THE VIRTUAL MUSEUM AS AN INCLUSIVE LEARNING ENVIRONMENT: TEACHERS' PERCEPTIONS OF AI, FLIPPED INCLUSION AND DIGITAL WELLBEING

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ABSTRACT
Within the framework of the Fourth Industrial Revolution, artificial intelligence is reshaping the cognitive, relational and affective conditions of educational experience. This shift makes it necessary to move beyond Digital Literacy towards a broader form of Digital Affective Literacy. From this perspective, the virtual museum can be understood as a hybrid environment. Cultural heritage, algorithmic technologies, accessibility and inclusive design may converge within it, opening new possibilities for teaching, cultural participation and digital wellbeing.
This paper investigates Italian teachers' perceptions of the virtual museum as an inclusive learning environment. It also examines the role of AI in educational processes and the need for critical, affective and design-oriented competences to inhabit digital environments responsibly. The study is based on an exploratory-descriptive quantitative survey conducted with a sample of teachers. Data were collected through an online questionnaire organised into sections on virtual museum experience, self-perceived competences, digital pro-sociality, museum-related affective wellbeing and orientation towards educational artificial intelligence.
The article proposes a pedagogical reading of the virtual museum as a space of mediation between artificial intelligence, Flipped Inclusion and digital affective competences. Its aim is to contribute to the debate on the design of virtual educational environments able to combine accessibility, algorithmic responsibility, relationship and inclusion.

KEYWORDS
Virtual museum; inclusive education; AI; flipped inclusion.

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1. Introduction

The ‘algorithmic heartbeat’ running through contemporary education recalls an old literary question: where does the boundary lie between the human being and its perfect simulation? In Isaac Asimov’s short story “Evidence” (1946), Stephen Byerley is suspected of being an automaton because nobody ever sees him eat or sleep. The story uses this ambiguity to question civil rights, human nature and the fear of artificial beings. Today, generative technologies reopen that dilemma in educational terms.

The Fourth Industrial Revolution does not simply introduce new tools into educational contexts. It reshapes their cognitive, relational and affective conditions. The entry of artificial intelligence into learning environments is no longer only a matter of technological innovation or the modernisation of teaching practices. It affects the very structure of educational mediation. Algorithms organise information, suggest pathways, personalise content, generate responses and guide attention. This paper takes the image of an algorithmic heartbeat as its guiding metaphor.

For a long time, pedagogical reflection on the digital focused on Digital Literacy. This was understood as the set of competences needed to access information, evaluate it critically, produce it and share it in technologically mediated environments (Rivoltella, 2008). This perspective remains essential. Yet it is now insufficient, given the growing ability of algorithmic systems to affect not only learning procedures but also the relational and emotional quality of learning. Artificial intelligence makes more visible a transformation already initiated by digital media. Technology is not simply a channel for transmitting information. It is a cultural environment in which trust, motivation, belonging, autonomy, dependence, responsibility and cooperation are constructed. For this reason, digital literacy must move from a mainly technical-cognitive model towards Digital Affective Literacy.

Artificial intelligence now occupies a central position in contemporary societies. It affects work, communication, cultural production and education. In technical terms, AI may be understood as a set of technologies and computational systems designed to simulate or support cognitive processes traditionally associated with human intelligence, such as learning, reasoning, perception, language understanding and problem-solving (Floridi, 2022; UNESCO, 2023). Yet speaking unambiguously of AI risks hiding its complexity. AI is not a homogeneous reality. It is an articulated ecosystem in which symbolic approaches, predictive systems, neural networks, machine learning and deep

learning coexist. This plurality makes AI more than an applied technology. It also makes it epistemologically problematic, because it raises questions about automated decision-making, human agency, knowledge production and social responsibility (Floridi, 2022; Kissinger, Huttenlocher, & Schmidt, 2023).

In educational contexts, this complexity has specific relevance. AI can be understood along at least three lines. It can function as a technology for learning, when it supports personalisation, intelligent tutoring, educational chatbots, adaptive systems and predictive tools. It can become an object of learning, when it is studied critically through its algorithmic mechanisms and machine-learning processes. It can also operate as an infrastructure for educational governance, when it is used to manage data, support decision-making and analyse educational performance (Ranieri, 2025). This tripartite reading clarifies that AI enters schools not only as an operational tool. It also acts as a cultural and organisational device able to reshape how learning is designed, supported, assessed and interpreted. For this reason, AI adoption in education cannot rely either on naive enthusiasm or on purely instrumental familiarity with platforms. Educational sciences and the humanities are called upon to develop a critical and informed approach to the ethical, cognitive and social implications of algorithmic systems. This is particularly important when such systems affect sensitive processes such as attention, motivation, assessment, autonomy and the educational relationship (Kissinger et al., 2023; UNESCO, 2023). AI can certainly become a resource for teachers, even a 'toolbox' for teaching design. Yet the decisive pedagogical issue concerns the selection, purpose and governance of these tools (Malavasi, 2019). It is not enough to ask what AI can do in education. We must also ask which tools are truly necessary, which are coherent with educational aims, what effects they produce on relationships and under what conditions their use is pedagogically justified.

Recent literature shows that many teacher-training initiatives remain fragmented. They are often introductory or focused on the operational use of applications, while critical, design-oriented and ethical-pedagogical dimensions are less established (Brandão et al., 2024; Karataş & Yüce, 2024). International guidelines also stress the need for transparency, governance, equity, rights protection and adequate professional competences (UNESCO, 2023). In Europe, this need is reflected in the DigCompEdu framework, which defines teachers' digital competence as not only technical, but also critical, pedagogical and ethically oriented (Redecker & Punie, 2017). The same direction can be found in the European Commission's Digital Education Action Plan 2021-2027, in OECD recommendations and in Council of Europe documents. These sources stress that AI adoption in education must be accompanied by attention to

algorithmic transparency, rights protection, decision-making responsibility and the democratic quality of innovation (European Commission, 2020; OECD, 2021; Council of Europe, 2022). A central issue follows from this: educating for AI does not mean merely training people to use intelligent tools. It means developing critical, reflective, design-oriented and affective competences. These competences allow teachers to question algorithmic outputs, select technologies according to educational goals and govern their cultural, ethical and relational implications.

In this context, the virtual museum is a useful case through which to examine the convergence of algorithmic mediation, cultural heritage, accessibility and inclusive design. It allows us to observe how digital environments may support not only access to content, but also interpretation, participation and shared meaning-making. This is where the Flipped Inclusion model becomes decisive. It makes it possible to move beyond an adaptive and residual view of inclusion, understood as a later intervention on a pathway already designed for a standard subject. By contrast, Flipped Inclusion takes the plurality of cognitive, sensory, emotional and relational profiles as the starting point for educational design (Corona & De Giuseppe, 2017). Applied to the virtual museum, this logic allows accessibility to be understood not only as technical compatibility of the interface, but as the real possibility of orienting oneself, participating, understanding, contributing and recognising oneself within the experience. From this perspective, perspective-taking becomes central. The capacity to take another person's point of view, by decentring one's own perceptual and emotional position, allows the virtual museum to be conceived as a learning environment that is not only informative, but also empathic, spatial and intersubjective (Di Tore et al., 2014; Di Tore et al., 2023).

This paper, starting from the framework of Digital Affective Literacy, investigates the virtual museum as an inclusive learning environment. It examines the relationship between educational artificial intelligence, Flipped Inclusion and digital wellbeing. The aim is to understand how Italian teachers perceive the educational value of virtual museums, the potential of AI for personalisation and accessibility, the affective dimension of digital experience and the need for training in the responsible use of algorithmic technologies. The study presents the results of an exploratory-descriptive quantitative survey conducted with a sample of N = 629 Italian teachers. The online questionnaire included sections on professional profile, experience with the virtual museum, self-perceived competences, digital pro-sociality, museum-related affective wellbeing and orientation towards educational AI.

The paper is organised as follows. Section 2 reconstructs the theoretical framework. It addresses the move from Digital Literacy to Digital Affective Literacy, the role of educational AI, the virtual museum as a hybrid environment, culture as a resource for wellbeing, and the relationship between Flipped Inclusion, accessibility and perspective-taking. Section 3 presents the methodological design, the sample, the instrument and the data-analysis procedures. Section 4 reports the main descriptive and correlational results. Section 5 discusses the patterns that emerged around three interpretive themes: openness to AI and the fragility of critical competence; the virtual museum as a relational rather than individual experience; and the need for teacher education that integrates AI literacy, Digital Affective Literacy and Flipped Inclusion. The concluding section highlights the pedagogical implications for designing virtual, inclusive and affectively responsible educational environments.

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2. Digital Affective Literacy and educational AI: beyond technical competence

The transition from Digital Literacy to Digital Affective Literacy does not mean underestimating digital competence. It means expanding it in a critical, relational and ethical direction. For Livingstone, media literacy is not simply a set of operational skills. It concerns the ability to access, analyse, evaluate and produce messages across multiple media contexts (Livingstone, 2004; 2008). Buckingham similarly argued that media education should be understood as a critical practice. It must question the languages, representations, symbolic economies and forms of power that run through media (Buckingham, 2003). This approach places digital literacy within a wider cultural perspective. The use of a tool is inseparable from an understanding of its social and educational implications.

As anticipated above, the entry of artificial intelligence into educational contexts radicalises this need. Algorithmic systems do not simply make some teaching procedures more efficient. They affect educational mediation.

Rivoltella showed that media are not simple channels for transmitting information. They are cultural and relational environments in which the subject learns, communicates and constructs identity (Rivoltella, 2008). This insight becomes even more relevant in the age of AI, because digital mediation becomes more adaptive, opaque and apparently responsive. Whereas traditional media organised content and representations, algorithmic systems also organise responses, preferences, anticipations and forms of interaction. The competence required of teachers is therefore not only digital in a technical sense. It is affective-digital. Teachers must recognise when personalisation genuinely supports learning and when it risks producing dependence, passivity, isolation or false proximity.

Damasio's perspective provides a non-dualistic theoretical basis for the relationship between cognition and emotion. In Descartes' Error, he shows that decision-making and cognitive processes are deeply intertwined with bodily and emotional feeling (Damasio, 1994). Transferred to education, this perspective allows us to state that learning is never a purely informational process. Knowledge takes shape within an affective tone: an experience of involvement, trust, recognition or distance. In digital environments, emotion does not disappear. It is reconfigured through

interfaces, avatars, feedback, recommendations and devices of mediated presence.

In this direction, contributions on embodiment, simplexity and perspective-taking help to avoid a disembodied reading of virtual environments. Perception, spatial orientation, motor simulation and perspective-taking participate in the construction of educational meaning. They show that the digital does not erase the body, but reorganises its possibilities for presence and relationship (Di Tore et al., 2014; Di Tore et al., 2023). This reference will be taken up again in relation to the virtual museum. Here, the main point is that Digital Affective Literacy does not concern only the recognition of emotions online. It also involves the ability to inhabit complex digital environments as cognitive, bodily and intersubjective spaces.

At this level, Digital Affective Literacy also has ethical and political relevance. Nussbaum argues that emotions are not irrational forces to be contained. They are intelligent forms of evaluating the world and can guide moral life, compassion, public judgement and coexistence (Nussbaum, 2001). In education, this means that training for AI use cannot be reduced to procedural learning. It must include an understanding of the affective and moral implications of algorithmic mediation: how a system decides what is relevant, which subjects risk being excluded, which emotions are elicited, which forms of attention are rewarded, and which relationships are strengthened or weakened.

The literature on educational AI confirms the need for this shift. Zawacki-Richter, Marin, Bond and Gouverneur identify profiling, prediction, automated assessment, adaptive systems and intelligent tutoring as key areas of AI in education. They also note the relative marginality of pedagogical and teacher voices in a debate dominated by technical perspectives (Zawacki-Richter et al., 2019). Holmes, Bialik and Fadel likewise highlight the transformative potential of personalisation, while warning against reducing educational complexity to computational logic (Holmes et al., 2019). UNESCO guidelines on generative AI point in the same direction. They call for a human-centred approach based on governance, transparency, equity, data protection and educational responsibility (UNESCO, 2023). These perspectives converge on a decisive point: AI can support learning only if it is embedded within a pedagogical framework able to govern its use critically.

In education, the so-called ‘Frankenstein complex’ does not simply indicate fear of technology. It points to a subtler formative ambivalence:

recognition of AI's potential coexists with uncertainty about the ability to understand and govern its effects. The literature on AI literacy helps to clarify this gap. Long and Magerko define AI literacy as a set of competences that enable individuals to understand, use, critically evaluate and communicate with AI systems (Long & Magerko, 2020). This definition distinguishes simple recognition of AI from the ability to evaluate its limits, biases, opacity and social implications.

The pedagogical risk is not only rejection of AI, but also naive adoption. This may be an apparently innovative use that lacks epistemological, ethical and affective awareness. Without Digital Affective Literacy, algorithmic personalisation can become emotional standardisation. Automated support can simulate proximity without producing genuine recognition. Efficiency can obscure the slowness required for understanding and care. Understanding AI therefore means knowing its general functioning and educational applications. It also means questioning how it redesigns the educational relationship, redistributes agency, changes the teacher's position and reorganises forms of attention.

From this perspective, Digital Affective Literacy is a prerequisite for a genuinely inclusive pedagogy of AI. Educating in the age of artificial intelligence means forming subjects who can inhabit complex digital environments without losing contact with the emotional, relational and moral dimensions of knowledge.

3. The virtual museum as a hybrid learning environment

Falk and Dierking's Contextual Model of Learning (2000) restored the situated nature of museum learning. It describes three constantly interwoven contexts: the personal context, made up of the visitor's motivations, expectations and prior knowledge; the sociocultural context, formed by social mediation and the intersubjectivity that often accompanies a shared experience; and the physical context, namely the architecture, spatial arrangement and opportunities for movement and discovery offered by the environment. In the virtual museum, the physical context is not simply lost. It is translated into interface architecture, navigation paths, visual orientation and forms of mediated presence. The sociocultural context can also be amplified by co-presence devices, chats, avatars and comment spaces, making virtual visits potentially more shared than many solitary visits to physical museums. In this recombination, the

virtual museum takes on the features of the hybrid space outlined above. It is not a weakened copy of the real museum. It is an environment that reorganises, through partly human and partly algorithmic logics, the three contexts of situated learning. If the virtual museum can generate a personal, social and cultural experience of this kind, the question is no longer only pedagogical but also policy-related: should an experience (potentially relevant to perceived wellbeing) be recognised beyond the strictly school or museum sphere?

4. **Culture as social prescription: from social prescribing to the State-Regions protocol**

   Starting in the United Kingdom, the therapeutic and preventive value of cultural participation has been progressively recognised in recent years. The British experience has then found support and funding in several European initiatives. The UK National Health Service helped to institutionalise a practice known as social prescribing. This allows general practitioners to direct patients towards non-pharmacological resources, such as community activities, artistic experiences and museum visits, as part of a care pathway. It is especially relevant in cases of loneliness, mild psychological distress or chronic conditions with a strong relational component.

   In Italy, the institutional pathway initiated in the State-Regions Conference in February 2026 and formalised through the April 2026 protocol between the Ministry of Culture and the Ministry of Health confirms the integration of cultural experiences, including museum visits, into public wellbeing pathways. Within this framework, the present study acquires a relevance that extends beyond the strictly pedagogical field. If culture can be 'prescribed', the virtual museum opens the possibility of extending this prescription to people for whom physical mobility, geographical distance or institutional constraints would otherwise make cultural prescription only a theoretical possibility.

5. **Flipped Inclusion, accessibility and perspective-taking: designing virtual environments as spaces of decentring**

   The framework of Flipped Inclusion (Corona & De Giuseppe, 2017) makes it possible to rethink inclusive educational design through a decisive reversal. Inclusion is not placed at the end of the process as a later adaptation of a pathway designed for a standard subject. It is placed at the beginning of educational action. From this perspective, the plurality of

cognitive, sensory, emotional, linguistic and relational profiles is not a variable to be corrected. It is the generative condition of design. An educational environment does not become inclusive because it adds compensatory tools to an already defined structure. It becomes inclusive when it takes difference as the organising principle of the experience from the outset.

Applied to the virtual museum, this perspective radically changes the problem of accessibility. Making a digital museum accessible does not only mean ensuring technical compatibility, subtitles, alternative descriptions, assisted navigation or interface usability. These elements remain necessary, but they do not exhaust the inclusive quality of the experience.

In this sense, Flipped Inclusion directly meets the issue of perspective-taking. If the former defines the design logic of inclusion, the latter represents a fundamental experiential competence. Perspective-taking can be understood as the ability to adopt, at least temporarily, another person's point of view by decentring one's perceptual, cognitive and emotional position.

Perspective-taking strengthens this approach because it introduces an intersubjective dimension into inclusive design. Inclusion does not concern only the adaptation of the environment to individual needs. It also concerns the formation of subjects able to recognise the position of others. In other words, Flipped Inclusion operates at the level of environmental design, while perspective-taking operates at the level of the subject's experience within that environment. The former builds the conditions for access, participation and co-construction. The latter activates the empathic-spatial competence that makes it possible to inhabit difference not as an obstacle, but as an interpretive resource.

This link is especially important in the age of artificial intelligence. Algorithmic systems can support accessibility through automatic translation, adaptive descriptions, personalised recommendations, differentiated pathways and cognitive-support tools. Yet algorithmic personalisation does not automatically mean inclusion. It often tends to model experience around the user's individual profile, with the risk of enclosing the person within comfortable, predictable and self-referential trajectories. An inclusive perspective also requires exposure to difference, encounters with other points of view and the possibility of negotiating meanings. For this reason, AI can support Flipped Inclusion only if it is

embedded within pedagogical direction able to turn personalisation into participation and adaptation into relationship.

The theoretical frameworks reconstructed here form a single conceptual arc: from the redefinition of literacy in affective and critical terms, through its spatial materialisation in the virtual museum, to the need for inclusive design able to bridge, rather than passively endure, the gap between algorithmic promise and educational competence. The methodological design presented in the next section is located within this arc. It seeks to explore empirically how far Italian teachers already perceive this algorithmic heartbeat as part of their professional culture.

6. Methodology

Research design and research questions

The study adopts an exploratory-descriptive quantitative design. This design is consistent with the aim of detecting teachers' perceptions, orientations and self-assessments regarding the virtual museum as an inclusive learning environment, the integration of artificial intelligence into educational processes and the dimension of digital wellbeing. The research does not aim to measure causal effects or evaluate the impact of a specific teaching intervention. Rather, it reconstructs an empirical picture of the professional representations that accompany the emergence of virtual, algorithmic and affectively characterised educational environments.

The design is suitable for identifying broad perceptual trends and associations between theoretically relevant constructs. These include digital and socio-affective competences, orientation towards AI, perception of the virtual museum as inclusive, and affective wellbeing. From this perspective, the results are interpreted as indicators of attitudes, pedagogical sensitivities and training needs, not as evidence of effectiveness in an experimental sense.

The study is guided by five research questions: (RQ1) how Italian teachers perceive the inclusive and cooperative potential of the virtual museum; (RQ2) how they self-assess a set of transversal competences potentially involved in mediating digital environments; (RQ3) what pro-social tendency they report in digital contexts; (RQ4) what affective and perceived wellbeing value they attribute to the virtual museum experience; and (RQ5) what orientation they express towards artificial intelligence applied to teaching.

Instrument

The instrument is an ad hoc questionnaire, organised into six sections (A-F) and comprising forty items. Section A collects sociodemographic information, including gender, age, educational qualification and professional role. Section B explores previous experience with virtual museums and perceptions of their inclusive potential, using categorical items and a five-point Likert scale. Section C asks respondents to self-assess four macro-areas of transversal competence: content competences, communication competences, cognitive and metacognitive competences, and social and pro-social competences. Each area is articulated into four specific indicators, again measured on a five-point Likert scale.

Sections D, E and F were designed to operationalise the theoretical frameworks discussed above and therefore require further specification. Section D (4 items) measures declared pro-social tendency in digital environments: understanding others' points of view, responsibility for the relational climate, inclination towards co-creation and readiness to offer mutual help. It shows very good internal reliability (Cronbach's $\alpha = .86$). Section E (5 items) measures the affective and experiential dimension associated with virtual museum use. It includes motivation, sense of belonging, perceived social recognition, mood, self-esteem, collective wellbeing and solidarity. The scale shows high internal reliability ($\alpha = .93$), indicating good coherence between the items that compose the dimension measured. Section F (3 items) measures self-perceived knowledge of AI, trust in its potential for teaching personalisation and perceived importance of specific training in responsible use. Despite the brevity of the scale, it shows good reliability ($\alpha = .78$). As will be shown, it is still able to reveal the internal gap between its own items.

Sample and procedure

The questionnaire was administered online through Google Forms to a sample of N = 629 Italian teachers. The sample was collected through non-probability convenience sampling, using professional networks and communication channels linked to the school sector. The sample is predominantly female (76.3%), with most respondents in the 40-50 age group (41.3%) and the 50-60 age group (28.6%). A total of 53.6% reported holding a master's degree, and 10.5% reported holding a postgraduate qualification, such as a master's course or doctorate. With regard to professional role, 80.4% of responses explicitly referred to teaching. Within this subgroup, 190 respondents identified as support teachers,

corresponding to 30.2% of the total sample and 37.5% of the teacher subgroup.

Data analysis

The data were processed using descriptive statistics (frequencies, percentages and central values) for Section B and for the sample profile. Mean scores and frequency distributions were calculated for the Likert scales in Sections C-F. Given the ordinal nature of the items, relationships between constructs were examined using Spearman's correlation coefficient. This was applied in particular to orientation towards AI (Section F), the affective dimension (Section E) and pro-social tendency (Section D). Correlations are reported and discussed in the results section alongside the descriptive distributions. The responses collected through Google Forms were exported as a .csv file and processed in a computational environment.

7. Results

This section reports the main descriptive and correlational results from the questionnaire analysis. In line with the exploratory-descriptive design of the study, the data are presented as indicators of respondents' perceptions, orientations and self-assessments, without inferring causal relationships. The presentation follows the structure of the instrument: sample profile and experience with the virtual museum; self-perceived competences; digital pro-sociality; wellbeing associated with the virtual museum experience; orientation towards educational artificial intelligence; and correlations between constructs.

Sample profile and previous experience with the virtual museum

The sample (N = 629; Table 1) is predominantly female (76.3%). Respondents are concentrated mainly in the 40-50 age group (41.3%) and the 50-60 age group (28.6%), and most hold a master's degree (53.6%). In total, 80.4% of respondents explicitly refer to a teaching role, and 30.2% of the whole sample identify as support teachers. This is a substantial presence and will be relevant to the discussion of inclusion. With regard to declared learning style, formal learning clearly prevails (67.4%). The inclination towards cooperative work is also widespread: 95.1% of the sample report being 'quite' or 'very' able to learn and work in a team.

Table 1: Sample profile (N = 629)

Variable	Category	N	%
Gender	Female	480	76.3%
	Male	146	23.2%
	Other / prefer not to say	3	0.5%
Age	40-50 years	260	41.3%
	50-60 years	180	28.6%
	30-40 years	122	19.4%
	20-30 years	50	7.9%
	Over 60 years	17	2.7%
Educational qualification	Master's degree	337	53.6%
	Upper secondary diploma	161	25.6%
	Postgraduate qualification (master's course, PhD)	66	10.5%
	Bachelor's degree	31	4.9%
	Other	34	5.4%
Professional role	Teacher / educator (incl. support)	506	80.4%
of which: support teachers	teacher subgroup	190	37.5%*

**Percentage calculated on the teacher subgroup (N = 506). The same group corresponds to 30.2% of the total sample.*

The data on direct experience with virtual museums are particularly interesting when read against this cooperative openness. Only 46.4% of respondents stated that they had ever visited one, while 52.0% answered negatively. Yet when asked to evaluate its potential, not the experience already lived but the expectation, the orientation changes almost completely. A total of 93.4% believe that the virtual museum can support inclusive and cooperative learning ('quite' or 'very much'; item B6), and 73.6% agree that virtual environments can reduce physical and cognitive barriers to cultural access (item B7, M = 4.03; SD = 0.98). The most interesting point is therefore not enthusiasm in itself, but the fact that it precedes direct experience. Trust in the inclusive potential of the virtual museum appears to be widespread even among those who have not personally experienced it.

Self-perceived competences

Table 2 reports the descriptive statistics for the four competence sub-areas investigated in Section C. All mean scores are oriented towards the positive end of the scale and are relatively homogeneous (M between 4.02 and 4.31, with good or very good internal reliability, α between .80 and .85). The only partial exception is a peak in social and pro-social competences (C4, M = 4.31), which show a slightly higher mean than the other three areas. This relative homogeneity across content, communication and cognitive-metacognitive areas suggests a solid and transversal professional self-assessment. As will be seen in the following sections, it also supports

an already favourable orientation towards the relational and social dimensions of teaching.

Table 2: Descriptive statistics and internal reliability by construct

Construct	N items	M	SD	α
C1 — Content competences	4	4.05	0.44	.80
C2 — Communication competences	4	4.08	0.49	.85
C3 — Cognitive-metacognitive competences	4	4.02	0.45	.82
C4 — Social and pro-social competences	4	4.31	0.49	.83
D — Digital pro-sociality	4	4.10	0.78	.86
E — Affective wellbeing	5	3.70	0.90	.93
F — Orientation towards AI	3	3.80	0.82	.78

Note. Mean scores on a five-point Likert scale. SD = standard deviation; α = Cronbach's alpha.

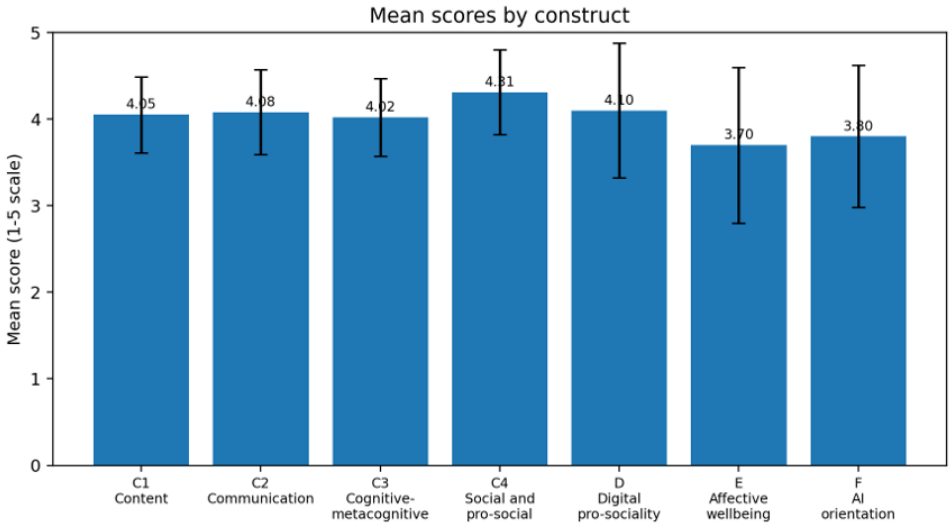


Figure 1: Mean scores (± SD) for the seven constructs investigated

Pro-sociality in digital environments

Section D, which refers specifically to digital contexts (virtual classes, virtual museums, forums and social media), shows high scores and very good internal reliability (α = .86; Table 2). As shown in Table 4, the most widely endorsed item is D4, readiness to help others overcome technological or communicative difficulties (M = 4.33; 83.5% of responses at 4-5), followed

by D2, responsibility for a respectful and cooperative relational climate (M = 4.14; 78.1%). Slightly lower, though still positive, are D1 (understanding others' emotions online, M = 3.92) and D3 (enjoyment of group work or co-creation of content, M = 4.00). The emerging picture is one of declared digital pro-sociality. It appears more readily as practical helpfulness and relational responsibility than as full mastery of empathic reading at a distance.

Wellbeing and affective experience in the virtual museum

Section E measures perceptions of the affective and experiential dimension associated with virtual museum use. The scale shows the highest internal reliability among the constructs investigated (α = .93; Table 2), with an overall mean score of 3.70 (SD = 0.90).

Item-level analysis (Table 4) shows a non-uniform distribution of scores. The item with the highest mean is E1, motivation and curiosity (M = 3.83; SD = 0.98; 65.2% of responses at 4-5), followed by E5, collective wellbeing and solidarity (M = 3.79; SD = 1.03; 64.2% of responses at 4-5), and E2, sense of belonging to the group (M = 3.73; SD = 1.00; 62.0% of responses at 4-5).

Lower values are observed for E3, feeling appreciated and recognised (M = 3.62; SD = 1.01; 56.4% of responses at 4-5), and E4, improvement in mood and personal self-esteem (M = 3.55; SD = 1.02; 51.7% of responses at 4-5). Overall, the data indicate a positive evaluation of the affective dimension of the virtual museum experience. Values are higher for motivation, curiosity, belonging and collective wellbeing, and more moderate for personal recognition, mood and self-esteem.

Table 3: Details of items in Sections D and E

Item	M	SD	% responses 4-5
D1 — Understanding others' emotions online	3.92	0.90	70.3%
D2 — Responsibility for the relational climate	4.14	0.91	78.1%
D3 — Enjoyment of group work / co-creation	4.00	1.01	71.2%
D4 — Readiness to help others	4.33	0.89	83.5%
E1 — Motivation and curiosity	3.83	0.98	65.2%
E2 — Sense of belonging to the group	3.73	1.00	62.0%
E3 — Feeling appreciated and recognised	3.62	1.01	56.4%
E4 — Improvement in mood and self-esteem	3.55	1.02	51.7%
E5 — Collective wellbeing and solidarity	3.79	1.03	64.2%

Literacy and attitudes towards artificial intelligence

Section F measures three dimensions relating to educational artificial intelligence: self-perceived knowledge of how AI works, perception of its potential for learning personalisation and importance attributed to training for responsible use. The scale shows good internal reliability (α = .78; Table 2), with an overall mean score of 3.80 (SD = 0.82).

As reported in Table 3 and Figure 1, item F1, self-perceived general knowledge of how AI works and of its educational applications, has the lowest mean in the section (M = 3.50; SD = 1.00), with 52.3% of responses in the 4-5 range. Item F2, the possibility that AI can support personalised learning, has a mean of 3.69 (SD = 0.97), with 59.8% of responses at the upper end of the scale.

The highest value is observed for F3, the importance attributed to specific training in the responsible use of artificial intelligence (M = 4.21; SD = 0.99), with 78.4% of responses in the 4-5 range. The distribution of items therefore shows a gap between self-perceived AI knowledge, which is more moderate, and the importance attributed to training, which is substantially higher.

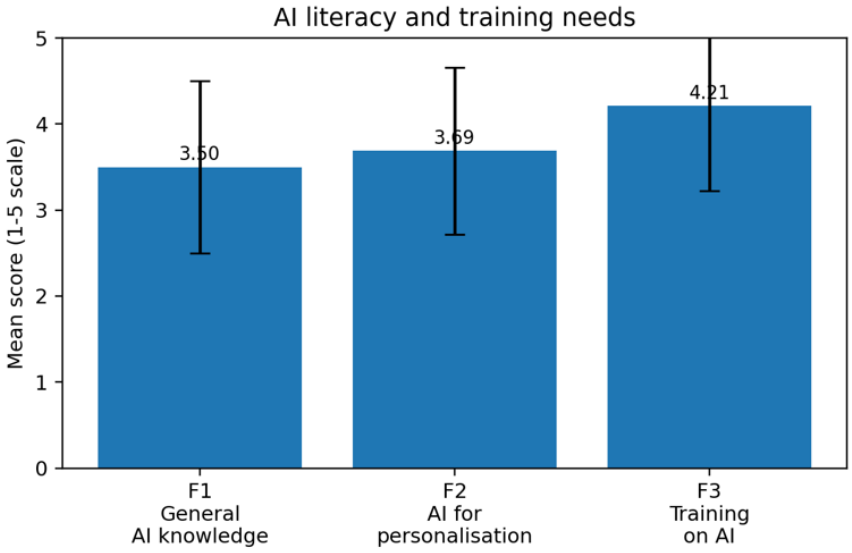


Figure 2: Mean scores (± SD) for the three items in Section F.

Table 4*:* Details of items in Section F

Item	M	SD	% responses 4-5
F1 — General knowledge of how AI works	3.50	1.00	52.3%
F2 — AI can support personalised learning	3.69	0.97	59.8%
F3 — Importance of training in responsible AI use	4.21	0.99	78.4%

Spearman correlations between constructs (Table 5) add a further element to this picture. Orientation towards AI (F) correlates moderately with both affective wellbeing (E; ρ = .48) and digital pro-sociality (D; ρ = .50). The strongest correlation in the matrix is between affective wellbeing and digital pro-sociality (E-D; ρ = .68). Correlations between F and the four competence sub-areas (C1-C4) are more modest (ρ between .24 and .31), as are those between wellbeing/pro-sociality and the same competences (ρ generally below .30). In line with the exploratory-descriptive design of the study, these associations are not interpreted causally. The correlational matrix nevertheless shows higher values between digital pro-sociality, museum-related affective wellbeing and orientation towards AI, while the associations between these constructs and self-perceived competences are more limited. These relationships are discussed in the next section in light of the theoretical framework.

Table 5: Spearman correlation matrix between constructs

	C1	C2	C3	C4	D	E	F
C1	1.00	0.62	0.65	0.45	0.26	0.16	0.30
C2	0.62	1.00	0.66	0.54	0.19	0.11	0.24
C3	0.65	0.66	1.00	0.51	0.24	0.21	0.31
C4	0.45	0.54	0.51	1.00	0.32	0.21	0.29
D	0.26	0.19	0.24	0.32	1.00	0.68	0.50
E	0.16	0.11	0.21	0.21	0.68	1.00	0.48
F	0.30	0.24	0.31	0.29	0.50	0.48	1.00

8. Discussion

The results describe a complex picture. Teachers' openness towards the virtual museum and artificial intelligence coexists with areas of formative caution. In line with the exploratory-descriptive design, the discussion does not assign causal value to the data. It interprets the main patterns in relation to the theoretical framework. Three elements are particularly relevant: the distance between positive orientation towards AI and self-perceived critical competence; the mainly relational nature of the value attributed to the virtual museum; and the need to rethink teacher education as an integration of AI literacy, Digital Affective Literacy and Flipped Inclusion.

Openness towards AI and the fragility of critical competence

The first relevant finding concerns the section on educational artificial intelligence. Respondents assign high value to the need for specific training in responsible AI use, while their self-perceived knowledge of how AI works and of its educational applications is more moderate. The distance between F1, general knowledge of AI, and F3, the importance of training, is one of the most significant findings of the study. Teachers recognise the urgency of educational AI, but do not yet seem to regard their own critical competence in this area as fully consolidated.

This gap should not be read as a rejection of technology. On the contrary, the intermediate value attributed to the possibility that AI can support personalised learning indicates an overall favourable, or at least open, disposition towards the educational potential of algorithmic systems. The critical issue concerns the quality of this openness. Recognising the transformative potential of AI does not automatically mean understanding how it works, what its limits are, where biases may emerge, what ethical implications it carries or under what conditions it can be used pedagogically.

The so-called Frankenstein complex can be located within this space of tension. In education, it does not necessarily take the form of paralysing fear of artificial intelligence. It appears rather as an uneasy trust: a willingness to recognise AI's possibilities, accompanied by awareness that not all the tools needed to govern it critically are yet available. The training-related result confirms this reading. Teachers are not simply asking to use AI. They are asking to be placed in a position to use it responsibly.

The correlations strengthen this interpretation. Orientation towards AI is more clearly associated with digital pro-sociality and museum-related affective wellbeing than with self-perceived professional competences. This pattern suggests that openness to AI, in this sample, is not only technical-cognitive. It is embedded in a broader relational sensitivity. In other words, AI is perceived not only as a tool for efficiency or personalisation, but also as part of an educational environment in which trust, responsibility, cooperation and wellbeing matter.

A first theoretical implication follows. From a pedagogical perspective, AI literacy cannot be limited to technical understanding of algorithmic systems. It must include the ability to question AI's impact on the educational relationship, on inclusion processes, on the construction of autonomy and on the affective quality of learning. AI literacy thus becomes

part of a broader Digital Affective Literacy, in which technical competence, ethical responsibility and relational sensitivity cannot be separated.

The virtual museum as a relational rather than individual experience

The second relevant element concerns the affective dimension of the virtual museum experience. The data show an overall positive but uneven evaluation of the items in Section E. The highest values concern motivation, curiosity, sense of belonging and collective wellbeing. More moderate values concern feeling appreciated, improvement in mood and personal self-esteem. This distribution suggests that the virtual museum is perceived less as a device for individual gratification and more as an environment able to support shared experience, belonging and solidarity.

The correlation between digital pro-sociality and museum-related affective wellbeing is the most relevant finding in this direction. The link between the two dimensions suggests that, in teachers' perceptions, feeling well in a digital environment does not simply mean receiving a pleasant stimulus or accessing motivating content. It means participating in a relational context in which mutual help, communicative responsibility and cooperation contribute to the quality of the experience. Digital wellbeing, from this perspective, is not only an individual condition. It is an emergent property of the relationship.

This is where the metaphor of the affective membrane can be used more precisely. The virtual museum does not appear as a simple container of cultural content or as a digital replica of the physical museum. It can be interpreted as a surface of mediation between subject, heritage and community: a space that filters, orients and makes cultural experience shareable. The affective membrane does not automatically produce wellbeing. It makes wellbeing possible when the environment enables recognition, participation and the shared construction of meaning.

This reading helps to avoid reducing the virtual museum to a compensatory resource for those who cannot access the physical museum. The data indicate that its value does not depend only on remote accessibility. It also depends on its capacity to generate interaction, belonging and participation. The digital dimension therefore does not erase the relational nature of museum experience. It reconfigures it through new forms of presence, orientation and sharing.

This confirms that the virtual museum should not be understood only as a compensatory or therapeutic resource, but as a mediated relational experience. Yet the data suggest that the educational and affective value

of the virtual museum cannot be understood in purely individual or therapeutic terms. It should be understood as a mediated relational experience, in which wellbeing emerges from the possibility of feeling part of a context, recognising oneself in a learning community and contributing to the shared construction of meaning.

Training teachers for algorithmic, affective and inclusive educational environments

The third core element of the discussion concerns teacher education. The results show a significant combination. On the one hand, the virtual museum is evaluated very positively in terms of its inclusive and cooperative potential. On the other hand, direct experience of virtual visits does not yet concern the majority of the sample. This is accompanied by strong self-perception of social and pro-social competences, together with an explicit request for training in responsible AI use. The emerging picture is one of pedagogical need that is already present, but not yet fully supported by specific experiences and competences.

This condition marks a crucial step. Digital inclusion does not arise from technological availability alone, nor from the presence of artificial intelligence, nor from teachers' positive openness. It requires design competence able to transform virtual environments into genuinely accessible, participatory and relational spaces. In this sense, Flipped Inclusion provides the design logic through which accessibility becomes a structural feature of the learning environment, rather than an additional corrective measure.

The virtual museum can become an inclusive environment only if it is designed from the plurality of cognitive, sensory, emotional and relational profiles. This implies differentiated pathways, multiple communication channels, opportunities for autonomous and cooperative exploration, reworking activities, moments of restitution and devices that can support perspective-taking. Perspective-taking is the empathic-spatial competence through which subjects learn to decentre their own point of view, adopt different perspectives and recognise the position of others.

The main contribution of the study lies in indicating the need for an integrated model of teacher education. This model should include at least three dimensions. The first is AI literacy, understood as the ability to understand the general functioning of algorithmic systems, their limits, the risks of bias, their ethical implications and the pedagogical conditions of use. The second is Digital Affective Literacy, understood as the ability to

recognise and govern the emotional, relational and moral dimensions of digital environments. The third is Flipped Inclusion, understood as a design logic that treats difference not as an exception to be managed, but as a generative principle of educational experience.

Integrating these three dimensions leads to a clear pedagogical conclusion. Training teachers for AI does not mean only teaching them to use intelligent tools. It means preparing them to design educational environments in which technology, relationship and inclusion can support one another. From this perspective, the virtual museum is a privileged laboratory. It makes visible the wider challenge of the Fourth Industrial Revolution: not the introduction of algorithms into education, but the construction of conditions that allow education to continue producing meaning, care and belonging, even within algorithmically mediated environments.

9. Conclusion

This study has examined the virtual museum as a site where cultural heritage, artificial intelligence and inclusive design intersect. The survey shows that teachers are open to algorithmic technologies, but also express a clear need for critical training. It also suggests that the educational value of the virtual museum lies less in digital access alone than in its capacity to support participation, relationship and shared meaning-making.

The central issue running through the study is therefore the pedagogical quality of digital mediation. Artificial intelligence can contribute to pathway personalisation, broadened access and more flexible environments. Yet its educational effectiveness depends on teachers' ability to orient its use towards clear, ethically grounded and relationally meaningful educational aims. Teacher education cannot therefore be limited to familiarisation with tools and platforms. It must promote critical, design-oriented and affective competences able to support the responsible use of AI in educational contexts.

These indications should be read in light of the exploratory-descriptive nature of the study. The data collected report perceptions, orientations and self-assessments, not causal effects or direct measures of the impact of specific virtual museum experiences. The sample, selected through a non-probability procedure, does not allow generalisation to the whole population of Italian teachers. In addition, the use of self-report instruments requires caution when interpreting declared levels of competence and wellbeing. These elements do not reduce the heuristic

value of the study. They delimit its scope and position it as an initial contribution to the mapping of a rapidly transforming educational field.

If the title of this work evokes an algorithmic heartbeat, the data discussed suggest that this heartbeat does not yet sound in unison in Italian schools. On the one hand, there is already a lively sensitivity towards the inclusive and relational dimensions of digital learning. On the other, full critical literacy in artificial intelligence still needs to be consolidated. Bridging this missing synchrony is one of the most urgent pedagogical challenges of the Fourth Industrial Revolution.

Future research, using mixed, quasi-experimental or longitudinal designs, may examine how virtual museum experiences designed according to inclusive criteria affect participation, perceived wellbeing, digital competences and attitudes towards AI. From this perspective, the virtual museum can become a privileged laboratory for observing not only technological innovation in educational processes, but also the possibility of building digital environments in which accessibility, algorithmic responsibility and relationship remain inseparable dimensions of learning.

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