Journal of Inclusive Methodology and Technology in Learning and Teaching
ISSN 2785-5104
Anno 6 n. 4 (2026)

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

The STIAEM Project: Human-in-the-Loop Posture and Italian Teachers' Agency Facing the Educational Challenges of GenAI

Viviana Vinci[1]*, Pierangelo Berardi[1]

[1] University of Foggia; viviana.vinci@unifg.it; pierangelo.berardi@unifg.it
* Correspondence: viviana.vinci@unifg.it

Abstract: The integration of generative AI in schools calls for a rethinking of the teacher's role. This study investigates the professional postures of Italian teachers facing the dilemmas posed by automation, adopting the Slow Tech paradigm and the human-in-the-loop framework. On a sample of 801 Italian teachers, the design integrates descriptive analysis, confirmatory factor analysis, multiple correspondence analysis, and psychometric network analysis. Results show that professional postures are not discrete classes but positionings along two continuous axes: critical collaboration/avoidance and caution/acceptance. A profound fragmentation also emerges between technical competence and reflective posture: operational mastery of tools does not automatically translate into the ability to govern ethical dilemmas, and the item measuring the ability to avoid techno-stress is completely disconnected from the competence network. Informational agency and special education background emerge as protective factors for positioning towards critical collaboration. The study invites a rethinking of teacher education not as procedural training, but as the cultivation of a reflective posture rooted in contextual knowledge and relational responsibility.

Keywords: GenAI; Professional postures; Human-In-The-Loop.

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1. Slow Tech and Human-in-the-Loop: the theoretical framework of the STIAEM project

The integration of Generative AI (GenAI) in education calls for a profound repositioning of the teacher's role. Basic digital literacy is no longer sufficient (Redecker, 2017): the current technological acceleration (Cosgrove & Cachia, 2025) requires a paradigmatic shift aimed at promoting a critical Human Agency that places educational responsibility above automation (Miao & Cukurova, 2024).

The problem is structural. Large Language Models (LLMs) operate without Contextual Knowledge (XK): they do not know the classroom, the students, or the educational relationship. This is why the Intelligent-TPACK (I-TPACK) model needs to be rethought (Mishra & Bozkurt, 2026): without a situated anchoring, teachers' action risks being reduced to mere procedural execution, generating an ethical gridlock in the face of automated planning (Chen et al., 2026).

To avert the risk of passive delegation to the algorithm, this study adopts the paradigm of Human-Centred Education (Romero et al., 2024) and the Human-in-the-Loop approach (Fajardo-Ramos et al., 2025). The idea is simple yet radical: keeping the teacher within the decision-making cycle, preventing interaction from

being reduced to mere execution (Memarian & Doleck, 2024) and subordinating the digital to relational responsibility (Webb & Galamba, 2026). In this perspective, the human-in-the-loop posture is not an additional technical competence, but a structural condition of educational action.

The risk of a techno-centric drift is not hypothetical. It manifests itself with particular evidence where performative pressure and standardisation logics make delegation to automation an apparently efficient shortcut (Ranieri, 2024). It is in these contexts that the fragmentation between technical competence and reflective posture becomes a critical problem: a teacher may master the tools without being able to govern their ethical and didactic implications.

The project adopts the Slow Tech paradigm (Patrignani & Whitehouse, 2014) as a regulatory principle, placing cognitive sustainability, equity of access and the integrity of assessment processes at its centre. In this perspective, AI is not a neutral tool, but an element that reconfigures teaching practices, educational relationships and assessment processes (Selwyn, 2024): its adoption must therefore be subordinated to the formative intentionality of the teacher and the educating community. The project moves neither from a technophobic position nor from an uncritical trust in technology, but from the recognition that hybridisation is a complex phenomenon involving individual dispositions, ethical postures in situation, teaching practices and institutional contexts. The aim is to elaborate an ecological theory of ethical hybridisation of AI in school contexts, starting from an understanding of the perceptions of teachers and students.

The project's design is articulated in five sequential and recursive phases: investigation, with the administration of questionnaires in partner countries and the drafting of national reports; pedagogical modelling, with the elaboration of a coherent model of ethical integration of AI in schools; formative design, with the creation of a MOOC and Open Educational Resources (OER); field experimentation, with teaching pathways in STEAM disciplines and in digital citizenship education, adopting the principles of Universal Design for Learning (CAST, 2024); dissemination and sustainability, with recommendations for policymakers, European guidelines and the creation of a hybrid, physical and digital Hub dedicated to teachers' continuing professional development and the exchange of good practices. The project thus establishes a circularity between university research and classroom practices: evidence gathered in pilot classes informs teacher education pathways, while university methodological reflection provides schools with criteria for monitoring their own processes (Perla & Vinci, 2021). The multi-level partnership, universities, school authorities, institutions, configures a horizontal cooperation in which researchers and teachers work jointly as co-designers (Wenger, 1998).

The national context in which STIAEM is situated is marked by rapid evolution. The Ministry of Education and Merit has recently published the Guidelines for the introduction of Artificial Intelligence in schools, and the National Plan School 4.0 has redefined learning environments and digital equipment in Italian schools. This study is situated at this historical juncture, at a moment when the Italian school system is called upon to redefine its relationship with algorithmic technologies. The work addresses three research questions:

RQ1: What are the latent dimensions that structure Italian teachers' responses to situated dilemmas of automation and automated assessment?

RQ2: How do Italian institutional factors (school level, subject area), teaching experience and individual informational agency predict teachers' positioning along these dimensions, and what role does special education background play?

RQ3: What is the configuration of the competence network in the Italian teaching body, and to what extent is the fragmentation between technical self-efficacy and reflective posture reproduced?

2. Research design and methods

This study adopts a quantitative, correlational and dimensional empirical design based on a sample of Italian teachers (N = 801) recruited within the framework of the research-intervention actions of the Erasmus+ STIAEM project.

The sample consists of in-service teachers in secondary schools. The distribution by school level, subject area, teaching experience and special education background was controlled to ensure the variability required for multivariate analyses. The sample was recruited within the framework of the research-intervention actions of the STIAEM project, in collaboration with the Regional School Office for Tuscany. Table 1 presents the distribution of the sample by the main structural variables.

Table 1. Sample description (N = 801).

Variable	Category	n	%
School level	Lower secondary school	342	42.7
	Upper secondary school	459	57.3
Subject area	Humanities	287	35.8
	Sciences	264	33.0
	Technology	142	17.7
	Other	108	13.5
Teaching experience	≤ 5 years	98	12.2
	6–15 years	241	30.1
	16–25 years	278	34.7
	> 25 years	184	23.0
Support teacher	Special education teacher	187	23.3
	Mainstream teacher	614	76.7
Gender	Female	621	77.5
	Male	174	21.7
	Not specified	6	0.8

2.1. The survey instrument

Data collection was carried out through a multidimensional CAWI (Computer-Assisted Web Interviewing) questionnaire co-designed by the European consortium. The instrument investigates teachers' perceptions by integrating four main dimensions, identified through confirmatory factor analysis:

- perceived technical competence (TCH_COMP_01–05);
- algorithmic anxiety (TCH_ANX_23–26);
- perceived usefulness (TCH_UTIL_31–33);
- critical agency (DIG_INF_1.1, DIG_COM_3.4, DIG_SAF_4.3).

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The core of the questionnaire incorporates three situated dilemma scenarios (SD01, SD02, SD03) aimed at mapping teachers' actual intentions along a continuum ranging from technological delegation to pedagogical resistance, through single-choice options (A, B, C, D):

SD01 — Didactic Planning: the teacher decides whether and how to use GenAI for the design of a learning unit.

SD02 — AI Tutor vs Educational Alliance: the teacher chooses whether to adopt an automated tutor for home support or to prioritise relational co-regulation.

SD03 — Academic Integrity: the teacher is confronted with the use of AI as a prosthesis for producing assignments, balancing efficiency and the autonomous development of thought.

2.2. Analytical workflow

The analytical workflow was developed in R (v. 4.5.1) through four sequential phases. The first involved a descriptive analysis of responses to the three dilemma scenarios, with frequency distributions and chi-square tests of independence. The second involved a confirmatory factor analysis (CFA) to test the latent structure of competences, with a four-factor model (technical competence, algorithmic anxiety, perceived usefulness, critical agency); model fit was assessed through CFI, TLI, RMSEA and SRMR, and factor scores were used as dependent variables in the regression. The third involved a multiple correspondence analysis (MCA) to explore the space of responses to the three scenarios and identify the main dimensions of professional positioning. The fourth involved a Psychometric Network Analysis (PNA), with a network of regularised partial correlations estimated through the EBICglasso algorithm with an active specificity threshold; the analysis included nodes relating to technical competences, critical competences, informational agency and situated dilemmas, and node stability was verified through case-dropping bootstrap. Linear regression on factor scores and MCA components was finally used to test the predictive weight of structural covariates: experience, informational agency, school level and subject area, with specific attention to the special education area.

3. Analysis and results: the dimensional structure of professional postures

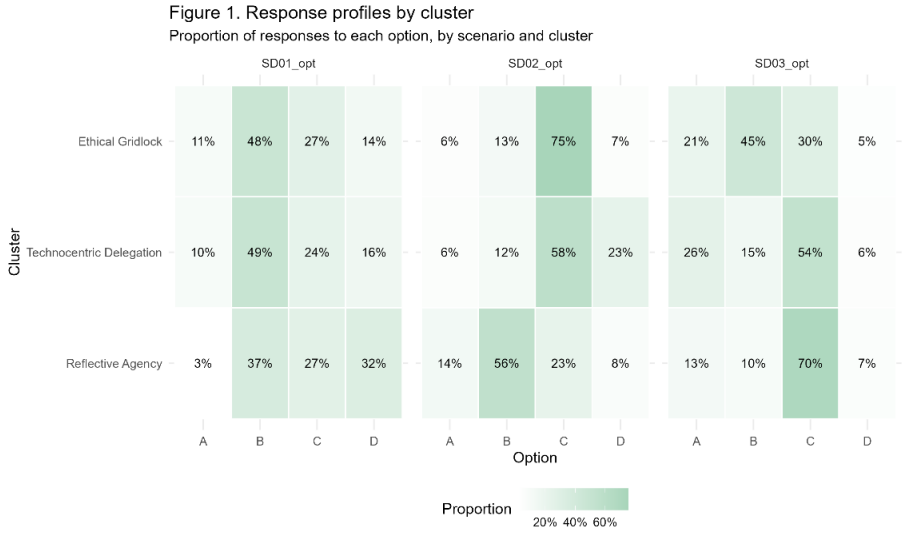
The descriptive analysis of responses to the three dilemma scenarios reveals distinct and non-overlapping patterns. In SD01 (Didactic Planning), the relative majority of teachers (44.9%) choose Option B, using GenAI for the initial outline, while reserving time to "humanise" the materials, followed by Options C (25.8%) and D (21.3%); only 7.9% opt for Option A (full delegation). In SD02 (AI Tutor vs Educational Alliance), the distribution shifts towards Option C (50.1%), which limits automated tutoring in favour of relational co-regulation. In SD03 (Academic Integrity), the absolute majority (53.4%) choose Option C (rejecting AI as a prosthesis in order to protect the autonomous development of thought). The chi-square test confirms that responses to the three scenarios are not independent: SD01 and SD02 are associated ($\chi^2 = 37.13$, df = 9, $p < .001$), as are SD01 and SD03 ($\chi^2 = 132.74$, df = 9, $p < .001$). This suggests that choices across the three scenarios

do not respond to a single underlying factor, but to partially distinct dimensions of professional positioning.

To test the latent structure of competences, a confirmatory factor analysis (CFA) was conducted on a four-factor model: technical competence (TCH_COMP), algorithmic anxiety (TCH_ANX), perceived usefulness (TCH_UTIL) and critical agency (DIG_CRIT). The model showed satisfactory fit (CFI = 0.956; TLI = 0.945; RMSEA = 0.064; SRMR = 0.041). All factor loadings are significant ($p < .001$), but with a heterogeneous pattern for DIG_CRIT: DIG_INF_1.1 (0.707) and DIG_COM_3.4 (0.701) load adequately, whereas DIG_SAF_4.3 loads only 0.220. This result is theoretically relevant: the item measuring the ability to avoid techno-stress is not an integral part of the critical agency construct, but constitutes a separate dimension. The strong positive correlation between technical competence and critical agency ($r = 0.725$) and the weak negative correlation between algorithmic anxiety and critical agency ($r = -0.103$) suggest that competence and reflexivity are associated at the latent level, but that anxiety is not counterbalanced by agency.

Multiple correspondence analysis (MCA) identified two main dimensions: the first (16.27% of variance) opposes critical collaboration with GenAI to avoidance/rejection; the second (13.09%) opposes caution/limitation to acceptance/delegation. The two dimensions together explain 29.36% of the variance. Although this percentage is not high, the two-dimensional structure is consistent with the theoretical framework: professional postures are not discrete classes, but positionings along continuous axes. Figure 1 presents the response profiles to the three scenarios for each cluster of teachers.

Figure 1. Heatmap of response profiles to the three dilemma scenarios (SD01, SD02, SD03) by cluster.

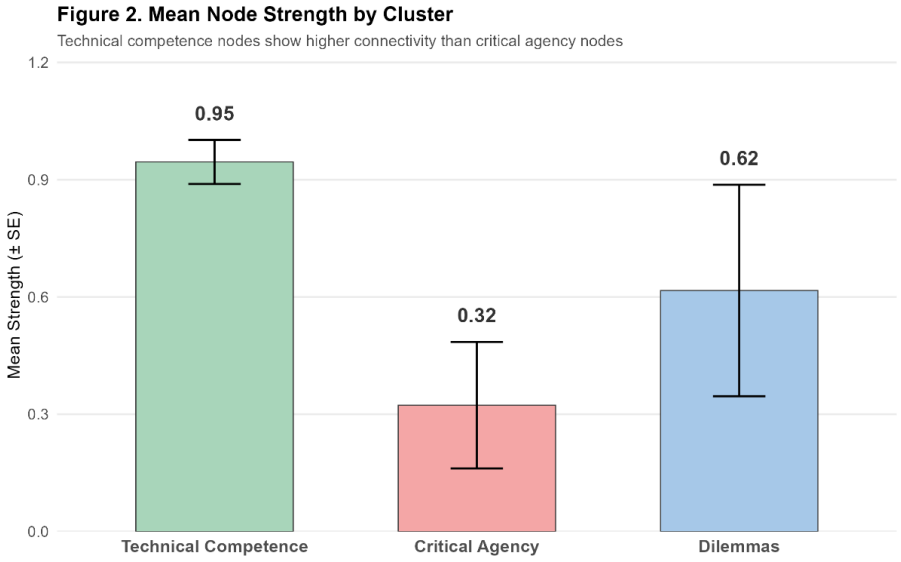


The heatmap shows that the three clusters differ mainly in SD01: the Reflective Agency cluster concentrates on Option B (critical collaboration), whereas the Technocentric Delegation cluster distributes across Options C and D (caution/avoidance). In SD02, all clusters converge on Option C (limitation of

tutoring), but with different proportions. In SD03, the Ethical Gridlock cluster is distributed in a dispersed manner, without a dominant choice.

The Psychometric Network Analysis (PNA), conducted through the EBICglasso algorithm with an active specificity threshold, highlighted a profound fragmentation in the competence system. Figure 2 presents the mean Strength of the three clusters of nodes.

Figure 2. Mean node Strength in the psychometric network, by cluster.



The technical competence nodes (TCH_COMP_01–22) show high Strength (M = 0.95, SD = 0.27), forming a cohesive and self-referential core. By contrast, the critical agency nodes occupy peripheral or isolated positions: DIG_INF_1.1 (0.471) and DIG_COM_3.4 (0.498) are peripheral, whereas DIG_SAF_4.3 is completely disconnected from the network (Strength = 0.000). The mean Strength of the Technical Competence cluster (M = 0.95) is approximately three times higher than that of the Critical Agency cluster (M = 0.32). The overall pattern indicates that technical self-efficacy and reflective posture operate on separate tracks: operational mastery of tools does not automatically translate into the ability to govern the ethical dilemmas generated by automation.

To test the predictive weight of structural covariates, two linear regressions were conducted on the MCA components. The first, on MCA_Dim1, which opposes collaboration to avoidance, explains 10.5% of the variance ($R^2 = 0.105$; $F(12, 788) = 7.67$, $p < .001$). The significant predictors are informational agency ($\beta = -0.160$; $t = -7.93$; $p < .001$) and special education background ($\beta = -0.245$; $t = -2.25$; $p = .025$): those with greater informational agency and those teaching in the special education area tend to position themselves towards critical collaboration. The second, on MCA_Dim2, which opposes caution to acceptance, explains only 2.7% of the variance ($R^2 = 0.027$; $F(12, 788) = 1.80$, $p = .044$). The significant predictors are teaching experience (Experience < 5 years: $\beta = -0.183$; $t = -2.38$; $p = .018$) and school level (School_LevelIeFP: $\beta = +0.323$; $t = +1.99$; $p = .047$). The predictors of professional positioning are distributed differently across the two

dimensions: the first is linked to competences and professional background, the second to biographical and institutional variables.

4. Professional postures, competence fragmentation and educational responsibility

The results converge on a picture that challenges dichotomous representations of teachers' responses to AI. Professional postures are not discrete classes, but positionings along continuous axes: multiple correspondence analysis identified two main dimensions, the first opposing critical collaboration to avoidance, the second opposing caution to acceptance, which together explain 29.4% of the variance. The postures (Reflective Agency, Technocentric Delegation, Ethical Gridlock) are therefore regions of a continuous space, not mutually exclusive types.

The most robust contribution of the study is the evidence of fragmentation between technical competence and reflective posture. The PNA showed that the technical competence cluster is hyper-connected (mean Strength = 0.95), whereas the critical agency nodes are peripheral or isolated (mean Strength = 0.32). In particular, the item measuring the ability to avoid techno-stress is completely disconnected from the network (Strength = 0.000), whereas the items relating to advanced search skills and to understanding algorithms load adequately on the critical agency factor (0.707 and 0.701). The CFA confirms this: the techno-stress item loads only 0.220, against markedly higher loadings for the other indicators. Operational mastery of tools does not automatically translate into the ability to govern ethical dilemmas: technophilia does not produce reflexivity. This confirms the thesis of the human-in-the-loop framework: keeping the teacher within the decision-making cycle is not an additional technical competence, but a structural condition of educational action.

The regression on MCA components highlighted two protective factors for positioning towards critical collaboration: informational agency ($\beta = -0.160$; $t = -7.93$; $p < .001$) and special education background ($\beta = -0.245$; $t = -2.25$; $p = .025$). Informational agency is a deterrent against algorithmic submission; special education background is a protective factor because inclusive pedagogy, situated and relational, demands an embodied knowledge of the micro-context that cannot be automated. The specialist teacher immediately detects the intrinsic deficit of algorithmic output, the absence of Contextual Knowledge (XK), and re-anchors the human-in-the-loop logic to situated flexibility. Inclusive pedagogy thus ceases to be a sectoral domain and qualifies as the design matrix for the entire teaching body.

The results on structural covariates are more nuanced: teaching experience and school level predict only the dimension opposing caution to acceptance, but not the one opposing collaboration to avoidance. Teachers with less than 5 years of experience position themselves towards caution ($\beta = -0.183$; $t = -2.38$; $p = .018$), while those in IeFP position themselves towards acceptance ($\beta = +0.323$; $t = +1.99$; $p = .047$). These results scale down initial expectations and invite us not to generalise the idea that standardised contexts are more permeable to automation.

4.1. Limitations of the study and future perspectives

The cross-sectional design does not allow causal inferences; self-report data are subject to social desirability; MCA explains only 29.4% of the variance; DIG_SAF_4.3 has a low factor loading (0.220) and a null Strength (0.000),

suggesting that the item does not adequately measure the critical agency construct; the sampling is non-probabilistic. Future research perspectives include longitudinal studies, qualitative validation of the MCA dimensions, experimentation with AI Hubs and methodological deepening on the stability of latent classifications.

The contribution offers three original advances. The first is a dimensional reading of professional postures, which moves beyond rigid taxonomies in favour of continuous and situated models. The second is the evidence of technical/reflexivity fragmentation: technical competence does not automatically produce reflective posture. The third is the identification of special education background as a protective factor against algorithmic delegation: inclusive pedagogy qualifies as the design matrix for the entire teaching body. These findings invite us to rethink teacher education not as procedural training, but as the cultivation of a human-in-the-loop posture rooted in contextual knowledge and relational responsibility. In an era in which automation tends to reduce educational action to execution, critical resistance is not a luxury, but a condition of professional survival.

On the training front, the results suggest moving beyond technical-procedural training in favour of pathways that cultivate a human-in-the-loop posture rooted in contextual knowledge and relational responsibility. On the governance front, they invite us to avoid one-size-fits-all solutions: the fragmentation of postures requires differentiated interventions, calibrated to contexts and profiles. The hybrid AI Hubs envisaged by the STIAEM project represent a concrete model of co-design between schools, universities and territorial governance, in which digital innovation is negotiated and subordinated to teacher authorship.

Disclaimer

This study is the result of reflections and activities developed within the framework of the Erasmus+ KA220-SCH project, "Slow Tech Innovation: AI, Ethics and New Teaching Methods" (STIAEM), funded under Grant Agreement No. 2025-1-IT02-KA220-SCH-000365213.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor the EACEA can be held responsible for them.



Co-funded by the European Union

Authors' contributions

This paper is the result of joint work. Sections 1, 2, 2.1 and 4.1 were written by Viviana Vinci; Sections 2.2, 3 and 4 by Berardi Pierangelo. All authors contributed to the final revision of the text.

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