
- **Representation & relevance**: STEM content draws on diverse contexts, avoids stereotypes, supports varied learners.
- **Outcomes**: Learners achieve proficiency and develop confidence and STEM identities.

2.4.2 Mechanisms via AI and DE

By pairing AI and Distance Education, the following mechanisms can drive inclusive STEM teaching:

- **Reach + flexibility (DE)**: Learners who cannot attend physical classes (due to geography, employment, disability, caregiving responsibilities) can access STEM instruction online, asynchronously or synchronously.
- **Adaptive scaffolding (AI)**: AI systems monitor learners' progress, detect misunderstandings, recommend remedial content or enrichment, adjust difficulty, and provide just-in-time feedback.

- **Data-driven instructional support (AI)**: Teachers receive analytics about learner engagement, misconceptions, at-risk learners, and can differentiate instruction accordingly.
- **Immersive/accessible modalities (AI + DE)**: Virtual labs, simulations and VR/AR (often powered by AI) can offer multi-sensory, interactive experiences, and accessible alternatives for students with disabilities (e.g., audio descriptions, visual aids) (Chalkiadakis, 2024)
- **Inclusive design via generative AI (AI)**: Generative AI tools (e.g., chatbots, language models) can help design inclusive STEM activities (e.g., gender-neutral robotics tasks) or detect bias in materials. For instance, an AI tool (ChatGPT) was used to generate gender-neutral robotics scenarios for girls in STEM. (Voutyrakou, 2025)
- **Scalability (DE + AI)**: Once developed, AI + DE resources can scale across large numbers of learners, enabling cost-effective inclusive programming.

Hence, the synergy can be expressed as: **Access & reach (DE) × personalization & analytics (AI) → inclusive STEM teaching**.

2.4.3. Enabling Conditions

For this catalytic synergy to work, certain enabling conditions must be in place:

- **Infrastructure & devices**: Reliable Internet, devices, and accessible platforms.
- **Teacher professional development**: Teachers must understand the pedagogical affordances of AI and DE and develop inclusive practices (Alkubaisi, 2025).
- **Design for equity**: AI systems must be developed with diverse datasets, inclusive design principles, and bias audits (Chalkiadakis, 2024).
- **Student digital literacy and support**: Learners require digital skills and ongoing support.
- **Institutional policy and ethics**: Data privacy, consent, algorithmic transparency, and equity must inform deployment.
- **Accessible content and pedagogy**: Materials must be accessible (for disabilities), represent diverse learners, and embed inclusive pedagogy.

3. Results

In conclusion, the bibliographic review of the research indicates that AI operates not merely as an auxiliary educational tool but as a structural mechanism for pedagogical differentiation and personalized learning. By employing adaptive learning systems, data analytics, and assistive technologies, AI enables the continuous regulation of teaching and learning processes. This includes the dynamic adaptation of instructional content, the removal of linguistic and communicational barriers, and the creation of accessible and socially inclusive learning environments. Thus, AI supports not only cognitive development but also the social inclusion of learners, establishing conditions for equitable participation in STEM disciplines.

Distance education similarly constitutes a vital field of application for inclusive pedagogy, particularly for students facing geographical, socioeconomic, or physical constraints. Within STEM contexts, distance learning enriched with AI technologies facilitates the personalization of instruction, the monitoring of individual learning trajectories, and the cultivation of collaborative skills through digital communities of practice. Despite persistent challenges, such as the adaptation of curricula and the need for digital pedagogical competence, distance education demonstrates the capacity to act as a lever for educational equity and democratization of STEM learning opportunities.

Concrete applications of AI in STEM teaching include: (a) differentiated adaptation of instructional materials based on individual learner profiles; (b) the development of intelligent educational tools and virtual assistants that aid in the comprehension of complex concepts and scientific processes; (c) the enhancement of collaborative learning through AI-driven platforms that match complementary skills and interests; and (d) systematic analysis of learning data combined with diagnostic assessment to enable timely and targeted pedagogical intervention. Representative tools encompass adaptive learning environments, text-to-speech and speech recognition systems, real-time translation services, eye-tracking devices, and AI tutors capable of adjusting teaching style, pace, and difficulty level to accommodate diverse learner needs.

Practical implementations illustrate the potential of AI-driven educational games to increase engagement and foster problem-solving skills in STEM, as well as speech recognition and real-time captioning technologies that support students with hearing impairments in lectures and laboratory contexts. Personalized learning platforms tailored to varying learning styles enhance the understanding of abstract or complex scientific concepts, while machine learning–based tools for the early detection of learning difficulties provide proactive support mechanisms.

The combined integration of AI and distance education offers an effective and innovative framework for inclusive STEM education. Positive research findings underscore their capacity to advance personalization, accessibility, and the quality of learning experiences for all students. The synergy of AI and distance learning contributes to the creation of dynamic, flexible, and adaptive learning ecosystems that strengthen inclusivity and educational justice, ultimately reshaping the landscape of STEM education. Nonetheless, questions remain regarding the long-term effectiveness and ethical implications of AI integration, particularly in relation to data privacy, algorithmic bias, and the risk of deepening digital divides. Further interdisciplinary research is therefore required to ensure that AI-enhanced distance learning environments are implemented responsibly and equitably, maximizing their potential to transform STEM education for diverse learners worldwide.

3.1 Illustrative Applications

To illustrate how AI + DE can catalyze inclusive STEM teaching, here are three example applications drawn from recent literature:

Application A: Adaptive STEM Modules in Open Distance e-Learning

In a conceptual paper, the transformation of open distance e-learning (ODeL) in STEM via AI was explored. The study highlights how AI-driven platforms provide personalized learning, real-time feedback, adaptive assessments, immersive simulations (AR/VR), thereby increasing student engagement and support—especially for learners lacking on-campus resources (Shabalala, 2024).The authors emphasize that this approach can help develop critical-thinking and problem-solving skills in STEM, and reduce barriers for underserved students.

Application B: Gender-Neutral Robotics Activities Using Generative AI

In Greece, a study explored use of an AI tool (ChatGPT) to generate gender-neutral educational robotics (ER) activities to bridge the gender gap in STEM. The AI tool was used to design inclusive activity scenarios, detect bias and suggest modifications in topics, materials, and team formations. The results indicated that AI couldhelp educators design more inclusive, unbiased STEM robotics experiences (Voutyrakou, 2025).

Application C: Assistive AI/VR for Students with Disabilities in STEM

A systematic review of AI + VR technologies for students with disabilities found that such tools can provide personalized, immersive experiences aligned with inclusive pedagogy: e.g., VR labs for visually or hearing-impaired students, AI systems that adapt to the learner's pace, provide audio descriptions or alternative representations (Chalkiadakis, 2024). This shows that inclusive teaching in STEM can be extended to all learners via AI-enhanced DE.

These applications show how the framework mechanisms (reach, personalization, scalable, accessible) operate in real (or conceptual) STEM-learning contexts.

4. Discussion

Barriers, Risks and Mitigations

However, there are limitations, issues to be discussed, and issues that need further investigation. Although it is promising, the integration of artificial intelligence and DE for inclusive STEM education that is friendly to everyone presents significant obstacles and potential risks. Some key issues:

4.1 Digital Divide and Infrastructure

Learners from remote or resource-constrained environments may lack devices, broadband, or reliable electricity, limiting access to DE and AI-rich experiences. Unless this is addressed, technology may widen rather than shrink equity gaps.
Mitigation: Institutions and governments must invest in infrastructure (connectivity, devices, power), consider low-bandwidth solutions, offline AI tools, and device-agnostic platforms. For example, research on "small language models" that run offline on low-power devices offers one path for under-resourced regions (Ghorbani, 2025)

4.2 Algorithmic Bias and Inclusive Design (Voutyrakou, 2025)

AI systems trained on skewed datasets may produce biased outcomes (e.g., faulty predictions for minority groups). This presents a profound risk for inclusive teaching.
Mitigation: Bias audit, diverse data collection, transparency in algorithms, participatory design involving under-represented groups, and designing for varied learners. The rapid review emphasizes that without deliberate efforts to embed inclusivity, AI may perpetuate inequalities (Chalkiadakis, 2024).

4.3 Teacher Readiness and Pedagogical Integration

Even the best tools won't yield inclusive outcomes if teachers lack training in integrating them effectively. Teachers may have limited technological knowledge or be skeptical of AI/DE adoption. For example, a case study found STEM teachers in Qatar have moderate technological knowledge but require deeper ethical and pedagogical understanding (Alkubaisi, 2025).
Mitigation: Professional development programs focused on inclusive pedagogies, training in AI/DE tools, continuous support, peer communities of practice, and time for co-design.

4.4 Privacy, Ethics and Data Governance

Using AI in education raises privacy, consent, surveillance and agency issues. Students' data may be used for predictive analytics without transparency.
Mitigation: Robust ethical frameworks, data governance policies, student agency, transparency about how data is used, and attention to digital rights.

4.5 Evidence and Evaluation of Inclusive Impact

Many AI/DE interventions lack rigorous empirical evaluation of inclusive outcomes, particularly long-term effects. This limits confidence in claims.
Mitigation: Researchers and institutions should embed formative and summative evaluation of inclusion metrics (access, engagement, outcomes), publish findings, share best practices, and invest in rigorous design-based research.

4.6 Recommendations for Practice and Policy

Based on the above analysis, the following recommendations are proposed for stakeholders (educators, institutions, policymakers):

For Educators and Instructional Designers

- Adopt a **universal design for learning (UDL)** mindset: design DE modules and AI tools from the outset for diverse learners (including disabilities, language, culture).
- Use AI tools to **augment rather than replace** pedagogy: e.g., intelligent tutoring for remediation, allow teacher time for design and relational support.
- Choose inclusive AI-DE platforms: those with accessibility features, multiple modalities (audio, visual, interactive), low-bandwidth modes.
- Facilitate **student agency and meta-cognition**: ask learners to reflect on how AI tools helped them, foster digital literacy and ethical use of AI.
- Monitor data and analytics for equity: watch for patterns of under-engagement or performance among subgroups and intervene.

For Institutions

- Invest in hardware, connectivity and technical support—especially for underserved student populations.
- Provide ongoing professional development for teachers focused on AI/DE pedagogies and inclusive teaching.
- Establish cross-functional teams (education technologists, AI developers, inclusive education specialists) to co-design tools with users from diverse backgrounds.
- Develop policies and ethical guidelines regarding AI usage, data privacy, transparency and accessibility.
- Embed evaluation of inclusive outcomes into all AI/DE initiatives: track access, engagement, retention, outcomes for under-represented groups.

For Policymakers

- Ensure funding and infrastructure for equitable access (broadband, devices, remote access) in underserved regions.
- Set standards for inclusive design in AI educational tools: accessibility certifications, bias audits, and evaluation frameworks.
- Promote open-access AI/DE platforms and share best practices to avoid duplication and reduce cost barriers.
- Support research into the inclusive impact of AI+DE in STEM: fund longitudinal, large-scale studies and implementation science.
- Encourage partnerships between academia, industry, and educational institutions to scale inclusive AI/DE solutions.

5. Conclusions and Future Work

In summary, the combination of artificial intelligence and distance education holds significant promise as a catalyst for inclusive teaching in STEM. By extending reach and flexibility (via distance education) and tailoring instruction and support (via AI), educators have the opportunity to better engage diverse learners, including those from underserved backgrounds, those with disabilities, or those whose lives preclude traditional classroom attendance.

However, fulfilling this promise demands more than technology—it demands intentional design for inclusion, rich support for teachers, equitable infrastructure, rigorous evaluation and ethical oversight. Without addressing these enabling conditions and barriers, the risk is that AI + DE simply magnifies existing inequities rather than dismantling them.

For STEM education to truly become inclusive, the field must embrace not just new technologies, but inclusive **pedagogies**, inclusive **design processes**, and inclusive **systems**. In this way, artificial intelligence and distance education can become **catalysts**—not just tools—for transforming STEM teaching into an inclusive, equitable endeavors that empowers all learners.

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Manuscript Title
Towards Trustworthy AI in STEM Education: Challenges and Strategies from the Trust-AI platform[1]
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Abstract

Artificial intelligence (AI) in education has the potential to personalize learning, but trustworthiness is essential for its successful implementation. The present paper provides an overview of the challenges identified during the development and evaluation of the Trust-AI platform. Based on literature review, teacher workshops, and system evaluation, we determine the challenges of the Trust-AI platform across the dimensions of the NIST AI Risk Management Framework: validity and reliability of assessments, explainability, safety, transparency and accountability, privacy, security and fairness. To address these challenges, this paper suggests strategies we have implemented during the design and development of the Trust AI platform, as well as the mitigation actions we plan to implement during the deployment phase of our platform. Trust-AI incorporates humanin-the-loop oversight, continuous benchmarking against international standards, and explainability mechanisms. The principles of privacy-by-design guarantee the anonymization of data processing and its compliance with GDPR, whereas high-level access control and integrity protection make the data security more robust. Fairness can be supported through bias detection, representative training data, and validation of AI outputs by teachers. The results indicate that trustworthy AI in learning is not a technical issue but a continuous ethical and collaborative
process. The paper concludes that the implementation and deployment of trustworthy AI systems in education needs to be driven by an ongoing, comprehensive dedication to trustworthiness assessment based on ethical values and stakeholder involvement.

Keywords: *Trustworthy AI, STEM education, Artificial intelligence*

[1] This work was also presented at TRUST-AI, the European Workshop on Trustworthy AI of ECAI 2025

1. Introduction

The potential of implementing AI in Science, Technology, Engineering and Mathematics (STEM) education is tremendous. AI has the potential to bring revolutionary changes in the learning process. AI enabled learning tools offer new capabilities in STEM learning, such as personalized learning, immediate feedback, and representation of concepts in exciting and interactive methods, which help to personalize the learning process to individual students [1]. AI technologies have the potential to accommodate both unique paces and forms of learning, and provide support tailored to the individual, which is important to the knowledge gap prevention and consequent mastering of the STEM courses.

As AI tools are growing more complex, they are not only used in basic grade calculation but is now used in smart tutoring [2], educational robots [3], and fully online teaching and learning systems [4], which are radically transforming the future of teaching and learning. However, there have been serious doubts raised about the ethical impacts and bias of AI systems, and thorough studies are needed to make sure that these tools of power are created and implemented in a way which people can trust and believe that their functionalities are sound and objective. Challenges associated with the deployment of AI in schools should be thoroughly examined to develop trust between teachers and students. For example, issues related to algorithmic bias need to be addressed, as the usage of AI might propagate or even increase social disparities based on race, gender, and socioeconomic background [5]. Moreover, privacy and security concerns regarding the amount of student data gathered are of paramount importance, which means that advanced data governance and security measures will be required [6], [7]. The necessity to gain the appropriate skills and knowledge to introduce AI into pedagogical practice and to critically assess the results of these systems also puts pressure on educators to acquire them. Failure to have proper training contributes to the likelihood of wrongful use of AI tools, which can become detrimental to the learning process. Another significant obstacle is the digital divide, where unequal access to AI technology may further harm students of communities with low resources and deepen the current inequality in education [8],[9].

This study aims to help advance the discussion of trustworthy AI in STEM education. The focus of our research is to identify the AI trustworthiness challenges associated with the Trust-AI platform [10],[11], an AI educational system that offers personalized learning and AI-driven student assessment during STEM laboratory and experimental teaching by providing continuous assessment and guidance. To clarify this focus, our research question is to explore the key challenges related to AI trustworthiness in the case of the Trust-AI platform and to investigate the ways in which they may be successfully addressed in STEM education. Further, we propose strategies addressing the identified challenges so that educational institutions can promote an environment of trust, transparency, and accountability in AI-driven education.

2. Methodology

This section presents the methodology (Figure 1) that we followed to identify the challenges related to trustworthiness of our Trust-AI platform. The approach follows a multi-phase process: first, core principles were defined based on a literature review; next, stakeholder workshops captured trust-related challenges; and finally, system demonstration and evaluation involved teacher interaction, feedback collection, and validation of AI features.

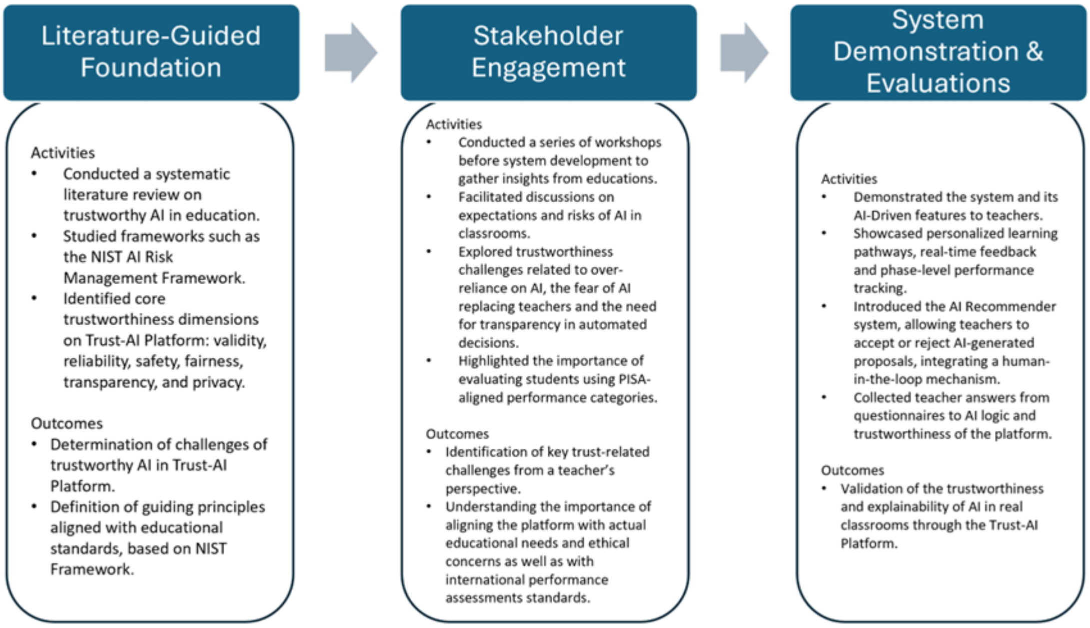

Figure 3: Overview of the multi-phase methodology followed to assess and enhance the trustworthiness of the Trust-AI platform.

Our research started by conducting a systematic literature review to determine the current challenges of trustworthy Artificial Intelligence in education [12]. We investigated how AI trustworthiness can be enhanced in real-world educational settings and surveyed state-of-the-art (SOTA) approaches, frameworks, and guidelines, with particular attention to their applicability in STEM education contexts. We then established the guiding principles which were primarily based on the NIST AI Risk Management Framework [13] and its core trustworthiness characteristics of validity, reliability, safety, fairness, transparency, and privacy, as it offers a systematic, risk-driven framework that goes beyond the ethical self-assessment frameworks like ALTAI. These principles served as foundational pillars in the design of our platform and the structure of our evaluation activities. In the second phase of our methodology, we engaged directly with relevant stakeholders through a series of workshops teachers to discuss the real possibilities and difficulties of the use of AI in the classroom. Among the key issues raised were fears of teacher replacement, over-reliance on AI, the opacity of automated decisions, and the need to align AI evaluation with educational standards such as PISA's performance level classification [15].

In the third phase of our methodology, the Trust-AI platform was demonstrated and explained during three workshops, involving 60 teachers, allowing them to have a first-hand understanding and evaluation of the system and its contribution to typical STEM teaching activities. With the Trust-AI platform, each student follows a customized learning pathway suggested by the AI assistant, which also corrects misconceptions and offers immediate feedback. This personalized interaction supports differentiated learning and encourages student autonomy while maintaining teacher oversight. By facilitating one-on-one interactions between students and tutors, this setup aims to improve the usual student-teacher dynamic and foster deeper learning. Additionally, teachers can track students' progress in real time, which enables them to offer tailored advice and step in when needed.

Additionally, the Trust-AI platform includes an AI learning pathways recommender system that flags underperforming activities using student performance data. Teachers can review these recommendations, so that they can either accept or reject them, assessing their alignment with educational standards and pedagogical goals. Their feedback is recorded and used to continuously refine the AI system through reinforcement learning, forming a human-in-the-loop architecture where educators remain central in decision-making.

Following the workshops and to uncover more information, we held interviews with teachers to elicit their opinion and evaluate trustworthiness characteristics of the Trust-AI platform. To quantify teachers' feedback, we also asked them to complete a structured questionnaire to gauge the perceived trustworthiness of AI effectiveness as well as perceived risks, such as over reliance, academic integrity, and data privacy. The combination of literature-grounded design, stakeholder consultation, live system evaluation, and teacher-centered feedback mechanisms enabled a comprehensive exploration of the challenges and opportunities in building a trustworthy AI system for STEM education.

3. AI Trustworthiness Challenges

This section discusses the challenges related to AI trustworthiness as identified in the Trust AI platform. We group the identified challenges under the seven characteristics of trustworthy AI systems defined by the NIST Framework [13].

3.1 Valid & Reliable

Validity and reliability were prioritized as the most important characteristics to ensure the trustworthiness of our platform. Failure in this area can lead to misleading guidance among students. Specifically, a major risk for the Trust-AI platform is its potential inability to accurately assess the level of a student's problem-solving skills. In case the system provides assessments that are not correct, teachers will not trust it. Teachers will not use the system if they lack confidence in it. Furthermore, inaccurate evaluation of student performance may result in recommendations for personalized learning that are not reliable. These problems have the potential to interfere with the learning process and produce unreliable educational results.

This risk of inaccuracy extends to all functions of the Trust-AI platform. The ability to suggest personalized learning paths depends entirely on the accuracy of problem-solving skills assessment. An inaccurate assessment can lead to learning recommendations that are not relevant to the students' needs. Similarly, feedback from the system should be consistently accurate and personalized for student learning needs. Unreliable or inaccurate feedback will result in students not trusting the system.

Equally important is the robustness of the Trust-AI platform. Robustness is the feature of the system to work with the same and reliable results in different classroom conditions, incomplete student inputs, and other unpredicted situations. Without a robust platform, there will be a possibility of having unstable or inconsistent outputs given unexpected inputs and variations in classroom conditions. These failures may disrupt the process of learning by providing incorrect suggestions, lowering the accuracy of feedback, and eventually making teachers and students unwilling to use the platform.

3.1.1 Explainability

When an AI's decision-making process is a 'black box', it creates a fundamental barrier to trust. Educators cannot be expected to implement recommendations without understanding their rationale. A significant challenge is the erosion of teacher trust. If a teacher cannot understand why the AI recommended a specific learning path, they cannot professionally endorse it or integrate it into their teaching. An AI learning pathway recommendation without justification is not useful. If the system flags an activity as 'at-risk' without explaining which concepts they are struggling with, the teacher has no basis for intervention. This lack of justifying a specific decision and clarity about the overall system design and data creates an 'accountability vacuum' where no one can be held responsible for the AI's outcomes.

3.2 Safety

In education, safety is related to the well-being of students and teachers. One relevant identified challenge is the fear of educators that their role may be replaced by the system. The feeling of potential loss of jobs due to AI performing and taking control of the essential teaching aspects encourages professional insecurity, causing teachers to distrust and resist the emerging technology in the educational field.
Another challenge related to safety is that over-reliance on AI for basic tasks such as lesson planning and assessment could cause reduced teacher involvement in the educational process. The blindly outsourcing of the basic activities to the AI system threatens the phenomenon of de-skilling. This may mean that pedagogical competence and creativity may be impaired in educators, and this compromises the teaching process and reduces the outcome of learning in the students.

3.3 Accountability & Transparency

One of the major challenges regarding the implementation of AI into education concerns transparency and accountability. One of the most important elements of the educational setting is transparency, which encourages trust needed among students, educators, and institutions. Yet, this contradicts this principle directly since the AI algorithm is usually opaque, as is the case with highly advanced AI algorithms. With our Trust-AI platform, it is important for teachers to understand the logic behind the algorithm. There is a strong need that teachers to understand how AI models are assessing the problem-solving abilities of students and what data have been used to train the AI model so as not to reproduce the biases built into the system. Moreover, at the central level, there must be transparency in order to allow a clear chain of accountability. When an algorithm fails or produces a biased result, the black box characteristic of a system is not known, and it is unclear who should be held liable between a teacher or the AI developer. This confusion is not only an undermining factor of trust, but it is also a violation of procedural fairness.

3.4 Privacy

Privacy protection of students' behavior data, skills, and performance was raised as a major concern by teachers. The NIST Privacy Framework [13] and General Data Protection Regulation (GDPR) [14] require systems to be designed based on the principles of privacy by design with respect to individual rights and without the possibility of unauthorized processing or identification. The possibility of reidentification, forming extensive profile data of users, and being able to misuse sensitive information poses a significant challenge. In case they are not handled properly, these security holes in privacy may result in misuse of personal data by unauthorized third parties. The loss of privacy that results due to this may in a sense be extremely damaging to the confidence of the educators in the system. This has a high potential of making teachers reluctant to stop using our platform. Within the framework of our system, the process of assessing students according to their problem-solving ability is performed utilizing entirely anonymized data. However, adherence to the principles established by GDPR is critical to guarantee that data anonymity is maintained at every level of data collection, analysis, and storage and that the utilization of such data has purely and merely educational intentions.

3.5 Security

Security is one of the pillars of trust in any education technology infrastructure, and the challenges it poses must be dealt with in a multidimensional manner. Although our platform is specifically built not to collect any personally identifiable student data, and hence addresses some of the most serious challenges, there are still some security concerns, particularly as far as application of an effective access control model is concerned. Since our platform works with anonymized data of interaction and assessment, it is necessary to prioritize data integrity, as well as the right to access information.
In a multi-user environment with different roles of users, like in our case where we have students, teachers and administrators access rights, incorrect access rights may create vulnerabilities that are cause of great concern to security. The possibility that the assessment results will be seen by the students is a serious one. Even anonymization of data may result in performance anxiety when students are afraid to make errors because of this perception. Also, presentation of assessment data to the students may result in inadvertent peer comparison or the sense of exposure, which interferes with psychological safety among students. Thus,

a well-defined access control mechanism cannot be seen as a system feature, but rather a basic requirement to address the confidentiality of data, maintain the integrity of a system, and achieve user confidence. Moreover, most systems containing student data are vulnerable to attacks. These risks include overt threats such as data breaches, which can seriously damage user trust, as well as more subtle forms like data poisoning, where malicious inputs manipulate the behavior of AI systems. However, our platform is less likely to face such severe consequences. Since the Trust-AI platform is designed to support the educational process, assisting students and teachers without storing sensitive personal data, it presents a lower-value target for potential attackers.

3.6 Fairness

In educational AI systems, fairness is crucial as any bias can reinforce or create inequalities, disproportionately affecting students based on different factors. Since our platform is not intended to hold demographic or any other sensitive personal data, direct discrimination by protected characteristics is automatically eliminated. Nonetheless, the issues of fairness remain on a more insidious, algorithmic level. One possible issue is bias in algorithms. This means that the AI models may be trained on biased data in the background. These may cause the system to be biased towards certain forms of expression or approaches to solving problems at the expense of the students who have alternative forms.

4. Strategies for Addressing AI Trustworthiness Challenges

To build a trustworthy AI system in the education domain, a wide range of mitigation actions must be taken across the different phases of the AI lifecycle. In this section, we present the strategies we have implemented during the design and development of the Trust AI platform, as well as the mitigation actions we plan to implement during the deployment phase of our platform to address the challenges described in the previous section.
Table 1 presents an overview of the main trustworthiness challenges identified, paired with a corresponding strategy, concrete mitigation measures implemented within the platform, and the potential risks if these issues are not addressed.

Table 8: Summary of key trustworthiness challenges identified in the Trust-AI platform, along with corresponding strategic responses, mitigation actions, and potential risks if left unaddressed.

Challenge	Strategy	Mitigating Action	Risk if Unaddressed
Invalid assessments	Accuracy of assessment and benchmarking of results; Integration of Human-In-The-Loop approaches	Correlate outcomes with PISA; continuously monitoring student performance; teacher review of AI outcomes; Use accurate interaction data	Unreliable educational results; misleading feedback; loss of teacher trust; withdrawal of using the platform
Algorithm opacity	Promote transparency and implement explainability features	Display performance metrics and explanations linked to proposals; allow human oversight;	Lack of explainability and accountability; teachers may not trust system decisions
Privacy concerns	Apply a privacy-by-design approach	GDPR-aligned data practices, secure storage, minimal data policy, anonymization of student data	Legal noncompliance, misuse of data, trust erosion
Fairness bias	Ensure fairness across student performance categories	Manual oversight of flagged issues; reinforcement learning with human feedback	Systematic exclusion of learners, amplifying inequities in outcomes
Security weaknesses	Design for minimal risk of data exposure	Clear access rules, data integrity enforcement, limited attack surface, adopt proactive security measures	Data breaches, unauthorized access, and loss of stakeholder confidence

Challenge	Strategy	Mitigating Action	Risk if Unaddressed
Teacher Over-Reliance on AI	Maintain human oversight and pedagogical control	Keep teacher in-the-loop, promote critical assessment of AI, offer AI training	Reduced teacher agency and resistance to system adoption; poor educational outcomes

Validity in educational AI systems refers to the degree to which the system's outputs, such as student assessments, feedback and content adaptation, accurately represent the intended learning outcomes. Ensuring validity is crucial when AI is used to estimate complex traits like problem-solving skills or conceptual understanding, as flawed evaluations might mislead both educators and students.

One prominent challenge related to the validity and reliability of our platform is whether the classification of students who used the AI system into high, low, and moderate performers has been done correctly. To confirm the validity of our student performance categorization, we will constantly monitor and assess students' progress in consecutive STEM lab courses. Additionally, the classification of the students will be compared to world-renowned models. In particular, our assessments of problem-solving abilities will be correlated with the performance indicators identified in the PISA framework of the OECD Program for International Student Assessment (PISA) [15], which categorizes students as high, moderate, or low performers. Our platform adopts several mechanisms to ensure valid assessment and be consistent and aligned with international education standards.

In addition, human-in-the-loop approaches for teacher oversight should be established. That way, the educators can revise and certify AI results and take over control of the process when they believe their professional discretion overrides the technology output in order to control quality and align the technology with their professional judgment. To address this, the platform allows AI suggestions to be monitored in real-time, and the educators are offered the analytics dashboard that displays the visualization of the student's performance and thus promotes the process of formative validation. Lastly, through providing educators with a choice to accept AI recommendations or reject them, the validity is once again strengthened so as to coordinate the automated products with the pedagogical intentions and the practical observations in a classroom environment.

The system should be highly explainable and transparent as a way of demystifying the black box and gaining confidence. The important step is to integrate explainable AI techniques, which give clear and human understanding explanations of the results of the system. This enables the teachers and students to know the reasons that a certain learning path was suggested, which is central to establishing trust. In our system, we have implemented explainability mechanisms that provide insights into the reasoning behind recommended learning pathway changes. By analyzing and displaying student performance data from prior implementations, our platform provides an explainability mechanism (Figure 2). The system presents aggregated performance metrics for each activity and highlights risk indicators when an activity either poses consistent challenges or lacks sufficient challenge for learners. This makes the rationale behind each recommendation explicit and provides teachers with transparent evidence supporting AI-generated suggestions. Specifically, the system offers teachers explanations as to why it identifies an activity as difficult for students and suggests that it needs to be modified. For every AI-generated activity suggestion, specific performance metrics are linked and made fully visible to the reviewing teacher. Educators can accept or reject these proposals, with each decision logged alongside the reviewer's identity and a timestamp, supporting human oversight and auditability.

Q1 - maximum kinetic energy & cutoff voltage

Category At Risk	Flag Type	Reason
Moderate	Extreme correctness pattern	Extreme correctness pattern: High (20.8%) or Low (92.3%) group not at extremes, Moderate wrong is high (76.9%).
Moderate	Engagement risk (too fast, question)	Engagement risk: Moderate group's Avg Time (58.7s) is > 1 std below mean (84.23 ± 24.45).
Low	Engagement risk (too slow, question)	Engagement risk: Low group's Avg Time (117.2s) is > 1 std above mean (84.23 ± 24.45).

Figure 2: Explainability view of the recommendation system. For each activity, the platform surfaces risk flags by learner category (High/Moderate/Low) when dynamic correctness thresholds are exceeded or engagement timing deviates from the cohort mean (e.g., >1 SD)

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To make sure the AI system does not become a crutch instead of the helping tool, a culture of responsible use has to be established. Both students and teachers should have clear and explicit policies outlining the effective use of AI and establishing acceptable limits between the use of AI and another form of academic dishonesty. This needs to be followed by AI training for teachers, which goes beyond technical knowledge to encourage the ability to critically assess the AI results and the limitations of the technology. The system itself is created in such a manner that it enhances and does not substitute for a person and his abilities. The AI can take certain administrative duties conventionally assigned to educators so that these professionals can work on the duties that only humans can perform. The concern with the integrity of the educational process also lies in the fact that it is essential that a human be in a loop during critical decision-making.

The security of student data is not negotiable and needs privacy by design strategy. This implies incorporating strong privacy-enhancing technologies at the beginning such as end-to-end encryption and strict regimes of data minimization to collect only the data that is strictly necessary. The system should be fully compliant with data protection laws such as GDPR and should have clear policies per user that allow him or her full control over the data. The school districts are supposed to maintain ultimate ownership of all the data of the students, and the contracts may not allow the vendor to use the data for other unintended purposes. There is also the need to adopt proactive measures such as giving the system frequent and stringent security scrutinizes, penetration, and malicious resistance testing to guard against external risks to security, such as the ability to deport venerability and counter malicious attacks that may occur.

A privacy-by-design approach has been developed, minimizing data collection to only what is necessary for its operation. No student data are collected or stored, and student interactions are linked to system-generated identifiers. Teacher accounts require names and emails for authentication on the platform. This data is collected with explicit consent during account creation, under clearly defined terms of use and data handling policies. All teacher data are securely stored, access-controlled and never shared with third parties. The solution was designed with security in mind and thus no identifiable student data is stored or processed. All data of the interaction is anonymized and can only be linked with machine-generated identifiers, keeping no sensitive information revealed and stored. With the implementation of this architecture, the threat of being victimized by the misuse of data or use of data to expose their identity as a result of breach of security is extremely minimized.

The willingness to implement fairness demands the initiative to investigate and detect bias in all phases of the AI lifecycle. It is important to integrate bias detection algorithms and conduct regular bias audits that can identify and correct discriminatory patterns. Using diverse and representative data to train the models is necessary to avoid a possible introduction of bias into the system in the first place. Last but not least, a multi-stakeholder AI ethics review board can offer essential guidance to keep the development of fair AI practices. Our solution, without relying on demographic or personal identifiers, supports equitable learning experiences by dynamically analyzing student performance. Interactional data such as correctness, and timing are the only factors on which all AI recommendations and analytics are made, which lowers the probability of bias caused by background knowledge and knowledge. Moreover, the system combines category-sensitive performance analysis and identifies activities that discriminate against any performance group, actively managing equity. Educators maintain absolute control over identified problems and suggested solutions and play the role of a human-in-the-loop to approve or ignore AI recommendations. Reinforcement learning in taking a decision to either approve a proposed change or even reject it encourages fairness as well as reduces algorithmic biases.

5. Conclusions and Future Work

In this paper we presented a comprehensive analysis of the AI trustworthiness challenges associated with the Trust-AI platform identifying significant challenges across validity, reliability, explainability, fairness, safety, and privacy. To address these issues, a wide range of mitigation actions must be taken during the design and development of our platform. We also presented several strategies for addressing the identified challenges, as well as the mitigation actions we plan to implement during the deployment phase of our system to address the identified challenges.

Our study is limited in scope by focusing on one specific AI system; still, it helped us identify several empirical findings and draw the following conclusions that may help educational institutions to promote an environment of trust, transparency, and accountability in AI-driven education. Building and sustaining a trustworthy, educational AI system requires a framework that incorporates validity assessment, explainable AI methodologies, bias detection algorithms, human-in-the-loop approaches for teacher oversight, and teacher training. Moreover, the successful integration of AI in education is not merely a technical achievement but an ongoing commitment to ethical principles and stakeholder collaboration, ensuring that technology serves to empower, not undermine, the fundamental goals of learning.

Acknowledgements

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Manuscript Title
Chatbots as Virtual Tutoring Assistants in Secondary Education
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Abstract

This study explores the effectiveness of AI chatbots as virtual tutoring assistants in secondary education, focusing on their role in supporting a geography lesson on map-reading fundamentals. AI tools including ChatGPT 5.0 and Gemini 2.5 were employed to generate instructional materials such as presentations, worksheets, quizzes, grading rubrics, and automated evaluation feedback. Results demonstrate high efficacy of AI in content generation, particularly in constructing quizzes and instructional presentations with zero major errors. However, workflow inconsistencies emerged in student tasks due to AI-suggested tools lacking necessary functions (e.g., scale, compass), revealing a mismatch between AI recommendations and real classroom constraints. Automated grading showed variable reliability, with discrepancies between AI-generated scores and teacher-verified assessments ranging from 0–100% offset. The findings suggest that AI tutors are valuable pedagogical assistants, yet human oversight remains essential, especially in qualitative assessment and context-dependent tasks. The study concludes by emphasizing the need for digital literacy training for educators, transparent AI use policies, and a balanced integration of technology and human judgment to ensure pedagogical integrity in AI-enhanced classrooms.

Keywords: chatbots, AI tutor, educators, teaching, automated evaluation scoring

1. Introduction

Artificial intelligence (AI) and chatbots present new opportunities for both students and educators, fundamentally reshaping the landscape of modern pedagogy. These advanced technologies are capable of learning, reasoning, and adapting, which enables them to transform learning and teaching processes by offering highly personalized learning and tutoring applications. By analyzing individual student performance and needs, AI systems can deliver tailored educational content and support, thereby fostering a more efficient, engaging, and individualized academic experience (Davar et al., 2025).
An **AI tutor** is an advanced instructional system leveraging the capabilities of machine learning (ML) and natural language processing (NLP) to personalize the educational experience. Its primary function involves analyzing, in detail, each learner's strengths and weaknesses across various subjects or skills. This data-driven assessment allows the AI tutor to dynamically provide tailored lessons and real-time feedback, ensuring the content and instructional pace are optimally matched to the individual student's needs, thereby maximizing comprehension and retention.
The AI tutor as a sophisticated instructional system fundamentally powered by machine learning (ML) and natural language processing (NLP), enabling it to function effectively as a virtual tutoring assistant. Its primary educational value stems from its ability to meticulously analyze a learner's strengths and weaknesses, which drives the subsequent provision of tailored lessons and real-time feedback. These systems offer real-time

interaction and 24/7 adaptive learning support, significantly improving accessibility and personalization in education. This robust, continuous support is widely applied across diverse academic fields, providing critical assistance for subjects such as programming, foreign languages, and general study support, thereby maximizing student learning outcomes and engagement (Lin et al., 2023*) figure 1.*

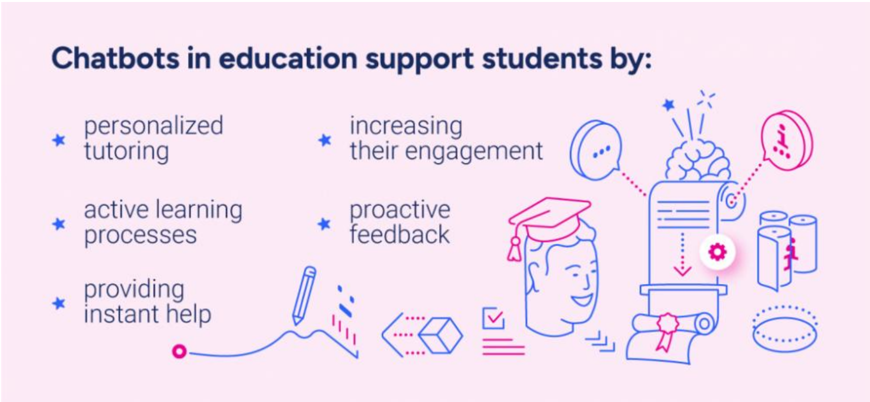

Figure 1: We can see different ways of how chatbots in education can support the students. Source: How using chatbots in education can change the way we learn? Retrieved from https://action.bot/blog/using-chatbots-in-education/

2. Methodology

Artificial intelligence (AI) can be utilized by educators in many ways, such as: student support, curated learning content, virtual teaching assistant, diagnostic assessment, automatic grading, feedback collection as shown at figure 2 and probably many more.

There are AI tools that are dynamic and accessible for both educators and learners. These include gamification, enable motivation, encourage improvement and engagement. This enhances enjoyment of the learning process but also fosters deeper connection to the material, driving users to master content at their own pace.

AI ChatBox *ChatGPT 5.0* and Gemini 2.5 were used in the design and implementation at all steps for teaching a geography lesson at A junior high school (ages 12-13) regarding main parts of a Map. Mains steps where: presentation, creation of a teaching scenario, worksheet, review quiz game (Hirulkar, & Athawale, 2024), homework and automatic evaluation of student assignments "map construction". All steps were evaluated regarding their effectiveness and the parts where the data were wrong or inadequate are presented here. Most of the inaccuracies were at the map evaluation.

Figure 2. Applications and interaction of artificial intelligence within an upgraded and evolving work. Source: 6 Ways Conversational AI Is Shaping the Future of Education - Edly. Retrieved from https://edly.io/blog/6-ways-conversational-ai-is-shaping-the-future-of-education/

Kobayashi & Takagi, (2024) have found that learning through quiz creation, where learners generate their own quizzes, demands a more profound understanding than learning through quiz-solving. Generative AI can improve learning outcomes by guiding learners to the appropriate process of quiz creation, and that it can help with flexible quiz creation, including the "natural language expression of a quiz setting".
For example, an educator can ask a chatbot “I am a teacher and want a quiz with multiple answers regarding a junior high school for geography, with questions for title of map, scale, compass and legend”. The reply was “Here is a 10-question multiple-choice quiz about the fundamental parts of a map—the title, scale, compass, and legend—suitable for a junior high school geography class” (figure 3).

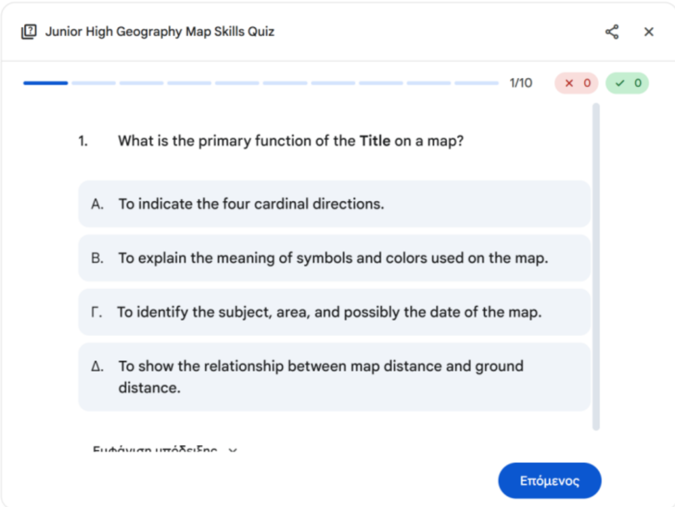

Figure 3. This is the first question of the quiz that was created by the ChatGPT (GPT-5.1) in compliance to the authors instructions (source OpenAI. (2025). ChatGPT (GPT-5.1) [Large language model])

Then an overall evaluation of the quiz follows, where it has highlights and focus points (figure 4). Highlights are all the correct answers. It tries to increase students' confidence, however some may be correct by accident but still it considers that the student has fully understood it. It offers small and smart tips. We focus on areas that are grey to the student, that they got it wrong, so they need to focus on these areas to improve their understanding.

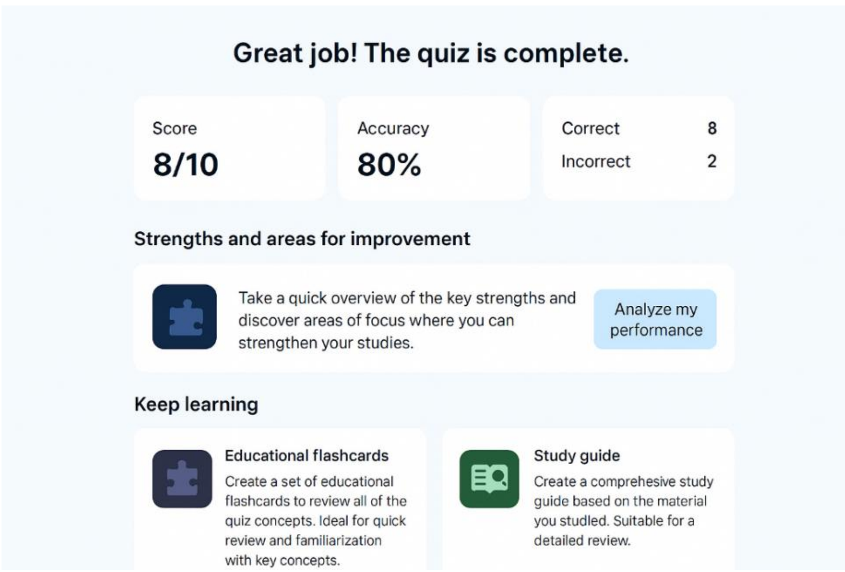

Figure 4. The overall score of the student that participated in the quiz. At this stage the author filled out the quiz and intentionally answered 2 questions wrong.

The main steps for the preparation for Geography class titled, "Interrogating" the maps, at grade A junior high school were as follows:

- Creation of **presentation** entitled “Understanding the main parts of a Map”
- Support of course content by creation of student class **worksheet** of 2 hours
- Generating a **quiz** of 10 questions with multiple answers
- Creation of Map **evaluation rubric** for grading of homework
- **Automated grading and feedback**

An overall evaluation of the assessment is shown at table 1.

Table 1. Shows the major and minor faults at each step of the process for the class of Geography titled, "Interrogating" the maps, and an overall effectiveness of AI ChatGPT 5.0 at each step

Steps	*Major Mistakes - Errors*	*Minor errors*	*Overall Effectiveness*
Presentation	*0*	*0*	*100%*
Scenario – worksheet	*2*	*1*	*85-100%*
Quiz	*0*	*2*	*95-100%*
Rubric for Evaluation	*0*	*0*	*100%*
Automated evaluation & feedback	*5*	*8*	*10-100%*

3. Results

Chatbot ChatGPT 5.0, as a virtual tutoring assistant, was very effective with zero faults in creating, altering and supporting **presentations** with the following workflow:

1. Title
2. Compass
3. Scale
4. Legend

Regarding the **worksheet**, there were some issues and the workflow had to be checked and altered as some of the suggested tasks and questions could not be fulfilled by the students using the AI suggested software, specifically:

- Part A – Exploring a digital map: one major mistake as at the suggested software there was no available title
- Part B – Legend and symbols: no mistakes
- Part C – Creating your own map homework: Scale and compass were not available by the Mapchart.net tool
- Part D – Reflection: no mistakes
- Part E – Feedback: no mistakes

The creation of a close type of **quiz** consisting of 10 questions with 4 multiple answers was very effective with no major faults and only 2 minor faults that could be corrected by the evaluator using different words (table 1). The creation of an **evaluation rubric** was very accurate and with zero mistakes (tables 1 and 2).

Table 2. It shows the 4 different criteria for map evaluation with a 4-scale scoring for each criterion alongside a small description explaining the scoring system.

🗺 ***Map Evaluation Rubric***				
Criterion	**4 – Excellent**	**3 – Good**	**2 – Satisfactory**	**1 – Needs Improvement**
1. Scale	The scale is clearly shown and accurate for the map's purpose.	The scale is correct but not very visible or slightly inappropriate for the map.	The scale is present but inaccurate or difficult to read.	No scale is shown.
2. Compass (Orientation)	The compass is correctly placed, clear, and accurately shows north.	The compass is present and shows north but is not very visible or well positioned.	The compass is present but does not correctly indicate north.	No compass is shown.
3. Map Title	The title is clear, specific, and accurately describes the map's content.	The title describes the content but is too general or slightly unclear.	The title is vague or doesn't fully match the map's content.	No title is shown or it's unrelated to the map.
4. Legend (Key)	The legend clearly explains all symbols and colors used on the map.	The legend explains most symbols but has minor omissions.	The legend is incomplete or hard to understand.	No legend or incorrect legend is shown.

On the contrary, the **Automated evaluation & feedback** as shown at table 1 was inadequate and disorientating in most cases as shown at tables 1 and 3 (figures 5-6). The results from the Gemini 2.5 evaluation were not included as the effectiveness was in some cases from 10% (underestimated) to 1000% (overestimated) of the overall score. Therefore we suggest that all automated evaluation and feedback must be checked and corrected by the educator.

Table 3. Shows the major and minor faults at each step of the process for the class of Geography titled, "Interrogating" the maps, and an overall effectiveness - offset of AI ChatGPT 5.0 at each step

Example – homework map	*AI Score*	*Score by the educator*	*Overall effectiveness offset Overestimation*
1	*9/16*	*9/16*	*0%*
2	*10/16*	*8/16*	*+25%*
3	*10/16*	*5/16*	*+100%*
4	*16/16*	*13/16*	*+23%*

During the **automated evaluation scoring** (AES) there were many major and minor mistakes. At figure 5, two almost identical maps, 2 and 3, that participated in the automatic evaluation procedure are shown. More specific, map 2, on the left, was uploaded first and it has scale included, which was added before uploading this map, the AES was 10, but as it does not contains a full legend the corresponding score at that criteria should not be 4 but 2 ending up with an overall score of 8 instead of 10 (table 3). Regarding map 3, on the right, that was uploaded afterwards, the AES was seeing the scale on the right map even if it didn't exist and was evaluating the right map as if it was the left map (figure 5). The educator needed to correct the Chatbot in order for it to reevaluate effectively.

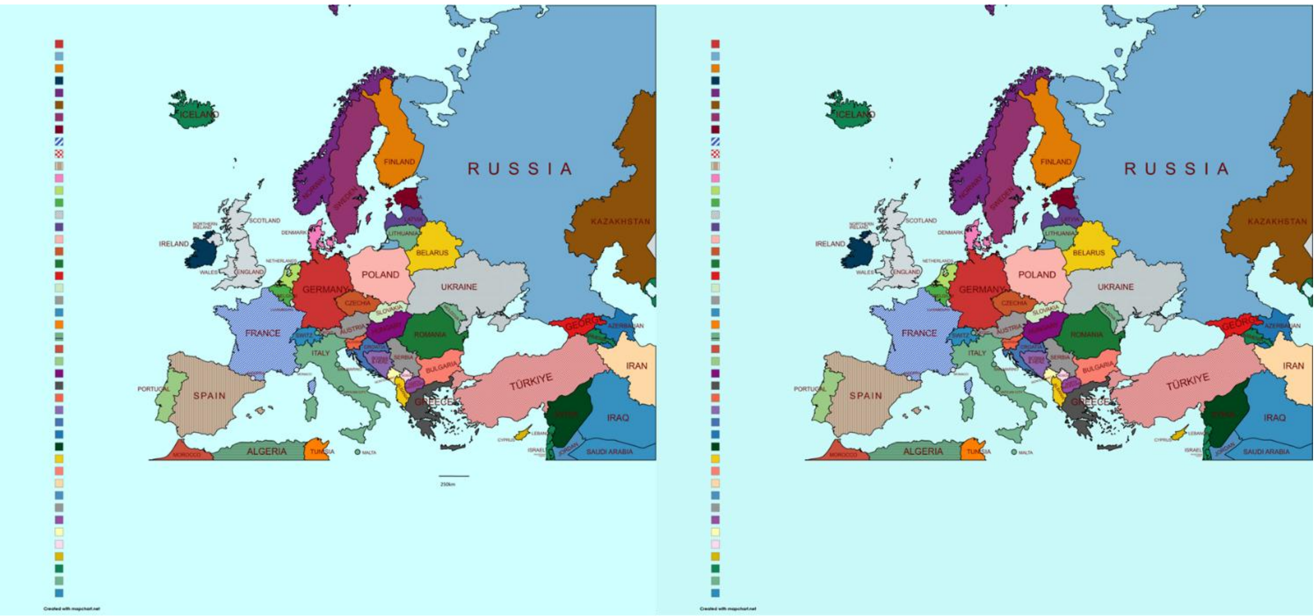

Figure 5. Two maps which seem very similar. The only difference is that the map on the left has scale.

The last example from the automated evaluation scoring (AES) is shown at figure 6 and it is example 4 at table 3. In this case the AES scored 16/16 while the educator 13/16, as the title was slightly wrong, the compass had E symbol at South and there was a park situated in the middle of the sea. All minor faults at this map are indicated with red color (figure 6).

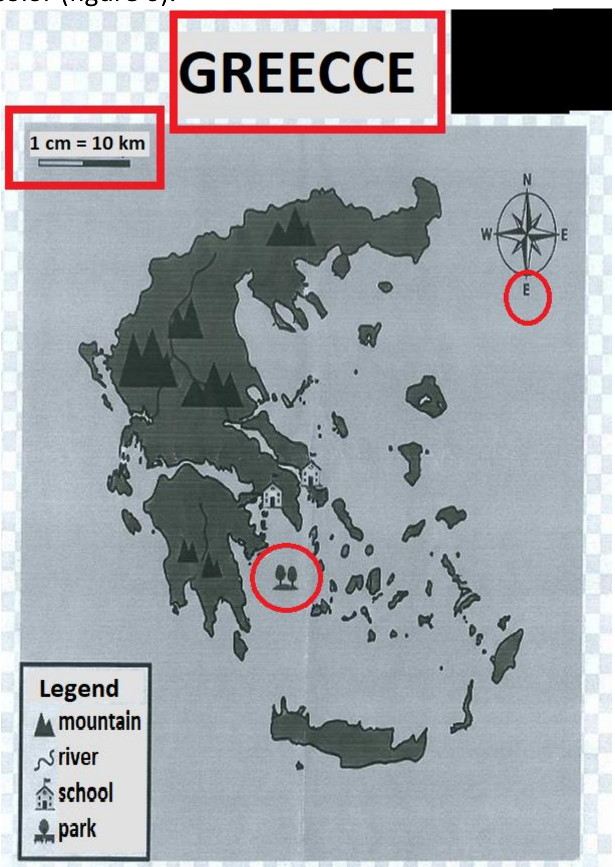

Figure 6. This map was scored excellent 16/16 from the automated evaluation scoring (AES) but it had some discontinuities, which are indicated with red color, and the score was altered by the educator at 13/16.

4. Discussion

The integration of Artificial Intelligence into educational ecosystems is not without significant challenges, necessitating careful ethical consideration and management. Foremost among these concerns are data security and privacy risks, as vast amounts of sensitive student data are processed by AI systems, requiring robust protective measures. Moreover, several ethical issues demand attention, including the potential for plagiarism, the danger of over-reliance on automated outputs, and the perpetuation of inherent system bias. Ultimately, the pervasive risk of over-reliance on technology underscores the critical need for complete transparency regarding AI mechanisms and a clear commitment to responsible AI use across all educational institutions.

Teachers need to be trained on the subjects of AI and digital literacy. They also need to teach students to use responsibly the AI tools. Schools must adopt clear AI policies or include them in their media strategies. These strategies need to be adopted by the teaching staff and the students.

There has to be a balance between Technology and Human Interaction. AI should be used just to complement teachers, and it does not replace them. It is important that human empathy and mentorship are essential and cannot be replaced. AI is meant to be a powerful assistant, not to replace the teacher. The goal is to combine the efficiency of AI (handling repetitive tasks like generating quizzes and data analysis) with the superior judgment, ethics, and creativity of the actual educator. It is this partnership that maximizes both productivity and teaching quality.

5. Conclusions and Future Work

AI and chatbots are undeniably transforming education, serving as highly effective virtual tutoring assistants, particularly in automating content development. They excel at creating, altering, and supporting presentations and generating quizzes quickly and accurately. However, their use requires human oversight; regarding student worksheets, issues may arise that necessitate the workflow being meticulously checked by the educator for accuracy and pedagogical alignment. In the realm of assessment, AI supports automated grading and feedback, showing high efficacy in the creation of rubrics. Conversely, The AI ChatGPT 5.0 was much more efficient than Gemini 2.5, while the effectiveness of automated grading ranges widely (10%–100%), demands significant supervision, and is specifically not suggested for subjects like Geology and Geography due to the need for human interpretation and qualitative judgment.
Future work in educational AI must prioritize ethical and inclusive design to ensure that continued integration into classrooms is successful and equitable. This involves a critical focus on enhancing accessibility and fairness of AI tools for all students, regardless of background or need. By committing to an ethical and inclusive AI design framework, researchers and developers can effectively support the sustained and beneficial continued AI integration in classrooms.

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Abstract

This paper presents the co-design and iterative development process of two conversational AI-powered educational assistants, Teacher Mate and Study Buddy, developed within the Erasmus+ project AI4EDU. Through a human-centred, participatory approach involving teachers and students from four countries, Cyprus, Greece, Ireland, and Sweden, the project explored how large language model (LLM)-based tools can be designed, tested, and refined to support authentic educational needs. The paper outlines the rationale for AI4EDU, its methodological foundations, the pedagogical framework underpinning the applications, and the design insights gained through co-creation. It concludes with reflections on what was learned from this process and how human–AI collaboration can enhance teaching and learning when grounded in trust, ethics, and pedagogical purpose.

Keywords: *Artificial Intelligence, Generative AI, Educational Technology, Conversational AI, AI assistant, teaching, learning*

1. Introduction: Why AI4EDU?

The integration of artificial intelligence (AI) in education is advancing rapidly, yet schools across Europe continue to face challenges, such as heavy teacher workloads, diverse learner needs, and fragmented digital practices. Generative AI, particularly large language models (LLMs), offers opportunities to address these challenges through personalization, immediate feedback, and new modes of interaction. At the same time, it introduces concerns related to trust, ethics, and pedagogy.

The AI4EDU project (Erasmus+ Forward-Looking, 2023–2025) was launched to explore how human-centred, conversational AI could enhance learning and teaching in ethical and pedagogically grounded ways, in line with EU priorities for inclusive and quality digital education. Its goal was to support educators in everyday teaching workflows and to help students become more autonomous and reflective learners.

Out of this vision came two assistants: Teacher Mate, a teacher-facing assistant for lesson planning, assessment, and feedback, and Study Buddy, a student-facing assistant for study support. Both applications were developed iteratively through cross-national collaboration, aiming to ensure that cultural and pedagogical diversity informed their evolution.

2. Methodological approach: Human-centred and participatory design

AI4EDU's methodology was grounded in human-centred design (HCD), a framework emphasizing technologies built around users' needs, values, and contexts. Building on this foundation, the project followed five interrelated methodological commitments.

Participatory design foregrounded teacher and student agency throughout the project. Educators and learners were engaged from the very beginning in articulating needs, testing early prototypes, and providing structured feedback. Their insights were foundational for the development process, shaping both the educational vision and the technical specifications of the tools. Building on this engagement, iterative development allowed for continuous refinement across two full design-evaluation cycles, ensuring that each prototype directly incorporated lessons from classroom practice and user experience.

Interdisciplinary collaboration further strengthened the development process. The consortium brought together expertise in AI, educational technology, pedagogy, educational science, and ethics, alongside the everyday practical knowledge of teachers and input from policymakers. This blend of interdisciplinary perspectives enabled the project to anticipate pedagogical opportunities and technical constraints, producing solutions that were both feasible and educationally meaningful.

Cross-national engagement added another crucial dimension. By involving schools and educators in Cyprus, Greece, Ireland, and Sweden, the project remained sensitive to the diversity of European classrooms, including differences in curriculum structure, digital maturity, pedagogical traditions, policy environments, and linguistic contexts.

Finally, ethical and equitable design served as an overarching principle, guiding decisions at every stage. The project aligned itself with major European and international frameworks on trustworthy and human-centred AI (European Commission, 2022; UNESCO, 2023a, 2023b), prioritising transparency, fairness, data protection, and human oversight.

The co-design process of the AI4EDU prototypes evolved into a shared capacity-building exercise to collectively shape responsible uses of AI in education: Teachers and students learned about AI as they helped shape it, while researchers and developers learned from the realities of classrooms.

3. A learning-centred pedagogical foundation

The design of Teacher Mate and Study Buddy was anchored in a learning-centred pedagogical framework, synthesizing established learning theories and empirical evidence from teacher and student perspectives gathered during extensive needs analysis. Four main pedagogical interconnected approaches guide the design of Study Buddy and Teacher Mate design:

(a) *Student-centred learning*: Both tools promote learner autonomy and self-regulation. Study Buddy supports students in adjusting their pace and strategies based on feedback, while Teacher Mate enables teachers to personalize instruction.

(b) *Inquiry-based and dialogic learning*: AI is positioned as a conversational partner that encourages questioning, exploration, and reasoning rather than simple answer retrieval.

(c) *Scaffolding*: Teacher Mate helps teachers adapt materials to different difficulty levels; Study Buddy adjusts responses to match students' needs and prior knowledge.

(d) *Inclusive education*: Accessibility and equity are central design goals. The tools support multiple languages and adapt to varied learning profiles and abilities.

To translate these pedagogical commitments into functional tools, the project adopted an iterative development process grounded in continuous feedback from teachers and students.

4. Iterative development process

The development of Teacher Mate and Study Buddy unfolded through two major design cycles, each combining empirical feedback with technical refinement.

The first phase began with a comprehensive needs analysis, involving 280 participants (134 teachers and 146 students). Workshops, interviews, and surveys identified educators' and learners' priorities. Teachers emphasized time-saving support for lesson planning, assessment, and differentiation, while students valued interactivity, feedback, and accessibility. These findings shaped the technical specifications of first version of Teacher Mate and Study Buddy prototypes, establishing the basic architecture of both tools: LLM-powered conversational interfaces enhanced with Retrieval-Augmented Generation (RAG) to ensure curriculum alignment.

The second cycle focused on usability, acceptance, and educational value through pilot implementations in real classrooms. Feedback guided extensive revisions: interfaces were redesigned for clarity and engagement, navigation was improved and tools became more adaptable to subject, grade, and learner profile.

Study Buddy evolved into an interactive learning environment with tools for text summarization, concept exploration through Socratic dialogue, and creative tasks such as "Conversations across Time" or "Debate tool." Teacher Mate expanded its pedagogical scope, introducing advanced features such as My Content (allowing teachers to upload and use their own materials), a Rubric Generator, a Group Project Designer, and Text Adaptation for differentiated reading levels.

Enhancements of the second development cycle reflected continuous teacher and student feedback, which transformed prototypes into mature educational partners capable of supporting differentiated instruction and self-regulated learning.

5. Design principles guiding development

Across both development cycles, the development of Study Buddy and Teacher Mate was shaped by a set of design principles that translated AI4EDU's pedagogical and ethical commitments into concrete technological choices.

A first guiding principle was usability. Teachers and students repeatedly emphasized the need for simple, accessible interfaces that reduced cognitive load. As a result, visual design was clarified, navigation and interaction pathways were simplified to reduce interface complexity.

A second principle was effectiveness, which focused on producing reliable and curriculum-aligned responses. This requirement guided the integration of RAG pipelines into both assistants, so that outputs were grounded in validated educational resources. Ensuring effectiveness also meant refining prompting logic and making system prompts visible, enabling users to understand and shape how the AI generated responses.

Closely related was the commitment to personalization and inclusivity. The tools were designed to adapt to different learner profiles, languages, and learning needs. This included the ability to adjust the complexity of explanations, tailor content to different grade levels, and support multimodal (text and voice) and multilingual interaction. These features were essential for accommodating diverse educational contexts across the four participating countries and for ensuring that AI-supported learning environments remained equitable and accessible.

Engagement emerged as another key principle. The assistants were not designed simply to deliver information, but to foster active learning and participation. This led to the inclusion of interactive tools, such as Socratic dialogue modes, self-assessment quizzes, creative exploration tasks, and debate simulations, which were intended to prompt curiosity, exploration, and sustained involvement from students.

Finally, the principle of teacher agency and trust was foundational. Teachers needed assurance that AI would support, rather than undermine, their pedagogical judgment. This emphasis on human oversight influenced several design decisions: outputs were made editable, prompts were transparent, and the tools were positioned explicitly as partners. The aim was to ensure that teachers remained in control of instructional decisions, while the AI provided scaffolding, inspiration, and efficiency.

These principles ensured that AI4EDU's technical development stayed anchored in educational values. They allowed the research team to balance innovation with responsibility, shaping AI tools that enhance teaching and learning while respecting human expertise, diversity, and ethical considerations.

6. Technological foundations: The AI4EDU platform

Both Study Buddy and Teacher Mate are built on a shared technological infrastructure. At their core, the assistants rely on the GPT-4 model accessed via the OpenAI API, but this foundation was adapted extensively to meet pedagogical, curricular, and ethical requirements. The most significant enhancement is the integration of RAG, a method that combines information retrieval with natural language generation to ensure that answers are not only fluent but grounded in authoritative sources.

In practical terms, RAG allows the system to search validated educational materials, such as official textbooks, teacher-provided documents, and subject-specific resources, before any response is generated. The retrieved content is then supplied to the language model as contextual input, guiding the generative process toward curriculum-aligned and factually accurate explanations. This mechanism directly addresses concerns raised by teachers during early workshops, who emphasized that reliability and alignment with the taught curriculum were prerequisites for adopting AI tools in their classrooms.

The incorporation of RAG also strengthens transparency, an essential dimension of trustworthy AI. As the AI4EDU assistants can indicate which sources were used to construct a given answer, teachers and students gain visibility into how information is produced. This fosters critical engagement, allowing users to evaluate, question, and modify the AI's outputs rather than accepting them uncritically.

Another key benefit of this architecture is adaptability. Teachers can upload their own materials, such as lesson notes, worksheets, or supplementary readings, making the system responsive to local curricula and individual classroom needs. This feature proved particularly valuable across AI4EDU's multinational pilot sites, where curricular structures, instructional traditions, and resource availability vary considerably.

Both assistants are guided by visible prompts, a deliberate pedagogical choice fostering prompt literacy, an emerging twenty-first-century skill (Federiakin et al., 2024; Kalantzis & Cope, 2025).

The platform combines the power of LLMs with retrieval-based grounding, operationalizing the project's commitment to trustworthy, human-centred AI. The resulting system is, thus, developed as a pedagogically sensitive assistant capable of supporting differentiated learning, accurate instruction, and meaningful teacher oversight.

6.1 Study Buddy: AI support for student learning

Study Buddy is the student-facing conversational assistant designed to scaffold self-regulated learning through interactive dialogue. Built on the common AI4EDU platform, it enables students to pose natural-language questions and receive explanations, examples, and clarifications grounded in curriculum-aligned materials through the RAG pipeline.

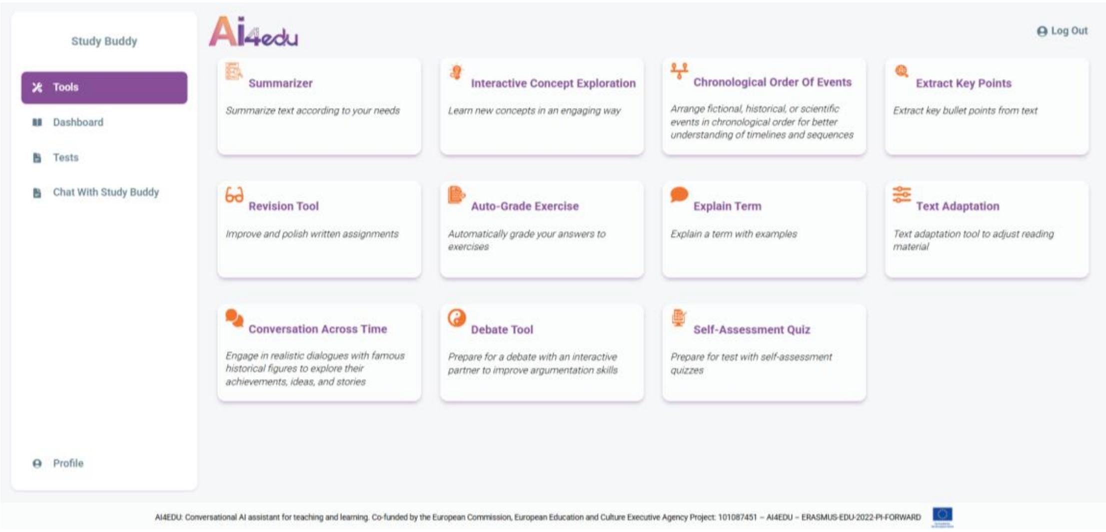

Figure 4: The Study Buddy interface

Beyond its core chat functionality, Study Buddy offers a comprehensive suite of learning tools, including text summarisation, key-point extraction, definition generation, concept exploration, self-assessment quizzes, essay revision, and self-evaluation tools. In the final development cycle, additional creative and discipline-specific tools were added, such as Text Adaptation, adjusting text complexity and style, Chronological Order of Events, constructing historical or scientific timelines, Conversations Across Time, offering dialogic exploration with historical or cultural figures, and a Debate Tool to engage learners in argumentation and critical thinking.

Study Buddy is complemented by a Student Dashboard, where learners can perform tests and track their performance on teacher-assigned tests created through Teacher Mate, view grades, and access teacher feedback.

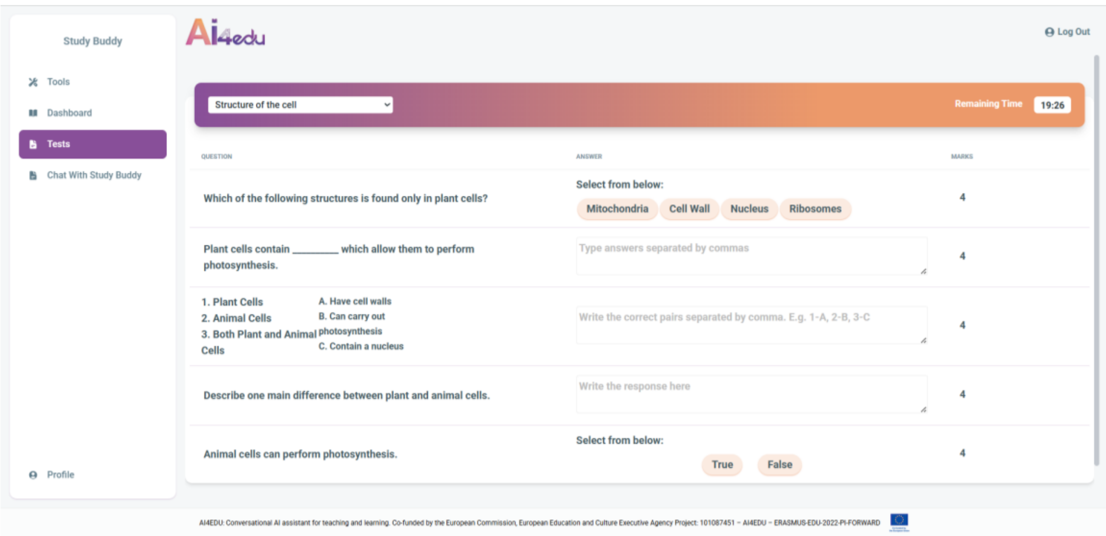

Figure 2: Study Buddy's test taking interface

These features collectively support metacognition, personalised study strategies, and meaningful learner autonomy, while maintaining pedagogical alignment through validated educational sources.

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6.2 Teacher Mate: AI Support for planning, instruction, and assessment

Teacher Mate is the teacher-facing assistant designed to reduce workload and enhance instructional design. In addition to its conversational interface, TM offers an extensive set of pedagogical tools that support lesson planning, differentiation, and assessment. These include tools for lesson plan generation, worksheet and activity creation, quiz and test generation, automatic grading, text adaptation for different reading levels, rubric generation, and group project design.

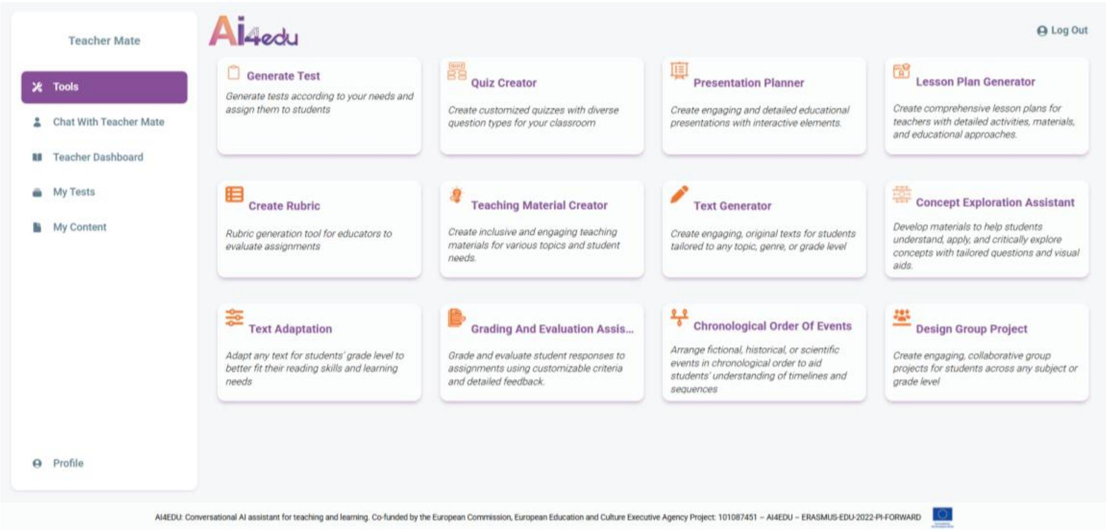

Figure 3: The Teacher Mate interface

A key innovation is the My Content section, which allows teachers to upload their own materials as PDFs and incorporate them directly into the RAG-supported tools. This enables quizzes, lesson plans, or explanatory texts to draw simultaneously from official textbooks and valid teacher-provided resources.

Figure 4: My Content section

Teacher Mate also includes a Teacher Dashboard with functionalities for class creation and management, test administration, longitudinal performance tracking, and AI-generated student feedback that teachers can edit and personalise.

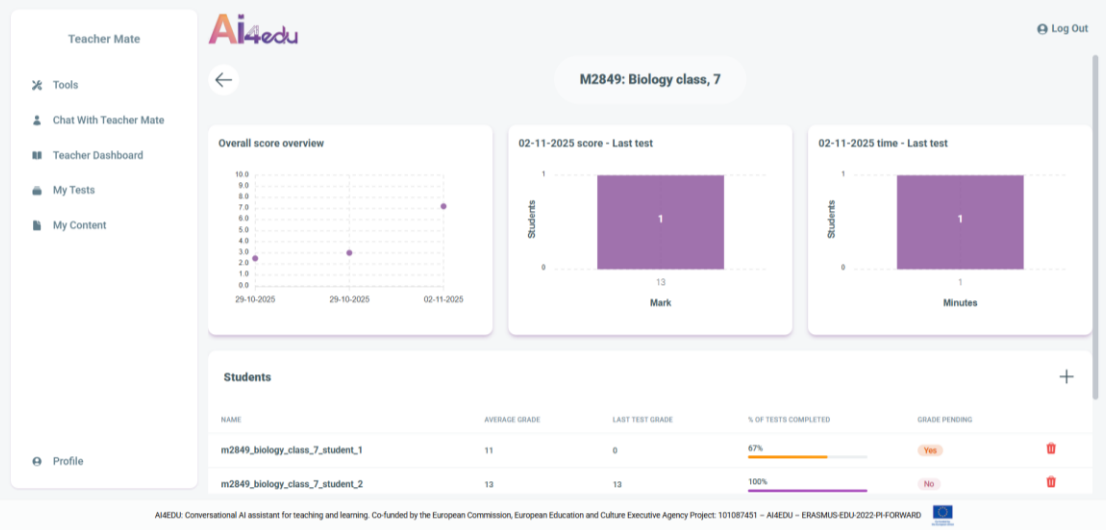

Figure 5: Teacher Dashboard class overview

All the above features were refined through iterative cycles to enhance usability, strengthen teacher control, and support inclusive, differentiated instructional practices.

7. Lessons learned from co-design

Across two years of participatory research and iterative prototyping, the AI4EDU project generated insights that extend beyond technical development. The co-design process revealed that engaging teachers and students as partners does more than refine technical features and functionalies: it reshapes attitudes, builds capacity, and anchors technological innovation in pedagogical purpose. The following overarching lessons emerged from this journey.

A first insight is that trust must be designed, not assumed. Early interactions with prototypes made it clear that teachers' confidence depended on the system's effectiveness, transparency and curriculum alignment. Visible prompts, curriculum-grounded retrieval, and editable outputs helped educators understand how the assistants produced information and ensured they remained in control of pedagogical decisions. Establishing clear boundaries between human and AI roles was essential for meaningful adoption, reflecting wider concerns in the educational community about the integrity and reliability of AI tools.

The second lesson concerns the power of participation in transforming adoption into ownership. When educators and students actively contributed to shaping the tools by expressing needs, testing features or indicating limitations, they moved from being passive recipients to co-creators of innovation. This participatory dynamic fostered professional learning, curiosity, and a shared sense of responsibility for responsible and effective AI use. Co-design thus functioned as both a methodological strategy and a form of capacity building that strengthened teachers and students' readiness to integrate AI meaningfully into their practice.

A third insight centers on the importance of pedagogy: human–AI collaboration works best within intentional, teacher-guided learning. The classroom pilots demonstrated that AI is most effective when embedded in structured activities guided by clear learning objectives, scaffolding, and opportunities for reflection. In these contexts, the assistants complemented teachers' expertise and further enhanced it. This finding underscores a recurring theme in the literature: that AI's value in education arises from thoughtful orchestration by educators who mediate between human and machine intelligence.

Finally, the project affirmed that one size never fits all: implementations across four countries revealed significant variations in language, curriculum structures, pedagogical traditions, and digital readiness. These differences highlighted the need for adaptable, flexible AI systems to fit educational and cultural realities. Design features enabling teachers to upload their own materials, adjust difficulty levels, or tailor prompts proved essential for ensuring contextual relevance and cultural responsiveness.

In general, insights from the co-design process demonstrated that human-centred design is not only a development philosophy but a pedagogical stance. AI in education succeeds when it amplifies human agency, respects diversity, and supports equitable participation. The co-design experience of AI4EDU thus offers a model for how educational AI can be developed responsibly, collaboratively, and in alignment with the complex realities of classrooms.

8. Conclusions

The final prototypes of Teacher Mate and Study Buddy are tangible outcomes of hundreds of teacher and student contributions across Europe. They embody AI4EDU's commitment to co-design, ethical innovation, and educational trust. Project's evaluation activities, demonstrated measurable gains in motivation, learning outcomes, and teacher efficiency when AI was used within guided pedagogical settings. Most importantly, AI4EDU has shown that responsible AI in education is possible when development is participatory, transparent, and grounded in real classrooms. The project's experience offers a model for future initiatives seeking to combine technological advancement with ethical, human-centred educational practice.

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Manuscript Title
AI4EDU Evidence into Action: WP7-Led Implementation Guidelines & Policy Recommendations for Responsible, Inclusive AI in Education

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Abstract

This paper presents deliverable 7.1 (D7.1), the capstone output of AI4EDU Work Package 7 (WP7), which translates multi-country pilot evidence and international guidance into a practical implementation playbook and policy recommendations for responsible AI in education. Drawing on pilots in Cyprus, Greece, Ireland and Sweden, and on cross-project outputs (D6.1/D6.2), we synthesise classroom practices that demonstrably reduce teacher workload while strengthening student understanding, metacognition and inclusion when AI is embedded within curriculum-first, teacher-mediated designs. We articulate a risk-based governance approach aligned with the EU Artificial Intelligence Act, and frame equity-by-design via accessibility, multilingual supports and baseline infrastructure. We propose a staged roll-out path (teacher-assistant → syllabus-grounded study buddy over 4–8 weeks), a light governance pack (disclosure norms, DPIA triggers, post-market monitoring), and shared indicators for monitoring learning, workload, inclusion and incidents. We conclude with actionable recommendations for ministries, school leaders and teachers to scale safe, human-centred AI use that augments—rather than replaces—teacher professionalism and learner agency.

Keywords: AI in education, implementation guidelines, policy recommendations, EU AI Act, teacher-in-the-loop

1. Introduction

AI4EDU explores how conversational AI assistants—**Study Buddy**[i] (students) and **Teacher Mate**[ii] (teachers)—can be integrated into everyday teaching and learning to enhance engagement, personalisation and assessment while protecting educational integrity. Within this programme, **WP7** focuses on human-computer interaction, ethics and equitable access, producing implementation guidelines and policy recommendations grounded in cross-country pilots and aligned with European and global frameworks. The contribution of this manuscript is twofold: (i) a synthesis of empirically grounded classroom practices that work across contexts when teacher-mediated and curriculum-first; and (ii) a governance and compliance compass that operationalises a risk-based approach in line with the EU AI Act and international guidance.

2. Methodology

We adopted a mixed-methods synthesis of AI4EDU pilot evidence (January–May 2025) across **Cyprus, Greece, Ireland and Sweden** and cross-referenced findings with the project's evaluation deliverables (**D6.1, D6.2**). The review considered:

(a) classroom orchestration patterns (teacher-assistant vs. study-buddy use);

(b) assessment integrity measures (disclosure, human-verification, authentic tasks); and (c) equity and accessibility enablers (UDL/WCAG-aligned design, multilingual supports, device/connectivity baselines).

In parallel, we mapped compliance requirements to the **EU AI Act** (risk-tiering, documentation, transparency and post-market monitoring) and to data-protection/security baselines to derive a light governance pack suitable for schools and ministries. Evidence was consolidated into good-practice guidance and a staged roll-out path validated with project partners.

3. Results

Practice: Teacher-mediated, curriculum-aligned use produces the clearest gains. Teachers reported **time savings** in planning and feedback and improved responsiveness via **quick formative checks**. Students benefited from clearer explanations, scaffolded practice and **metacognitive** prompts when AI use was disclosed and critically appraised.

Constraints: Timetable pressure, device/connectivity variability and **short pilot windows** suggest a need for staged adoption over **4–8 weeks**.
Technical enablers: Prompt libraries (persona + few-shot), **syllabus-grounded RAG** corpora with citation, and simple classroom routines supported reliable integration.

Organisational enablers: A light governance pack—**school AI charter**, disclosure norms, Data Protection Impact Assessment (**DPIA triggers**)[iii], logging/incident response—enabled assurance without constraining teacher agency.

4. Discussion

Findings align with a **human-centred** vision of AI in education: teachers remain the decision-makers; AI augments planning, feedback and differentiation; and students learn to evaluate AI critically. **Equity-by-design** must be embedded from the outset: accessibility, multilingualism and infrastructure baselines are not add-ons but preconditions for responsible scale. **Policy alignment** is essential:
risk-tiering and documentation per the EU AI Act, data-protection/security controls, and transparent assurance artefacts (e.g., **model cards**) should be normalised through procurement and CPD. Finally, **monitoring** must be light but continuous: shared KPIs should capture learning, workload, inclusion and incident rates, with **quarterly dashboards** informing iterative improvement across the partnership.

5. Conclusions and Future Work

D7.1 operationalises AI4EDU's evidence into a classroom **playbook** and a **policy/assurance compass** for ministries, leaders and teachers. Immediate priorities are:

1. stage adoption (teacher-assistant → syllabus-grounded study buddy),
2. protect Professional Development (PD) time and communities of practice,

3. institutionalise light governance and transparency, and 4. monitor with shared Key Performance Indicators (KPIs).

Future work should extend longitudinal evaluation, deepen syllabus-grounded RAG resources across languages, and pilot **regulatory sandboxes** with national agencies to align innovation, assurance and equity at scale.

Table 1: Monitoring indicators and evidence loops

Domain	Example KPI	Evidence Collection (Quarterly)
Learning	Mastery of curricular targets; gains on formative checks	Quiz analytics; teacher annotations; student self-reports
Teacher Workload	Time saved in planning/feedback	Time-use logs; teacher surveys; exemplar artefacts
Inclusion & Access	% learners with access/assistive needs supported	Device/connectivity inventory; accessibility checks
Integrity & Safety	Disclosure rate; incident frequency/severity	Classroom audits; incident log; corrective actions

Figure 1: AI4EDU WP7 evidence-to-action pathway—staged roll-out, light governance and monitoring KPIs (schematic).

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Discovery Space based on rooted research in the field and long-lasting experience employing ICT-based innovations in education is proposing the development of a roadmap for the AI-enhanced Classroom for Deeper Learning in STEM that facilitates the transformation of the traditional classroom to an environment that promotes the scientific exploration and monitors and supports the development of key skills for all students. The project designs an Exploratory Learning Environment (Discovery Space) to facilitate students' inquiry and problem-solving while working with virtual and remote labs. This is enabled by an AI-driven lifelong learning companion to provide support and guidance and with VR/AR interfaces to enhance the learning experience, to facilitate collaboration and problem-solving. **https://discoveryspace.eu**

The FAITH innovation initiative aims to develop and validate a human-centric ecosystem for optimizing trustworthiness in AI systems. This ecosystem will enable the measurement, optimization, and mitigation of risks associated with AI adoption in critical domains such as robotics, education, media, transport, healthcare, active aging, and industrial processes. This will be achieved through seven international Large-Scale Pilots. A significant aspect of the project is the cross-fertilization actions, which will integrate the insights and unique aspects of all pilots into a unified outcome. To achieve this, the project will implement a dynamic risk management approach, adhering to EU legislative instruments and ENISA guidelines. It will deliver tools that can be widely utilized across various countries and settings. Additionally, diverse stakeholder communities will be actively engaged in each pilot, resulting in seven sector-specific reports on trustworthiness to accelerate the adoption of AI. **www.faith-ec-project.eu**

The AIware project aims to develop a competency framework for schools between grades 7 and 12 and provide learning scenarios and materials for teachers and students. The project's main goal is to enable schools and teachers to incorporate AI into regular and extra-curricular classes, motivate engagement with future topics, and offer adaptable learning resources. Additionally, the project seeks to assess AI readiness in schools, share effective practices across Europe, and develop policy recommendations for educational authorities. By addressing the needs of schools, teachers, and students, the project aims to prepare educational institutions for the future. **www.aiwareproject.eu**

The GenAI4ED project aims to support educators and students in navigating the rapidly evolving landscape of AI-based educational tools powered by Generative AI and Large Language models. Recognizing both the immense potential and the associated risks of these technologies, the project seeks to develop a digital platform that evaluates popular GenAI tools based on carefully designed criteria, helping users identify the most appropriate solutions for their needs. Through pilot experiments in selected schools and an interdisciplinary approach involving educators, AI experts, psychologists, and ethicists, the project will assess the real-world impact of these tools on teaching and learning. **https://genai4ed.eu/**

AI4EDU offers two AI-powered solutions for education. The first platform, the Teacher Mate, offers comprehensive lesson planning, AI-powered grading and assessment, dynamic teaching materials, and an interactive teacher dashboard for managing classes, tracking student progress, and providing personalized feedback. The second one, the Study Buddy, provides AI-generated term and concept explanations, text summarization and key points extraction, interactive assessment tools with quizzes and feedback, and real time chat and voice interaction for an accessible learning experience. **www.ai4edu.eu**

ACT-AI Academy (European Academy for Teachers' skills and competences development for an effective AI Integration in education) aims to establish a pan-European academy for student-teachers, in-service teachers, and school leaders, focusing on equipping and/or upskilling them with the competences required to utilise AI effectively and ethically within the educational conAtext, as well as part of their professional engagement. Additionally, the project aims to raise awareness about the potential benefits of AI for enhancing educational outcomes and supporting the holistic development of students while addressing societal and ethical challenges. It seeks to increase awareness within the educational community and advocate for policy recommendations to ensure the responsible and equitable integration of AI in education. **https://actaiacademy.eu/**

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