Implementing a Statewide AI Curriculum: One Brazilian Experience

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Abstract. Since 2024, the Brazilian state of Piauí has incorporated a weekly Artificial Intelligence (AI) subject into the curriculum of public full-time high schools, where it is mandatory, with phased expansion by grade level through 2026. To support this statewide implementation, we developed an AI literacy curriculum aligned with Brazilian education standards. We adapted AI competency references to local constraints and emphasized both learning about AI and learning with AI through plugged and unplugged activitiesrationalized the curriculum through Open teacher-support resources, including a textbook for Basic Education (45 instructional sequences across 24 themes, 300+ pages) and 17 h of video lessons, all released under Creative Commons licensing. In parallel, we delivered an online distance-training program with synchronous sessions (recorded for asynchronous access), tutoring, and sustained teacher support throughout the school year. We present evidence from the first two years of the implementation, combining pre- and post-assessments and module-level evaluations, alongside participation and completion metrics. A total of over 650 unique teachers have been certified through the training across the first two years. The initiative currently reaches approximately 120,000 students across 494 full-time schools offering AI. We discuss design choices for resource-constrained settings and propose practical recommendations for scaling AI education across public-school systems.

Keywords: Artificial Intelligence Curriculum · AI Literacy · Basic Education

1 Introduction

Artificial Intelligence is increasingly embedded in everyday life, yet understanding remains limited regarding how AI systems work, what they can and cannot do, and how they impact society. As AI becomes a vital tool for civic life and work, schools must cultivate AI literacy that is relevant both to academic learning and to students' daily lives, integrating it into the formal curriculum through feasible plugged and unplugged approaches. Because AI-mentioned services shape students' lives regardless of school infrastructure, combining unplugged and plugged activities can help connect concepts to real-world uses of AI.

Since 2024, the Brazilian state of Piauí has incorporated a weekly AI subject into the curriculum of public full-time high schools, making it mandatory and expanding grade-by-grade through 2026. This paper reports how this statewide implementation has been supported through the development of an AI literacy curriculum framework and Creative Commons–licensed Open Educational Resources (OER), alongside sustained teacher support. The teacher training followed a cascade model, equipping teachers to implement AI literacy activities with their high-school students within the weekly AI subject, which is mandatory in public full-time high schools; accordingly, the evidence reported here focuses on teacher learning and classroom practice. Student outcomes are not assessed directly; instead, we report teacher learning gains and evidence of classroom implementation.

We present the AI literacy curriculum framework we developed to support this statewide implementation. The framework aligns with Brazilian education standards and UNESCO's 2024 competency guidance, with adaptations to the Brazilian context, including planet-centered considerations and workforce-related competencies for students [1]. In particular, we shift the emphasis from human-centered AI to planet-centered AI, highlighting the natural resources required to sustain AI systems (e.g., water, electricity, and critical minerals). Brazil is home to several large data centers, which makes these considerations especially salient in our context [2]. Building on our previously delineated curriculum [3], we operationalized the framework through OER (instructional sequences, teacher guides, video lessons, and lesson plans) released under Creative Commons licensing [4], and through an online professional development program combining synchronous meetings (recorded for asynchronous access), tutoring, and sustained teacher support throughout the school year.

Our approach conceptualizes AI literacy through AI Thinking, inspired by Computational Thinking [5,6], which integrates "thinking with AI" (effective use for problem-solving and creation) and "thinking about AI" (understanding the foundations, limitations, and ethical and societal implications). Given connectivity and infrastructure constraints, the framework prioritizes unplugged strategies, drawing on Unplugged Computational Thinking [7].

This work is motivated by equity concerns: digital divides in access to technology [8] may evolve into an AI divide shaped by access to services and the ability to use them critically [9]. Finally, we present learning evidence and participation indicators from the first two years of implementation, combining pre- and post-assessments in year 1 with module-based evaluations in year 2. We also discuss design decisions, constraints, and recommendations for scaling AI education within public-school systems. This paper makes four contributions. First,

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we propose an AI literacy curriculum aligned with Brazilian education standards and grounded in an AI Thinking perspective. The curriculum balances learning about AI and learning with AI through plugged and unplugged activities under infrastructure and connectivity constraints. Second, the curriculum was operationalized as an open teacher-support package, combining a textbook and video lessons, released under Creative Commons licensing to enable reuse and adaptation at scale. Third, the initiative was designed and delivered as a statewide online teacher training program with synchronous sessions (recorded for asynchronous access), tutoring, and sustained pedagogical support throughout the school year. Fourth, evidence from the first two years of implementation is reported, combining pre- and post-assessments, module-level evaluations, and participation/completion metrics.

The remainder of the paper is organized as follows: we first present the theoretical and design foundations that guided the curriculum; we then describe the curriculum and its open educational resources, followed by the teacher training program that supported statewide adoption; next, we detail the evaluation design and report results from the first two years of implementation; finally, we discuss implications for large-scale AI literacy initiatives and outline directions for future work.

2 Theoretical Framework and Design

This section summarizes the theoretical basis and design principles that informed the statewide implementation, connecting prior work on AI literacy and K-12 curricula to the constraints and opportunities of public education systems.

AI Literacy in K–12. It is understood that the level of literacy in AI expected from students varies substantially across educational stages. In early childhood and elementary education, students are typically introduced to foundational AI concepts and simple mechanisms through age-appropriate activities [10], while high school students are expected to have a deeper understanding of AI, being able to use AI tools to solve school-related tasks, and critically evaluate predictions, recommendations, and decisions produced by AI systems [11]. Correspondingly, several K–12 proposals design AI curricula for adolescents grounded in Computational Thinking and connected to everyday AI applications [4]. [12] propose a discovery and inquiry-based learning approach incorporating storytelling activities for early childhood education. They argue that fundamental AI concepts can be taught to kindergarten students. AI literacy without using machines can also be used in preschool education, as it reduces screen exposure in early childhood (under 5), for which the World Health Organization recommends limiting sedentary screen time [13]. AI-powered applications can support inclusion in education by enabling personalization and accessibility. Examples include adaptive learning platforms that tailor content to students' pace and preferences [14], speech recognition and text-to-speech tools that assist learners with disabilities [15] and interactive environments such as augmented reality

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that provide additional supports [16]. Adaptive assessment and feedback systems, including Intelligent Tutor Systems, can also adjust task difficulty and provide real-time feedback [17,18]. While these applications are relevant to educational practice, this paper focuses on AI literacy, that is, the competencies required to understand, use, and critically engage with AI systems and their impacts.

AI in Schooling: Opportunities and Risks. A recent study [19] about AI and programming skills indicates these tools will enable users to solve complex problems beyond their skill level in areas such as software development. However, the authors highlighted that this improved performance does not translate into improved skill acquisition and can leave users with an illusion of competence. We can infer that, as AI becomes increasingly integrated with education, it risks turning into an obstacle to learning. Not only as a mere "shortcuts for answers", providing answers, it can also be poorly suited to specific contexts or contents. Depending on its training, it may generate incorrect content (hallucinations) and also present underlying biases and promote discrimination and racism [20]. There is a need to create and spread good AI practices for teaching and studying, guaranteeing its use as a supporting technology.

AI Literacy Definition and Design Implications. This UNESCO Chair (UNESCO Chair ID omitted for anonymization) employs the term "AI literacy", a concept still in development as seen in [21–24] to describe the emerging set of skills necessary to live in an AI-mediated world. These new competencies may complement or replace existing ones as interacting with AI becomes essential for work and full participation in civic and private life. They also raise critical ethical issues regarding the responsible use of AI.

From our implementation experience, we derive three design implications about teaching AI in schools. The first one is that a general AI curriculum can tackle innovations brought forward by technological development. One example is that, even though it was written before the large adoption of generative AIs, the curriculum was considered relevant and was the basis for classes on prompt engineering and ethics, and fake news. The second one was that, although there is a lack of teachers with computer sciences degrees (only 70 participated), AI can be taught at the basic education level and, as it is an interdisciplinary field, it thrives in an interdisciplinary teaching system, being either a subject of discussion (thinking about AI), or a tool for learning (thinking with AI). While the classes on AI were given in a specific discipline, teachers came from many backgrounds and used their original fields to plan and create their lessons. The third finding is that there is a need to think about unplugged AI, and promote activities without the need to use computers. This is not only necessary because there are still several schools that do not have access to digital hardware, but also because these activities are very powerful interdisciplinary tools and easily applied to the disciplines. One such activity, the decision tree [24], involves the students creating a decision tree about a subject they are studying. As one

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of the teachers said, "It was considered a success, since the students had the opportunity to apply the logic of the artificial intelligence in a practical and interactive activity".

3 Curriculum Framework

This section describes the curriculum framework adopted in the statewide implementation and how it was operationalized through open teacher-support resources.

3.1 Curriculum Framework

In this context, our group developed a curriculum aligned with the National Education Standards [25] to support AI literacy in basic education, building on the experiences with the curriculum for high school students. This initiative includes teacher guidance and age-appropriate educational materials, as well as recommendations for the critical, inclusive, ethical, and responsible use of AI in classrooms.

The curriculum is organized around five aspects of AI, derived from the four aspects of the UNESCO proposal [1], and categorizes the set of abilities addressed across the instructional sequences. We understand ethics as a transversal requirement across these aspects rather than as an isolated component. We also include both a planet-centered perspective, going beyond human-centered framings to examine societal and environmental impacts, and a personal and professional improvement dimension, given the effects of AI on the world of work and civic participation. The aspects are:

– **Planet Centered AI:** Recognize Artificial Intelligence systems in different contexts, understanding their characteristics, capabilities, and impacts on society, while differentiating them from human intelligence; Manage your data with responsibility, protecting your privacy; Understand that AI requires natural resources to function and that these resources must be used ethically; Understand that AI is steered by humans and that its creation and use depend on human action and leadership, considering legal aspects and impacts on the planet; Relate human responsibility and skills with the intentional and ethical use of AI.
– **AI Foundations:** Describe real problems and their solutions in natural language and math; Describe computable solutions or algorithms; Recognize problems and use simple techniques to organize information to solve them through classical algorithms; Create solutions by drawing paths (graphs) showing possible options; Use organizational techniques and symbolic reasoning to implement solutions; Understand the theoretical limits of Computers and Artificial Intelligence; Understand the relationship between AI and Statistics.

- **Use and Design of AI Systems:** Understand that AI needs data (from different sources) to function; Use multimodal AI systems in a critical and reflexive way; Relate data privacy to ethics in AI; Experiment with AI solutions for inclusion; Evaluate data and its quality, applying preprocessing methods; Identify computer requirements, physical or virtual; Analyze and evaluate answers generated by AI systems, investigating the process and exploring alternatives for improvement; Apply the AI lifecycle, creating a solution that guarantees ethical principles from conception to implementation, ensuring transparency, equity, and accountability at all stages; Recognize the ethical and legal implications of using AI computer systems in society.
- **Techniques and application:** Use simple algorithms to classify and group objects; Relate machine learning to AI; Understand the limits and ethical concerns when using AI solutions; Understand what Deep learning is and how AI solves complex problems; Describe and experiment with an AI that learns from examples; Describe and experiment with an AI that learns by itself; Describe and experiment with an AI that uses reinforcement learning; Compare different types of machine learning in everyday situations; Train an AI for specific objectives, respecting ethical and privacy concerns.
- **Personal and professional improvement:** Understand AI's impact on social relations; Understand the relationship between AI and labour; Prepare and present AI problems and solutions clearly, adapting it to different audiences; Propose solutions using mixed teams cooperation (humans and AIs); Evaluate and criticize the result of a task solved by mixed teams; Use data responsibly, ensuring privacy and demonstrating personal and social commitment in AI-driven societies.

The aspects and abilities are connected with five technical dimensions (Human-AI interaction, Perception, Representation and Reasoning, Machine Learning, and Social impact). For example, the ability "Use forms of organization and symbolic thinking to implement solutions" is mapped to Perception and to Representation and Reasoning. This matrix was created based on Bloom's Taxonomy, as reviewed by Ferraz and Beilhot (2010), to support progression and to inform the design of learning activities and assessments.

To translate these abilities into broader educational goals, we define five competencies adapted from [26], presented in Table 1. Through this organization, we have three complementary ways to think about the curriculum: the aspects provide thematic organization, the dimensions support technical grounding, and the competencies clarify overarching learning goals to guide lesson planning.

Through this organization, we have three complementary ways to interpret and design learning activities: the aspects provide thematic organization, the dimensions provide technical grounding, and the competencies provide broader educational goals to guide lesson planning and assessment.

In this context, the challenge for educators remains the same: to prepare individuals who are equipped to face the present moment. This moment is marked by changes in how we interact socially, in learning environments, in work groups, and in legal frameworks, as well as changes in the skills required professionally.

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Table 1. List of competencies

Code	Competency
C1	Understand the principles of planet-centered AI, identifying risks, ethical implications, and its applications to society, analyzing challenges and impacts on social coexistence and human rights.
C2	Demonstrate knowledge of the fundamentals of AI, including basic concepts and operational principles, using critical thinking to analyze its limitations, possibilities, and social and ethical impacts.
C3	Evaluate AI systems with ethical solutions for real-world problems and create innovative applications, considering ethical aspects and exploring the potential of AI in different contexts.
C4	Understand and apply concepts of AI and analyze their possibilities, limitations, ethical impacts, and applications in various contexts.
C5	Relate Artificial Intelligence to the world of work, investigating how it transforms professions and contributes to the development of new skills.

Technology enters people's daily lives almost invisibly, and must be made visible. Human history shows that, over time, some competencies become obsolete while others become essential. Education must address these shifts consciously, focusing on practices that enhance human capabilities. Education is about that too: competencies and skills, and what matters is that technology should be taught consciously, focusing on practices that serve humans, in other words, technology that enhances human capabilities.

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3.2 Open Teacher-Support Resources

We operationalized the curriculum through open teacher-support resources released under a Creative Commons license, including a textbook for Basic Education (45 instructional sequences across 24 themes, 300+ pages) and 17 h of video lessons. The materials were designed to support plugged and unplugged activities and to help teachers from diverse disciplinary backgrounds adapt AI literacy lessons to local constraints. To support teachers in translating curriculum goals into classroom practice, we provided a lesson-plan template aligned with Brazilian national curriculum standards. Teachers were encouraged to adapt and author lesson plans tailored to the specific context of their schools. The template records the maturity level of the school and the teacher, the required resources, linked subjects (reflecting the cross-disciplinary nature of AI teaching), and important guiding questions to structure classroom discussion (e.g., "How does AI capture data?" and "How are or can these data be used?"). It also specifies lesson objectives and maps the targeted skills to the brazilian computing curriculum standards, supporting traceability between curricular goals and classroom activities.

4 Teacher Training Design

In 2024 and 2025, we developed a teacher professional development project in Piauí, Brazil, accompanying the phased rollout of the mandatory AI subject in public full-time high schools. The teacher training followed a blended approach, incorporating both plugged and unplugged AI methods. To achieve this, freely available AI technologies were utilized by different tech companies, focusing on everyday AI tools, such as those found on mobile phones, apps, and prioritizing cloud-based platforms. The goal of the training was to empower teachers to create their AI literacy content independently, regardless of the local context or the technology available at the time.

Piauí is a socioeconomically and geographically diverse state, and the public-school systems involved in the AI rollout operate under heterogeneous local conditions. Across municipalities, schools vary in connectivity quality, digital infrastructure, and access to devices, with more constrained conditions in many inland contexts. In addition, the teachers responsible for the subject come from different disciplinary backgrounds, which creates varying levels of familiarity with digital technologies and AI-related content. For this reason, both the curriculum and the teacher training model were designed to remain feasible across different school realities, combining unplugged and low-barrier plugged activities, mobile-friendly tools, recorded sessions, and ongoing tutoring support.

To design the training strategy, we use the proposal of [27] to invest time in providing individualized, one-to-one feedback with a holistic approach, engage with learners in asynchronous discussion forums, curate relevant supportive content resources, and deliver instructional content in efficient and versatile formats.

AI literacy followed the rollout progression: in the first year, the focus was on "understanding AI" (activities aimed to break the ice in the use of AI technologies); in the second year, the focus was on "applying AI" (training centered on technical aspects and classroom applications); and in the third year (2026, planned), the focus shifts to "creating with AI" (developing projects that involve the entire AI lifecycle).

The course lasted for three months each year and included weekly synchronous meetings. All sessions were recorded, allowing teachers to watch the synchronous lessons at their convenience, according to their schedules. Participants were divided into classes of no more than 30 teachers. Using an active learning methodology while cataloging several AI tools and activities, we also focused on a hands-on approach using practical class examples. Each class was supported by a tutor who answered questions in real time. After completing the training, teachers continued to receive ongoing support through tutoring sessions and monthly synchronous meetings to address questions and explore new AI topics and applications.

A local platform called "Mais Formação," from a company based in Piauí, was used to deliver the training. The goal was to preserve data by ensuring it was stored in Brazil. Regarding the profile of teachers trained in the distance learning modality, their degrees covered a variety of high school disciplines (355

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teachers), with 70 from computer science fields and 19 from areas not directly related to high school subjects.

5 Evaluation and Evidence from the First Two Years

We evaluated the first two years of implementation using a mixed evidence approach combining (i) a pre-test and post-test applied to teachers in year 1, (ii) module-level evaluations in year 2, and (iii) descriptive evidence of classroom enactment collected from school-shared artifacts and records (e.g., school social media). The analyses reported here focus on teachers who completed the teacher training and the associated assessments (N).

5.1 Teacher Learning Gains

Teachers completed a pre-test before starting the year-1 teacher training and a post-test after its completion. Both instruments were validated bu a group of 22 teachers who did not belong to the training sample. The analyses reported here focus on the 447 teachers who participated in the year-1 training cohort. As this was a large-scale implementation study, no control group was used. Results for the five assessed axes are presented in Table 2.

Table 2. Teachers' performance on AI main concepts before and after training

	Computational Thinking	Pattern Recognition	Symbolic Reasoning	Statistical Reasoning	Machine Learning
Pre-test	65.6%	58.6%	49.6%	52.3%	54.6%
Post-test	89.7%	77.7%	76.0%	71.0%	76.3%

Analyzing pre- and post-test scores with paired Student's t-tests for each axis, the observed differences are statistically significant at the 99% confidence level. Overall, the teacher training was associated with improved post-test performance across all assessed axes.

5.2 Module-Level Checks

In year 2, we complemented the pre/post evidence with module-level mastery checks embedded in the teacher training. The training was organized into seven modules, each concluding with a short multiple-choice assessment composed of ten items targeting the module's core concepts and classroom application points. To progress to the next module, teachers were required to achieve a minimum score of 7 out of 10. All questions related to AI literacy were assigned equal weight. Teachers who did not reach the threshold could retake the assessment until meeting the mastery criterion.

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A total of 414 teachers participated in year 2. In Table 3, Teachers completing module (N) refers to the number of teachers who completed each module by reaching the $\leq 7/10$ criterion (i.e., obtained the passing score at least once). For each module, Passed on 1st attempt (%) is computed among module completers as the proportion of teachers who reached the passing score on their first attempt. Mean attempts reports the average number of attempts required by module completers to reach the passing score for the first time.

These module-level indicators provide complementary evidence about learning progression and feasibility under a mastery-oriented training design, beyond the end-of-course gains reported in Table 3.

Table 3. Module-level mastery check outcomes in year 2 (criterion: $\geq 7/10$)

Module	Teachers assessed (N)	Passed on 1st attempt (%)	Median attempts
Module 1	414	79.71%	1.40
Module 2	396	71.21%	1.41
Module 3	383	68.66%	1.35
Module 4	374	85.29%	1.09
Module 5	372	77.69%	1.23
Module 6	369	84.28%	1.05
Module 7	359	86.62%	1.02

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Overall, the results indicate that the mastery threshold was attainable for most teachers, with first-attempt pass rates ranging from 68.66% (Module 3) to 86.62% (Module 7) and a low average number of attempts (approximately 1.02–1.41). Modules 2 and 3 show comparatively lower first-attempt pass rates and higher average attempts, suggesting that these modules may have posed greater conceptual or instructional demands and could benefit from additional scaffolding (e.g., worked examples, extra practice items, or clearer guidance tied to classroom applications). The gradual decrease in N across modules (from 414 in Module 1 to 359 in Module 7) also suggests cumulative workload effects over time, reinforcing the importance of pacing and support mechanisms in large-scale online training.

5.3 Classroom Enactment Evidence

Beyond test-based learning evidence, classroom enactment provides insight into how teachers translated training content into practice under real school constraints. Figure 1 illustrates complementary ways teachers introduced algorithmic reasoning and AI concepts by combining unplugged and low-barrier digital activities. On the right, students co-constructed and presented a large decision tree as an unplugged activity, making classification criteria explicit and discussable. On the left, teachers leveraged shared devices and whole-class projection to conduct plugged activities, including guided experimentation with Teachable Machine and small-group exploration of everyday AI applications on mobile devices. Together, these examples show how teachers adapted the curriculum to limited infrastructure while sustaining engagement and preserving core conceptual goals.

Fig. 1. Classroom enactment examples combining unplugged and plugged AI literacy activities under constrained infrastructure.

Figure 1 presents three complementary classroom enactments. In the top-left panel, students work in small groups using a shared mobile device to explore an everyday AI application, supporting discussion about how AI systems produce outputs from inputs in familiar contexts. In the bottom-left panel, the class uses Teachable Machine with a projected interface to collectively experiment with training and testing a simple classifier, enabling whole-group reflection on data, labels, and model behavior. In the right panel, students construct and present a decision tree as an unplugged activity, making classification criteria explicit and open to critique.

These enactments were not isolated classroom examples, but reflected the progression of the teacher training itself, which was carried out in parallel with school implementation. Early activities emphasized foundational AI concepts through low-cost and context-adapted tasks, such as identifying inputs and outputs in everyday AI applications, collectively training simple classifiers with shared devices and projected interfaces, and constructing decision trees as unplugged representations of classification logic. As the course advanced, teachers gradually incorporated activities involving data capture and introductory machine-learning ideas, adapting them to local school conditions. This parallel structure also allowed teachers to rely on ongoing tutor support and follow-up synchronous meetings as they translated course content into classroom practice.

5.4 Synthesis and Implications

Across two years of implementation, the teacher training supported measurable gains in core AI-related concepts (Table 2) and also led to diverse forms of classroom enactment documented in school contexts. Together, these results suggest that a curriculum grounded in AI literacy, supported by a structured teacher-support package and by plugged and unplugged strategies, can be enacted in practice by teachers from different disciplinary backgrounds.

Importantly, the classroom examples reinforce that enactment is not limited to tool use: teachers and students engaged with algorithmic ideas (e.g., decision trees) and with ethical questions central to AI literacy (e.g., misinformation), using formats that remain feasible under varying levels of infrastructure. These findings inform the discussion of design choices and recommendations for scaling AI education within public-school systems.

6 Conclusion and Future Work

Education is vital for society, as it supports personal development, social inclusion, and active citizenship, as well as innovation, creativity, and economic activities. In this context, ethics becomes indispensable for both the development and the use of AI. We need to understand what AI can offer and what it requires from us, particularly in terms of data, privacy, and power, so that we can decide which AI we want.

This project engaged teachers from various academic fields, fostering a cross-disciplinary approach to ensure that AI education is meaningful across diverse high school subjects. Initially, many teachers were hesitant to embrace technology. However, initial hesitation appeared to decrease as teachers engaged with unplugged activities and practical classroom applications. Rather than focusing only on using AI tools, the training emphasized understanding how AI works and its underlying mechanisms, aiming to support responsible and context-sensitive classroom practices.

In an era increasingly shaped by AI, expanding opportunities for teachers and students to engage critically, ethically, and creatively with these technologies is becoming an important educational priority. The curriculum framework presented here, grounded in AI Thinking and aligned with international references while responding to Brazilian constraints, represents an effort to broaden access to AI literacy through a structured and scalable approach.

As future work, building on the high school implementation and the evidence reported in this paper, our next steps are to further refine the curricular matrix, expand the set of activities and lesson suggestions associated with each ability, with special attention to unplugged AI as a recurring demand in teacher training.

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We also plan to extend the approach to additional remote regions, strengthening support materials and implementation guidance to enable adaptation across contexts. Finally, a new training cycle is planned to support the next phase of rollout, emphasizing project-based activities that move toward "creating with AI" and, when feasible, projects that address broader AI lifecycle phases.

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