



STIAEM

Slow Tech Innovation

AI, Ethics and
New Teaching Methods

PEDAGOGICAL MODEL



Università di Foggia
Studi Umanistici, Lettere, Beni Culturali,
Scienze della Formazione



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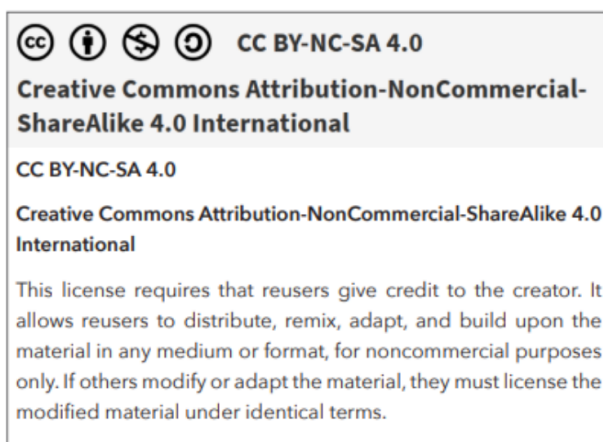
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PROJECT STIAEM INFORMATION

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Introduction

In the current scenario of accelerated digital transformation, the integration of Artificial Intelligence (AI) in education has established itself as an unavoidable priority. However, this development raises the urgency of confronting “technological accelerationism”, a phenomenon that often prioritizes technical speed over critical reflection and respect for human learning rhythms. In this sense, the model aims to promote Cognitive Sustainability, protecting the space for critical reflection from automated delegation and ensuring that algorithmic integration enhances, rather than replaces, the learner’s Epistemic Agency. The STIAEM (Slow Tech Innovation: AI, Ethics and New Teaching Methods) pedagogical model emerges as a necessary response to ensure that educational innovation is not only advanced, but also ethically responsible and socially just.

The justification for this model lies in the imperative need to move from purely instrumental training to deep and humanistic AI literacy (Patrignani & Whitehouse, 2014a; 2014b; 2019). STIAEM proposes a balance between technical innovation and social responsibility, ensuring that technology maintains the centrality of people and mitigates critical risks such as technostress or algorithmic biases (Patrignani & Whitehouse, 2014a; 2014b; 2019). Within this balance, AI is redefined as an Epistemic Co-creator (Cognitive Partner): the student does not passively receive content but negotiates meaning with the machine, using it as a lever to reach complex cognitive goals otherwise out of reach. This approach is operationalized through the Slow Tech Attitude paradigm, which articulates technology under three essential dimensions: *Good IT* (well-being and ethics), *Clean IT* (environmental sustainability), and *Fair IT* (equity and social justice) (Patrignani & Whitehouse, 2014a; 2014b; 2019).

To achieve these objectives, the model integrates and coordinates several fundamental scientific and pedagogical elements:

- AI4K Standards¹²: To structure technical knowledge through its “Big Ideas” (Miao et al., 2024; Cosgrove & Cachia, 2025)

- UNESCO Framework: To define competencies that preserve critical judgment and teaching authority (*human-in-the-loop*) (Miao & Cukurova, 2024).
- UDL and the ARTE Model: To guarantee inclusion (Roski et al., 2024; Stelea et al., 2025) through Agency, Reflection, Transformation and Ethics in learning. The integration of UDL and the ARTE model is not limited to providing multimodal supports but is configured as a strategy to manage Learner Variability, acting on executive functions (planning and self-monitoring) to break down specific cognitive barriers through AI's adaptive scaffolding.

Finally, the document is organized into four sections that define its structure:

1. **Theoretical foundation:** Where the scientific pillars and international frameworks are detailed.
2. **Structure of the model:** The scientific validation of the framework adopts the PDCA (Plan-Do-Check-Act) model, ensuring an iterative refinement based on the evidence emerged in real-world contexts.
3. **Cooperative development methodology:** Which explains the convergence between Slow Tech and UDL for educational inclusion.
4. **Implementation and assessment:** Detailing the practical tools and criteria for validating teaching experience and learning in real-world environments

1. Theoretical foundation

The pedagogical architecture of the STIAEM model is not merely an adoption of technological standards; rather, it constitutes an integrated framework designed to reconcile algorithmic innovation with the primacy of human agency. The theoretical core of the project is grounded in the human-in-the-loop paradigm, ensuring that intentional control, critical validation, and pedagogical authority remain firmly in the hands of teachers and students, preventing a passive cognitive delegation to automated systems. The foundations of the model are organized through a logical hierarchy (Figure 1): starting with socio-technical ethics (Slow Tech Attitude), moving through scientific literacy standards (AI4K12) and professional competency frameworks (UNESCO and DigComp 3.0), and finally reaching inclusive methodology (Universal Design for Learning). This synergy allows the model to position AI as a dynamic cognitive scaffolding, capable of enhancing learning processes without ever displacing human

judgment. In the following sections, each pillar is detailed not only in its theoretical sense but operationalized to ensure a balance between digital progress, equity, and the natural rhythms of the human mind.

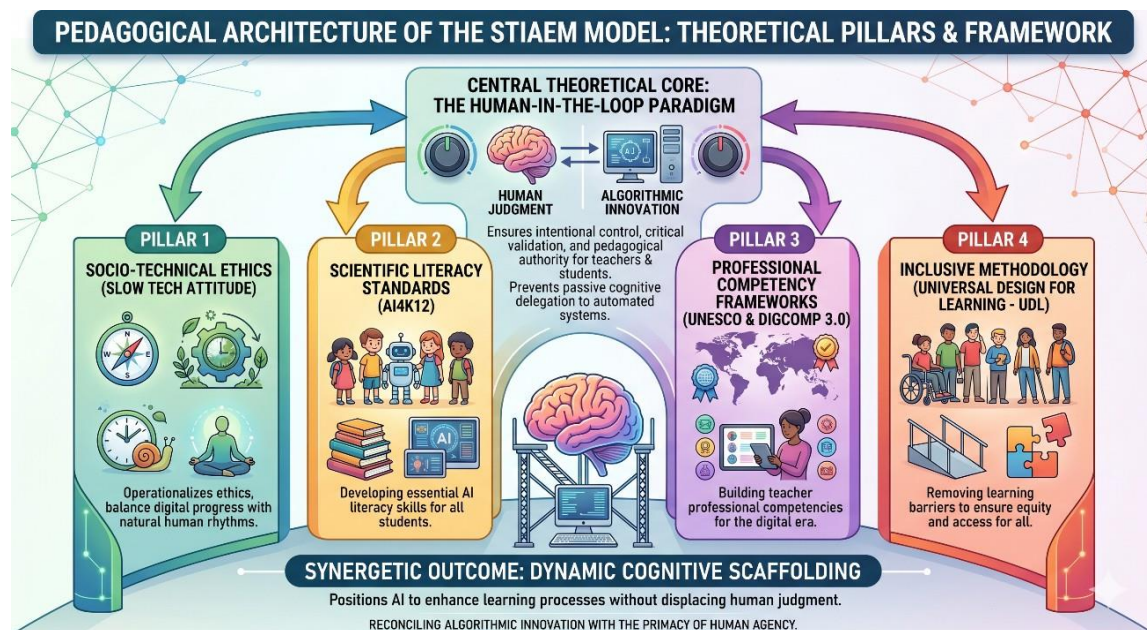


Figure 1. STIAEM Pedagogical Foundations. A mapping of scientific constructs designed to reconcile algorithmic innovation with the primacy of human agency.

1.1 Ethical Paradigm: Slow Tech Attitude

The Slow Tech Attitude paradigm is the central interpretive key of the STIAEM project, designed to promote a conscious digital transformation that opposes technological accelerationism devoid of critical reflection. This approach structures the pedagogical model under three fundamental dimensions (Patrignani & Whitehouse, 2014a; 2014b; 2019).

The Good IT dimension focuses on ethically acceptable technology that prioritizes human well-being and the centrality of people in decision-making processes. Within this framework, AI integration is operationalized through a human-in-the-loop architecture, ensuring that intentional control remains with the teacher and the student to mitigate risks such as technostress and excessive cognitive offloading. The Clean IT dimension addresses the ecological footprint of AI systems in the school environment, aiming to promote sustainable digital practices and the selection of energy-efficient hardware and software. Finally, the Fair IT dimension focuses on assessing the fairness and social desirability of technology. It critically analyzes algorithmic biases, such as those in auto-correctors that may penalize non-native students, and works to eliminate inequalities of access. Given that training data may lack representation, AI is viewed as a sociotechnical

phenomenon that requires constant human oversight to prevent rights violations and ensure genuine inclusion for all students. Ultimately, sustainability literacy and AI ethics are proposed as essential components for educators to adopt a Slow Tech Attitude, capable of balancing innovation with social responsibility and the natural rhythms of learning (Yue et al., 2024).

1.2 Scientific Literacy Standards (AI4K12)

To ensure deep and humanistic Artificial Intelligence (AI) literacy, the development of the STIAEM Pedagogical Model is not limited to adopting international standards, but integrates and reworks them under the prism of the Slow Tech Attitude paradigm (Miao et al., 2024; Cosgrove & Cachia, 2025; Yue et al., 2024). Knowledge is organized around the sociotechnical pillars that allow teachers and students to understand AI as a complex phenomenon and not merely technical (Miao et al., 2024; Cosgrove & Cachia, 2025).

This approach makes it possible to go beyond mere technical training to focus on the pedagogical “why” and the proposed paradigm of human centrality (Patrignani & Whitehouse, 2014a; 2014b; 2019) and the teacher’s decision-making and ethical reflection in the face of classroom challenges (Wang et al., 2025; Miao & Cukurova, 2024).

The two fundamental frameworks incorporated are summarized below, such as AI4K12’s 5 “Big Ideas”. This standard, known internationally as AI4K12, is one of the scientific pillars of the STIAEM project to define what Artificial Intelligence literacy really means beyond the technical use of tools (Cosgrove & Cachia, 2025). The model organizes knowledge into five “Big Ideas” that allow AI to be understood as a complex sociotechnical phenomenon (Miao et al., 2024; Cosgrove & Cachia, 2025).

Each concept is then explained in depth according to the project framework, which integrates the international standards of the AI4K12 initiative and UNESCO’s competency frameworks (Miao et al., 2024; Cosgrove & Cachia, 2025).

1.2.1 Perception and representation of models

AI systems acquire data from the environment using sensors, but lack a real understanding of the world; what they do is build models of reality to simulate reasoning processes (Miao et al., 2024; Cosgrove & Cachia, 2025).

STIAEM approach: It is essential that the classroom recognizes that AI is a probabilistic simulation based on models that may be incomplete. This critical awareness allows the

teacher to act as a human-in-the-loop, always validating the veracity of the technological representation (Miao & Cukurova, 2024; Patrignani & Whitehouse, 2014a)

1.2.2. Machine Learning and Data Dependency

Machine learning allows the system to improve by identifying patterns in large training datasets (Miao et al., 2024).

STIAEM approach: It is emphasized that the algorithm depends entirely on the nature and quality of the data. If the data is not representative, the system will inherit biases, which connects this area directly to the Fair IT dimension to actively combat algorithmic discrimination in valuation (Patrignani & Whitehouse, 2014a).

1.2.3. Natural interaction and human centrality

AI seeks to communicate intuitively by mimicking human behavior, such as natural language (Miao et al., 2024).

STIAEM approach: The model strongly warns about the risks of anthropomorphization, where the user attributes feelings or consciousness to a software. An interaction that uses AI as an epistemic co-creator is promoted, but always maintaining the pedagogical authority and intentional control of the human to avoid excessive cognitive delegation (Miao et al., 2024; Patrignani & Whitehouse, 2014a).

1.2.4. Social and ethical impact of AI

This is the core dimension of the project, focused on ethics, responsibility, and respect for human rights (Miao et al., 2024; Cosgrove & Cachia, 2025).

STIAEM approach: It is operationalized through the Slow Tech paradigm, assessing whether a technology is:

Good IT: If it promotes well-being and respects human rhythms (Patrignani & Whitehouse, 2014a; 2014b; 2019).

Clean IT: If it is environmentally sustainable and efficient in its energy consumption (Patrignani and Whitehouse, 2014a; 2014b; 2019).

Fair IT: Whether it is socially just, transparent and free of bias that violates privacy (datafication) (Patrignani and Whitehouse, 2014a; 2014b; 2019)

This dimension constitutes the fifth major idea of the AI4K12 international standard and is the most relevant axis for the STIAEM project, focused on ethics, responsibility and respect for human rights (Miao et al., 2024; Cosgrove & Cachia, 2025).

In depth: AI can generate algorithmic biases (discrimination), affect privacy (datafication) and change the labor market. The model proposes a “Slow Tech Attitude” to assess whether a technology is good (good IT), clean (clean IT: environmental sustainability) and fair (Patrignani & Whitehouse, 2014a; 2014b; 2019).

- **Application in the classroom:** Dilemma scenarios are used, Situational Judgment Test (SJT) where teachers must decide, for example, whether to use an automatic corrector that saves time, but can penalize non-native students for biases in their training (Miao & Cukurova, 2024; Wang et al., 2025).

1.3 Teacher Competency Framework (UNESCO)

UNESCO’s framework is used to promote a humanistic vision of technology, ensuring that AI is at the service of human rights and educational equity (Miao & Cukurova, 2024).

1.3.1 Human-Centered Mindset

This pillar seeks to ensure that the teacher always maintains authority and critical judgment in the face of automated decisions, that is, to ensure that AI supports and never replaces human judgment in teaching processes (Miao & Cukurova, 2024).

- **Deepening:** It is linked to the “Good IT” dimension of the Slow Tech paradigm, which prioritizes human well-being and the centrality of people (Patrignani & Whitehouse, 2014a; 2019).
- **Application:** The teacher must act as a “human-in-the-loop”, ensuring that the AI respects natural learning times and mitigates technostress

1.3.2 Ethics of AI

It goes beyond knowing rules; it implies constant ethical vigilance to detect risks of discrimination and information asymmetries. Understanding and applying core values such as justice, sustainability, and algorithmic transparency in the Miao & Cukurova classroom, 2024; Wang et al., 2025).

- **Deepening:** It connects directly with the dimensions “Fair IT” (algorithmic equity) and “Clean IT” (environmental sustainability) (Patrignani & Whitehouse, 2014a; 2019).
- **Application:** Teachers should critically evaluate algorithmic biases (e.g., in auto-correctors that penalize non-native students) and the ecological

footprint of AI systems (Miao & Cukurova, 2024; Patrignani & Whitehouse, 2014b).

1.3.3 AI pedagogy

Identify where technology can truly enhance learning and foster student engagement and empathy (Miao & Cukurova, 2024).

- **Deepening:** Use the 5 “Big Ideas” of AI4K12 (perception, representation, learning, interaction and impact) to structure the didactic content (AI4K12 Initiative; Miao et al., 2024)
- **Application:** It seeks to understand the pedagogical “why” of adopting technological practices, avoiding “digital accelerationism” without reflection (Patrignani & Whitehouse, 2014a).

1.3.4 Professional Development

Use AI for the continuous growth of the teacher, allowing them to design personalized and meaningful teaching strategies (Miao & Cukurova, 2024).

- **Deepening:** The project seeks to enhance digital skills so that teachers move from a merely instrumental vision to a less deterministic vision of technology (Patrignani & Whitehouse, 2014a; 2019).
- **Application:** It translates into the creation of a MOOC (massive online course) and a repository of Open Educational Resources (OER) based on the validated pedagogical model.

The combination of these frameworks allows the project to take a “deep picture” of the current state of AI in schools. Rather than just measuring whether a teacher knows how to use a tool, STIAEM uses these standards to assess the teacher’s critical ability to mitigate risks such as algorithmic bias and protect student privacy.

1.4 Digital Competence Framework (DigComp 3.0)

The European Digital Competence Framework (DigComp 3.0) is an evolution of the original framework developed to improve the understanding and development of digital competences in Europe, structured in five areas with 21 competences and three levels of proficiency for each (Institute for Prospective Technological Studies, 2013).

Since 2022, research has mainly explored the practical application of DigComp in the assessment of digital competences using questionnaire-based instruments, although a lack of robust procedures to ensure its validity and reliability has been identified (Mattar et al.,

2022). In addition, specific frameworks have been proposed for different groups, such as the DigCompEdu for educators, which seeks to align teaching competencies with the challenges of the twenty-first century and facilitate continuous professional development and institutional improvement (Caena & Redeckeer, 2019). In the field of education, a framework adapted to primary and secondary students has also been developed that incorporates specific performance criteria to promote and assess digital competence at these levels (Guitert et al., 2020).

Recent research includes conceptual proposals that extend DigComp 2.0 to include competencies related to mobile environments and professional aspects relevant to students, highlighting the need for specific frameworks for different user profiles (Hammoda & Foli, 2024).

Finally, empirical studies applied in national contexts such as Vietnam confirm the validity of the DigComp framework for measuring citizen digital competences and highlight the influence of individual factors such as gender, education and work context on digital competence levels (Nguyen et al., 2024).

Overall, this research shows a consensus on the usefulness of the DigComp 3.0 Framework as a key reference for the development, assessment and certification of digital competences in various social and educational sectors, although it underlines the continuous need to adapt tools and instruments to specific contexts and ensure their methodological rigour

1.5 Universal Design for Learning (UDL)

UDL “is the process that allows addressing and responding to the diversity of the needs of all students through greater participation in learning and reducing exclusion from the education system”.

It is essential to clarify that UDL in this model is not only to offer “several formats”, but to eliminate barriers to learning and participation. It should be emphasized that AI acts as a “cognitive scaffolding” that supports the strategic networks (the “how”) of students with specific needs.

It is based on three principles related to the three neural networks that have the greatest involvement in learning (CAST, 2024):

1. The Why. They activate affective networks. Multiple forms of engagement. Use different strategies to motivate students and facilitate participation, taking into account the variability or heterogeneity of the student.

2. The what. They activate recognition networks. Multiple means of representation. Present the information in different media to take into account the different ways of accessing and processing the information.

4. The How. They activate strategic networks. Offer different possibilities of expression, organization and planning (Fernández, 2025, p. 6).

2. Model structure

The teaching of AI in the STIAEM model is not organized in isolation, but as a hybrid and socio-technical process:

Diagnostic Phase: It is based on a “deep picture” obtained through comparative research in five countries (Italy, Spain, Turkey, Greece and Lithuania).

Cross-Mainstreaming: The structure combines technical literacy (the “how”) with pedagogical and ethical reflection (the “why”), integrating the AI4K12, DigComp 3.0 and UNESCO guidelines frameworks (Miao & Cukurova, 2024; Cosgrove & Cachia, 2025).

Continuous Improvement Cycle: Adopts the PDCA (Plan-Do-Check-Act) method to ensure that the model is dynamic and adjusts after actual experimentation in the classroom.

2.1 Content Dimensions for Active Digital Citizenship

The contents of the STIAEM model are restructured to foster active digital citizenship, evolving the foundational concepts of AI4K12 into a more integrated and original conceptual framework. This curriculum is organized around four interconnected dimensions that guide students from technical understanding to ethical awareness. The first dimension, world decoding and reality modeling, examines how systems perceive their surroundings and construct digital representations of knowledge. This leads to the study of algorithmic logic and data stewardship, where the principles of machine learning are explored alongside the critical dependence of outcomes on data quality and provenance. The third dimension, symbiotic interaction and human presence, focuses on human-machine communication, promoting a conscious use of natural language that avoids excessive anthropomorphization while reaffirming the learner’s intentional control. Finally, socio-technical responsibility and systemic ethics represents the core of the model; here, the critical analysis of bias, privacy, and datafication merges with the Slow Tech paradigm to assess the impact of technology on both society and the environment (Miao et al., 2024). This approach transforms technical content into tools

for empowerment, ensuring that every competency acquired is consistently mediated by critical reflection and human agency.

2.2 Emergence of “Implicit Knowledge”

Strategies to capture the ethical and pedagogical decisions that teachers make in their daily practice and that are not codified (Wang et al., 2025).

To capture teachers’ uncoded ethical and pedagogical decisions, the model implements “ethics in action” strategies:

- **Situational Judgment Tests (SJT):** Use of real dilemma scenarios (e.g., Efficiency vs. Equity) to observe how the teacher makes critical pedagogical decisions in the face of AI in everyday situations.
- **Qualitative Methodologies:** Co-design workshops, focus groups and the use of reflective logbooks to surface fears and perceptions that do not appear in standard surveys.
- **Triangulation of Perspectives:** Compare the views of teachers, students, and administrators to identify systemic barriers and real training needs.

It is necessary to keep in mind that resistance is not only technical, but also ethical and emotional, and that it is managed through Situational Judgment (SJT) tests and reflective logbooks, which allow these tensions to come to light to be analyzed instead of being ignored.

2.3 ARTE Model: Constructs of Human Interaction and Student Heterogeneity - AI

The ARTE (Agency, Reflection, Transformation and Ethics) model is defined in the STIAEM project to focus on the emerging constructs of deep AI literacy. This interpretation acts as a epistemic compass for teachers and students, ensuring the core balance between digital innovation and pedagogical responsibility.

A- Agency: The user’s ability to maintain intentional control over the educational process, avoiding excessive cognitive delegation. In this framework, AI does not displace thought but amplifies its reach under the learner’s constant critical direction, ensuring the principle of human-in-the-loop.

R- Reflection: Promotion of a constant critical analysis of the functioning of technology, opposing technological accelerationism lacking deep thinking. This dimension transforms human-machine interaction into an exercise of meta-reflection, where algorithmic output is treated as the subject of critical debriefing rather than a final verdict.

T- Transformation: The use of AI to redefine cognitive tasks, allowing pedagogy to evolve towards levels of creation and analysis that were previously unattainable. Aligning with the “Redefinition” stage of the SAMR model, AI serves as a catalyst for intellectual challenges of superior complexity.

E- Ethics: A proactive assessment of algorithmic bias and privacy (datafication) aligning with the Fair IT dimension of the Slow Tech paradigm. Ethics ceases to be a mere regulatory constraint and becomes a design pillar that safeguards equity and digital sustainability.

By integrating these four pillars, the ARTE model provides the operational foundation for the UDL (Universal Design for Learning) method. Consistent with the most recent literature on Learner Variability, the STIAEM model moves beyond static profiles to focus on the elimination of barriers through flexible design (CAST, 2024; Fernández, 2025, p. 1). Under this paradigm, AI is leveraged to offer multiple options that respond to the genuine heterogeneity of the classroom (CAST, 2024; Fernández, 2025), ensuring that technological innovation serves as a tool for inclusion rather than an end in itself.

This approach allows AI to act as a dynamic cognitive scaffolding that enhances students’ executive functions (García-Campos et al., 2018). Rather than being a mere transmitter of information, technology provides specific supports for the planning, organization, and self-regulation of study (Romero-Esquinas et al., 2024). Such a structure enables each student to navigate knowledge according to their own abilities and rhythms (Barna et al., 2025), selecting the itinerary that best compensates for specific learning difficulties or special educational needs (Edyburn, 2021). This dynamism is essential for consolidating the balance between digital innovation and pedagogical responsibility that defines the project’s identity.

Ultimately, by providing various forms of engagement, representation, and expression, we ensure that digital literacy is both inclusive and respectful of the learner’s Agency. This involves applying UDL not just as a structural framework, but through an emotional and affective lens, working on affective regulation and self-regulation areas that represent a vital frontier for future research (Farina and Del Carmen, 2025). This methodological commitment, supported by a Mixed Methods research design, aims to transform numerical data into a dense pedagogical narrative, fostering an AI integration that is genuinely conscious, ethical, and sustainable.

3 Validation methodology and cooperative development

This proposal for the STIAEM Pedagogical Model is based on the convergence of the Slow Tech paradigm and the Universal Design for Learning (UDL) approach, with the aim of transforming Artificial Intelligence into an engine of educational inclusion for students between 14 and 19 years of age.

3.1 Pedagogical model

The model organizes the teaching of AI and the use of tools through the three UDL learning networks (Bray et al., 2024; Mary, 2023). Its purpose is to address diverse student needs through multi-format learning designs, ensuring inclusion as a human right. By leveraging Artificial Intelligence, it respects student dignity, autonomy and capacity while providing teacher training and continuous process oversight (Fernández, 2026). We aim to integrate the consolidated analysis of learning styles within the dynamic paradigm of Learner Variability, using AI not only to map individual preferences but also to respond in real-time to the dynamic nature of learning profiles and remove barriers to participation. It is essential to clarify that UDL in this model is not only to offer “several formats”, but to eliminate barriers to learning and participation. It should be emphasized that AI acts as a “cognitive scaffolding” that supports the strategic networks (the “how”) of students with specific needs. In this context, we seek to position AI as an extension of self-regulation skills, acting on executive functions to facilitate mental load monitoring and thought organization.

To strengthen this design, the STIAEM model is based on a socioconstructivist and connectionist matrix. From this perspective, Artificial Intelligence is redefined as an epistemic co-creator, moving beyond a simple channel for transmitting content to becoming an agent with which the student negotiates meanings. We advocate for understanding AI as an active cognitive partner with whom the student interacts to question, refine, and transform their own mental constructs, ensuring that learning remains an active process of discovery.

From connectionism, AI acts as a critical node that expands the learner’s learning networks, facilitating the creation of new connections between complex concepts. From socioconstructivism, a dialogic construction of knowledge is promoted where the student (Vaičiūnienė & Kazlauskienė, 2022), through their Agency (ARTE model), interacts with AI to question, refine, and transform their own mental constructs, ensuring that learning

is an active process of discovery and not a passive reception of automated information (Mishra, 2023; Saleem et al., 2021).

The model as indicated by the *UDL* and the ARTE model (Figure 2):

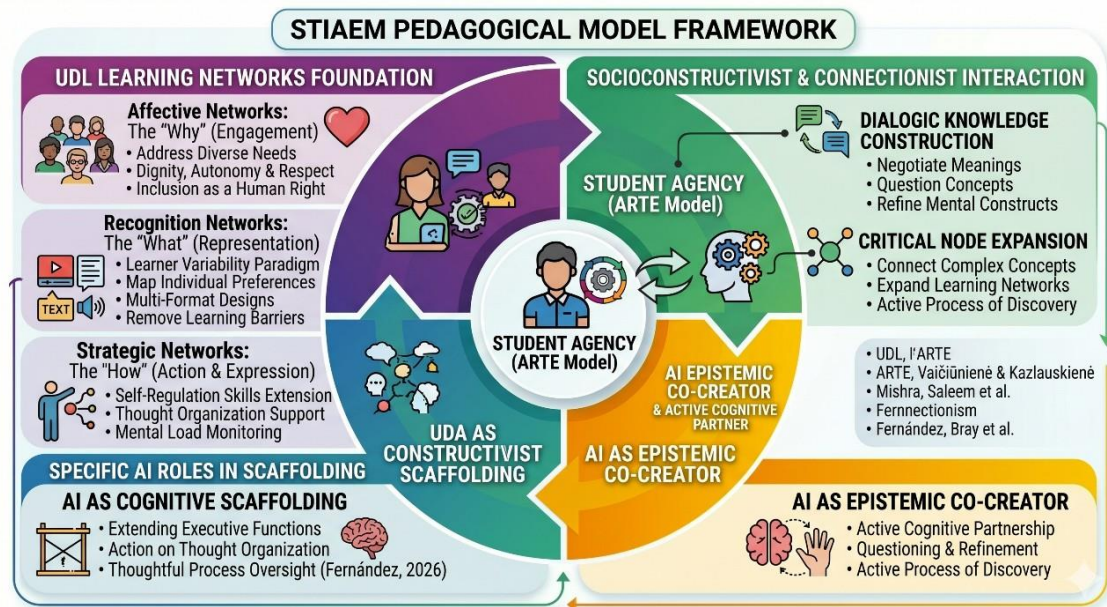


Figure 2. STIAEM pedagogical model: Slow Tech Innovation

A. The “What” of Learning (Representation- Multiple Media- Plan-Agency)

The literature shows that AI-powered digital resources can improve accessibility by offering personalized, multimodal paths to access content, generated for different ways of learning, although many solutions do not yet fully implement the three UDL guidelines in textbooks and digital content.

It allows the student to actively choose how the AI presents information to them.

Strategy: Use of AI to adapt information and create materials that reduce learning gaps.

Tools: Application of generative AI for the structuring of visual artifacts adapted according to age and the needs of the topic to be addressed, is aligned with the recommendations to apply principles of flexible representation and improvement of accessibility in AI environments (Saborío-Taylor, S., & Rojas-Ramírez, 2024) and use of the Universal Design of Learning wheel (Márquez, 2020).

B. The “Why” of Learning (Commitment – Motivate – Ethics and Reflection – ART)

Recent reviews indicate that most experiences with technology in UDL focus on representation, with student engagement and self-regulation being less explored (Bray et al., 2024) The use of AI to diagnose prior knowledge and generate Open Educational

Resources (OER) such as quizzes, cards and presentations with AI tools that adjusts to personalization and gamification proposals that increase motivation and commitment to learning (Mullah, 2025).

It explores the motivation and ethical sense of tasks. Ethics and reflection motivate the student by dealing with real problems such as algorithmic justice and the social impact of technology.

Strategy: Use of AI initially to diagnose students' previous knowledge and encourage engagement with the content.

Tools: Generative AI for the structuring of visual artifacts.

C. The “How” of learning (Action and Expression- acting and verifying-Transformation-ART)

UDL underscores the importance of multiple forms of action and expression, including the creation of varied digital products (audio, video, interactive text) (Mary, 2023). The literature on interactive platforms and AI in Education 4.0 highlights the value of gamified quizzes (with generative AI for the structuring of visual artifacts), simulations, and games for students to demonstrate what they have learned in a diverse and active way (Mullah, 2025). The creation of a final product (generated with generative AI for the structuring of visual artifacts) aligns with recent proposals for inclusive environments where AI and UDL are combined to favor autonomy and self-regulated learning (Saborío-Taylor, S., & Rojas-Ramírez, 2024).

It demonstrates a redefinition of knowledge and not a mere automated copy.

Strategy: Students and teachers create final products that integrate multiple formats (audio, video, and text) to express their knowledge through the use of generative AI for the structuring of visual artifacts (Macchia & Torri, 2025).

Tools: Use of generative AI for the structuring of visual artifacts (Aula Desigual, 2024). Given AI's role as an active partner, the model establishes a mandatory protocol for managing the risk of excessive cognitive delegation (cognitive offloading), ensuring that technology supports but never replaces human judgment (human-in-the-loop). The protocol integrates the following phases:

- **Activation:** Understanding and activating prior knowledge.
- **Guided Practice:** Receiving immediate feedback on student procedures.
- **Reflective Disconnection (AI-off):** Strategic moments of “technological silence” where the digital scaffolding is suspended. These periods are essential to respect

human learning rhythms and ensure that long-term memory consolidation occurs within the learner's brain rather than being delegated to the machine.

- **Spaced Review:** Utilizing algorithms to modulate the pace of presentation and combat the forgetting curve, facilitating more efficient knowledge retention than traditional models (Bran et al., 2025; Gkintoni et al., 2025).

This protocol reinforces the Agency (A) and Reflection (R) of the ARTE model, transforming sociotechnical interaction into internalized and critical knowledge.

4 The paradigm of formative assessment in STIAEM

The STIAEM pedagogical model adopts a dynamic and participatory approach where formative assessment is the central axis of practical implementation. Under this paradigm, it is recognized that, in secondary school, experiences with technology in UDL have focused mainly on multiple forms of representation and expression, but there are gaps in the use of technologies for self-regulation and self-evaluation (e.g., automated feedback tools) (Bray et al., 2024).

Therefore, the model proposes that AI acts as an immediate feedback engine (González-Calatayud et al., 2021) allowing real-time adjustments according to the student's zone of proximal development (Macchia & Torri, 2025; Martínez-Comesaña et al., 2023; Owan et al., 2023; Vaičiūnienė & Kazlauskienė, 2022)

Following Bran et al. (2025), this assessment does not seek to qualify a static final product, but rather to personalize the educational itinerary through algorithms that detect patterns of confusion or knowledge gaps in a preventive manner. In this context, teachers perceive that UDL favors formative assessment, individual monitoring, and the use of interactive techniques, so its regular use is recommended to monitor progress in an inclusive and adaptive way (Abdullah et al., 2025).

This approach is complemented by the research of Gkintoni et al. (2025) on the effectiveness of learning, ensuring that monitoring cognitive load using AI strengthens long-term memory without overwhelming the learner.

Finally, this paradigm ensures that the teacher maintains his or her pedagogical authority and critical judgment (human-in-the-loop), validating automated suggestions so that technology supports and never replaces the teaching process (Miao & Cukurova, 2024).

The STIAEM pedagogical model adopts a dynamic and participatory approach to its assessment, overcoming the traditional vision to focus on the real teaching experience.

The validation process follows a structure of three consecutive stages:

- **Starting Point (Situational Diagnosis):** Teachers start the process by providing real topics and challenges that they are currently working on in their schools, ensuring that the integration of AI responds to authentic curricular needs.
- **Practical Experimentation:** Teachers implement the model in their classrooms, using the principles of Slow Tech Attitude (Good, Clean and Fair IT) and the guidelines of the AI4K12 standard to mediate their practice.
- **Critical Validation:** The final assessment is carried out by validating these experiences according to the ethical and technical principles of AI. This process includes the use of Situational Judgment Tests (SJT), where the teacher reflects on real ethical dilemmas, such as the tension between efficiency and equity, that arose during their experimentation.

4.1 Tools for the emergence of knowledge and Development Cycle

The development of the STIAEM model is structured around the PDCA (Plan-Do-Check-Act) architecture, ensuring a logical and rigorous progression from empirical diagnosis to final framework validation (Figure 3).

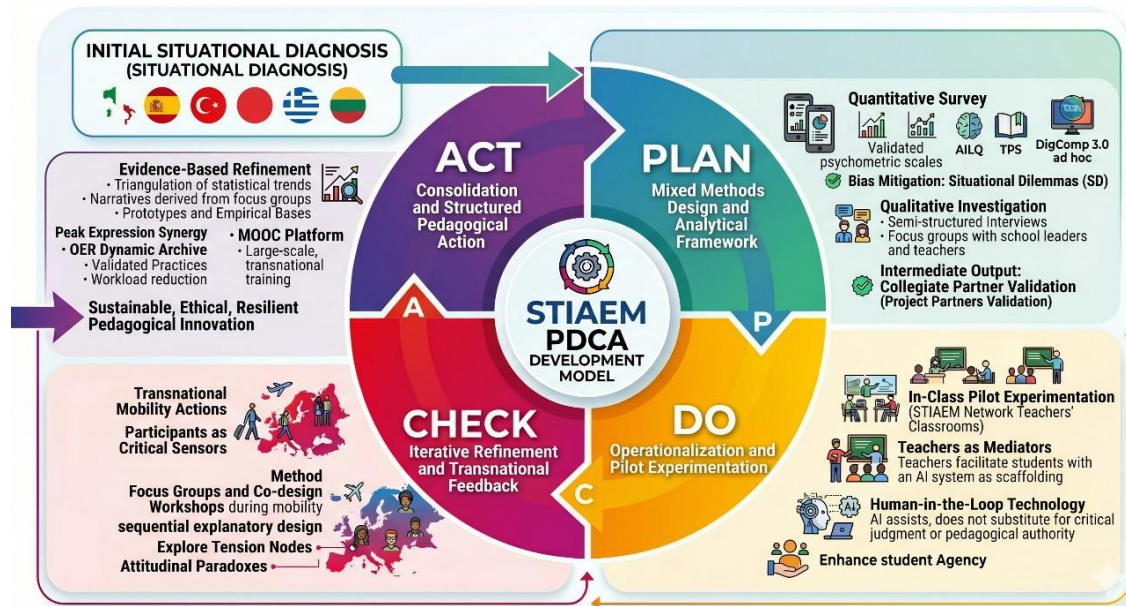


Figure 3. STIAEM operational architecture. Synthesis of the iterative process based on mixed methods, empirical classroom validation, and dissemination through MOOC and OER platforms.

The starting point is a situational diagnosis phase conducted across Italy, Spain, Turkey, Greece, and Lithuania. The initial planning phase (Plan) adopts a Mixed Methods design, structured to converge quantitative and qualitative data into a coherent and scientifically robust analytical framework. The quantitative survey utilizes standardized tools integrating validated psychometric scales, such as the Teachers' Perception Scale (Işık, Çakır, & Korkmaz, 2024). and the *Artificial Intelligence Literacy Questionnaire* (AILQ) (Ng, Wu, Leung, Chiu, & Chu, 2024), augmented with *ad hoc* items to map competencies defined by the European DigComp 3.0 framework. To mitigate social desirability bias, "Situational Dilemmas" (SD) were introduced: realistic scenarios that compel participants to confront critical choices in daily school life. These numerical data were systematically triangulated with an intensive qualitative investigation based on semi-structured interviews and focus groups, aimed at exploring ethical barriers and resistances among school leaders and teachers. Upon completion of this research, the model's theoretical draft undergoes collegiate validation by all project partners.

In the subsequent implementation phase (Do), the model is operationalized through pilot classroom experimentation conducted by teachers within the STIAEM network, translating theoretical pillars into concrete AI-mediated teaching actions. During this phase, teachers act as mediators of the socio-technical process. Technological integration strictly follows the human-in-the-loop principle, where AI serves as cognitive scaffolding to enhance student Agency without replacing critical judgment or the teacher's pedagogical authority.

The verification phase (Check) constitutes the core of the model's iterative refinement and leverages the strategic contribution of participants in transnational mobility actions. On this occasion, mobility participants act as critical on-the-ground sensors, providing essential qualitative and operational feedback to identify criticalities and methodological successes based on direct experience. Following a sequential explanatory design, focus groups and co-design workshops are activated specifically during the mobilities to explore in depth the "nodes of tension" or attitudinal paradoxes identified by the initial surveys, transforming numerical data into a dense pedagogical narrative.

Through evidence-based refinement, the model reaches its final configuration in the consolidation (Act) phase, where research translates into structured and validated pedagogical action. At this stage, the interpretive synthesis produced by the triangulation of statistical trends, focus group narratives, and prototypes from co-design workshops provides the definitive empirical basis for STIAEM. Finally, the consolidated model finds

its peak expression in the synergy between the OER Repository and the MOOC platform. While the repository offers a dynamic archive of validated practices and open educational resources that reduces preparatory workload, the MOOC platform ensures large-scale training and transnational dissemination of the framework, guaranteeing sustainable, ethical, and long-term resilient pedagogical innovation.

4.1.1 Practical application of UDL and AI for inclusion

The STIAEM model uses AI not only for multimodality, but as an essential tool for the planning and organization of study methods (Salazar et al., 2025) in students with and without Special Educational Needs (SEN).

This need for personalization is supported by studies on Chemistry web platforms (9th-10th) that show that the use of UDL options, such as video/text combination, help scaffolding, and self-assessment, generates differentiated usage patterns among students (Roski et al., 2024). And other studies especially support students with disabilities, learning difficulties or Special Educational Needs (SEN) (Ahmed et al., 2025; Hyatt & Owenz, 2024). The implementation of technological solutions such as AccessiLearnAI exemplifies how responsible AI and Universal Design for Learning (UDL) can converge to remove barriers and ensure educational equity (Stelea et al., 2025).

Planning and Organization: The use of AI tools serves to break down complex projects into manageable subtasks, create custom schedules, and reminders that compensate for difficulties in executive functions.

Cognitive Accessibility: AI can be used to simplify complex texts or convert formats instantaneously (e.g. from speech to text or from image to sound description), ensuring that “digital literacy” is accessible to all profiles.

Example:

Topic: Life cycle analysis of plastics and chemical optimization using AI. Objective: To understand polymer synthesis and negotiate solutions with AI to reduce its environmental impact, applying the Clean IT paradigm.

1. Multiple Forms of Commitment (The “Why” - Affective Networks)

Activity: Discussion on the ethical dilemma: “Is it lawful to use energy-intensive AI models to discover new biodegradable plastics?”

Use of AI: Generative AI is used for the structuring of visual artifacts that allows students to visualize the comparative environmental impact of different chemical materials.

ARTE Construct (Ethics and Reflection): Students assess whether the technological solution respects human and environmental well-being, avoiding technological accelerationism.

2. Multiple Forms of Representation (The “What” - Recognition Networks)

Accessibility and Variability: To address the heterogeneity of the classroom, the content on molecular structures is processed with AI-based synthesis and documentary analysis tools.

Various Supports:

Summary podcast: Automatically generated to facilitate access to information by auditory means.

“Easy Reading” Version: Simplification of complex texts on polymerization for students with cognitive processing difficulties.

Visual simulations: 3D models of molecules generated by AI for the most visual learning style.

3. Multiple Forms of Action and Expression (The “How” - Strategic Networks)

Executive Function Support: Students with planning and organizational difficulties use AI-based teaching assistance platforms to break down the lab report into manageable steps and create custom checklists.

AI as Epistemic Co-Creator: Students do not ask AI for the solution, but negotiate meanings. They debate with the machine about the feasibility of a specific chemical reaction, questioning the AI’s training data and maintaining its Agency (human-in-the-loop).

ARTE Construct (Transformation): The use of AI allows the redefinition of cognitive tasks, such as simulating complex chemical reactions that could not be physically performed in the center due to safety or cost.

4. Evidence of Learning (ARTE Model)

Multimodal End Product: Students create a “Sustainable Chemistry Handbook” using multimodal digital authoring tools.

Inclusion in the submission: The student chooses his or her way of expression: an explanatory video, an essay with the support of an intelligent corrector or a detailed visual synthesis.

Evaluation criteria: It is validated that the product is not an automated copy, but that it demonstrates a critical reflection on the sources and a clear transformation of the original content under an ethical responsibility.

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