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From Artificial Interaction to Relational Engagement: AI Literacy, Educational Experience and Co-Regulation in Hybrid Learning Environments

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Abstract: An AI-generated answer can be scientifically plausible and nevertheless leave the teacher uncertain about what a pupil has learned. This article examines that uncertainty as a pedagogical rather than merely technical problem. We develop a conceptual argument drawing on Dewey's account of educational experience, multidimensional theories of engagement, AI literacy and collaborative regulation. Three educational situations are differentiated: task completion, independently sustained inquiry and AI-mediated relational engagement. We then construct a primary-school science example in which two explanations of plant growth are compared against disciplinary sources. The example serves to identify conditions under which AI-supported work becomes discussable and revisable among people: continuity of inquiry, accountable decisions, accessible participation and negotiated criteria. It also exposes counterexamples. A pupil can learn through careful private checking; a group can participate actively while leaving an error unexamined. The proposed categories are analytical distinctions, not observations of a sample or validated indicators of achievement. Their intended use is to inform instructional design and to formulate questions for future classroom investigation.

Keywords: AI literacy; relational engagement; co-regulation; generative artificial intelligence; hybrid learning environments

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1. Introduction[1]

In an elementary science lesson, the teacher asks pupils to account for the material gained as a seedling grows. One fluent text produced by a generative system lists water, light and minerals; another also mentions carbon dioxide. Both could be accepted by pupils who have learned to associate plant growth with sunlight. Yet the lesson asks a more discriminating question: where does the plant's additional matter come from? Our example is deliberately constructed; it is not a classroom episode that we observed. Its purpose is to expose a problem of interpretation. Completing the worksheet, identifying a missing concept and revising an initial explanation are different educational events, even when the submitted products look similar.

A log of commands supplied to a chatbot would not settle the issue. The learner who requests five reformulations might be postponing a decision; another who makes one request might subsequently compare the result with a scientific illustration and

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challenge its assumptions. The research literature has long rejected an exclusively behavioural view of engagement (Fredricks et al., 2004). Generative systems make that caution more consequential: a continuous exchange may be a record of convenience rather than intellectual work. We therefore ask what kind of evidence a teacher can reasonably request without confusing the trace of interaction with the quality of experience.

Our earlier studies approached the same setting from different directions. Fabiano and Cirolia (2024) considered hybrid teaching in inclusive schooling; Fabiano (2024) discussed the connections among AI, curriculum and digital citizenship; Fabiano (2026) examined AI literacy through educational experience. Cirolia and Nobile (2026) addressed the hybridisation of learning spaces, while Nobile and Cirolia (2026) discussed agency within socio-technical learning environments. The present contribution asks a narrower question left open by those accounts: what changes when a privately obtained AI answer becomes a claim that a pupil must defend, revise or withdraw before other people?

The analysis is guided by two questions. What makes AI assistance compatible with inquiry rather than a shortcut to task completion? Under which additional conditions does the episode merit the description relational engagement? We do not use the term for a conversational interface or simply for group work. It applies to occasions in which a proposition can be answered by another person and the response has consequences for the learner's judgement.

2. Theoretical Approach and Scope

2.1. Conceptual procedure

The analysis proceeds through three conceptual operations. We first distinguish the educational issue addressed by each framework: the continuity of experience in Dewey (2014), the multidimensional character of engagement in Fredricks et al. (2004), the evaluative demands of AI literacy in Ng et al. (2021), and the distribution of regulatory responsibility in Hadwin et al. (2018). We then apply these distinctions to a deliberately constructed science task. Finally, we examine two countercases that challenge the proposed category. The sources were selected for their conceptual relevance, not through a systematic search. No pupils were recruited, no classroom observations were collected and no effects were measured.

Two countercases matter. A pupil may correct a misleading output after privately checking a diagram: the activity can be educative without being relational in the particular sense used here. A group may agree on a persuasive answer without checking its scientific content: the exchange is social, yet the quality of the underlying inquiry remains uncertain. Any useful account of relational engagement must accommodate both cases. Otherwise, it risks treating individual study as deficient and collective talk as sufficient evidence of learning.

2.2. Experience, continuity and interaction

Dewey's account makes the quality of an experience depend on its relation to later experience, not simply on satisfaction with an immediate result (Dewey, 2014). A digital explanation may remove a linguistic obstacle and make a previously inaccessible question discussable. It may also resolve the assignment so completely that there is nothing left for a pupil to investigate. Both uses can save time. Only the first necessarily offers a route back to the subject matter. This suggests a practical distinction for the

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teacher: not whether assistance occurred, but whether the learner can resume the inquiry with better resources than before.2

Dewey's distinction is demanding for lesson design. Assistance with vocabulary can remove a barrier while preserving the intellectual task. Assistance that supplies both an answer and the standards by which it should be accepted may remove the occasion for inquiry. The same tool can perform either function depending on when it is introduced and how the teacher frames the subsequent work. Spadafora's discussions of Deweyan intelligence and democratic education (2017, 2024) support this emphasis on judgement in experience. Fabiano et al. (2025) similarly connect AI and experience to inclusion. These affinities do not establish that a particular AI activity is educative; that remains to be shown in the activity itself.

2.3. Engagement is more than interaction

The distinction between behavioural, emotional and cognitive engagement (Fredricks et al., 2004) warns against inferring learning from visible activity. Five successive prompts may record difficult inquiry; they may equally indicate that a pupil is trying to obtain an acceptable sentence without examining it. Reassurance can help a hesitant learner begin, but it cannot establish that a misconception has been corrected. In the present analysis, participation is therefore interpreted in relation to a disciplinary claim: what has the learner come to understand, question or justify? Neither the number of interactions nor the fluency of the final output answers that question on its own.

We reserve the adjective relational for a more exacting event: someone offers an interpretation that another person is able to question, extend or refuse, and that exchange bears on what the participants do next. A simplified AI explanation may help a quiet pupil enter such an exchange; it does not itself constitute one. Conversely, four pupils can agree enthusiastically with a generated paragraph and remain uncritical of its claims. The relevant relation is therefore not contact or sociability alone. It is a situation in which reasons can be answered by other reasons and responsibility for the conclusion remains with people.3

2.4. AI literacy and the location of agency

Ng et al. (2021) present AI literacy as involving more than facility with interfaces. In the plant-growth task, that distinction becomes concrete. An answer may correctly mention sunlight as an energy source and still fail to identify where much of a plant's new carbon-based material originates. A pupil needs subject knowledge, an appropriate source and an opportunity to question the output in order to notice the omission. Asking the model to "explain it better" might leave the scientific difficulty untouched. For the

2 In a Deweyan perspective, continuity is not the uninterrupted use of a tool: an experience is educative when it enlarges the conditions for later inquiry. The distinction is important when AI removes difficulty without strengthening the learner's judgment (Spadafora, 2017, 2024).

3 The proposed relational dimension should not be mistaken for a psychometric scale or an empirically validated fourth component of engagement. It specifies an interpretive question about the place of peers, teachers and shared recognition in AI-mediated activities.

purposes of this paper, AI literacy is exhibited less by the elegance of a prompt than by the grounds offered for keeping or rejecting a proposition.4

A defensible decision can take different forms. A pupil may retain an illustration because it fits a source already examined, reject a sentence because it confuses the source of energy with the origin of matter, or withhold judgement until the claim can be checked. None of these decisions requires the pupil to pretend that the final product was written without assistance. What matters is the account the learner can provide of a consequential choice. Equally, displaying a carefully formulated prompt is not in itself evidence of such agency. The proposed distinction keeps technical proficiency in view without making it a substitute for epistemic responsibility. The pedagogical relevance of this distinction is also discussed within algorithmic pedagogy (Panciroli & Rivoltella, 2023).

2.5. Regulation and educational reciprocity

The vocabulary of regulation requires a further safeguard. Hadwin et al. (2018) distinguish self-regulation, co-regulation and socially shared regulation within learning activity. An automated system can suggest a sequence, remind a pupil of a goal or flag a possible inconsistency. Such prompts may affect self-regulation; they are not, simply by virtue of sounding responsive, co-regulation in the same sense as a learner negotiating a strategy with a teacher or peer. When a class changes its criterion for evaluating an answer, we need to ask who recognised the problem, whose reasons were heard and who accepted responsibility for the revised decision.5

The distinction becomes visible when a pair receives competing explanations. One pupil argues that a reference to sunlight is sufficient; the other points to a passage about carbon dioxide in the science material. They must first decide what evidence would answer the original question. Should they observe change in height, identify inputs and products of photosynthesis, or compare two diagrams? The educational value does not lie in making them disagree. It lies in whether the disagreement produces an examinable criterion and whether the criterion survives comparison with a reliable source. That is a human regulatory process in which the AI output supplies material to be judged, not an actor who assumes educational responsibility.

3. AI-Mediated Relational Engagement: A Provisional Framework

3.1. Definition and boundaries

We use AI-mediated relational engagement to identify a specific educational occurrence: an AI-produced claim is opened to human questioning, and that questioning can affect the interpretation or decision that follows. Three exclusions clarify its scope. The software is not a reciprocal educator; responsibility for the inquiry remains with pupils and teachers. A carefully reasoned individual correction may be educative without meeting the relational condition. Finally, the mere circulation of a generated

4 Operational AI literacy should be distinguished from prompt fluency. A well-formed request can produce a persuasive answer while leaving the evidential basis unexamined. Educationally significant literacy requires justification, source-checking and recognition of the limits of delegated work.

5 Human co-regulation involves reciprocal interpretation and responsibility among participants. Automated suggestions may facilitate regulation, but the availability of a responsive interface does not establish shared intentions, mutual accountability or a pedagogical relationship.

answer in a group does not suffice if no one can examine the reasons for accepting it. The expression is an analytical proposal, not a label to be attached to all collaborative uses of AI.

Four questions give the proposal a form that can be criticised. Continuity: did the output lead to a further question about the subject matter? Accountability: can a learner say why a claim was retained or revised? Relation: was that interpretation available to meaningful human response? Regulation: did participants reconsider the standards used to assess the claim? These questions are not a scale, and an unanswered question is not a diagnosis of a pupil. They identify features of a learning arrangement that a teacher might examine. Table 1 connects them with illustrative traces while deliberately avoiding numerical ratings.

3.2. Continuity of inquiry

In our constructed task, the missing reference to atmospheric carbon is productive only if it helps the class recover the question about the source of plant material. A teacher might ask pupils to draw arrows showing what enters the plant and to mark which arrows refer to matter and which to energy. The first explanation could then be revisited: does it answer the question, or merely name conditions that assist growth? A revised diagram would not prove understanding by itself; it would provide a concrete object for discussion about what the pupil has changed and why. The sequence preserves a difficulty that the initial polished paragraph appeared to remove.

3.3. Accountable agency

An instruction to "choose the better explanation" can be answered by selecting the text that sounds more technical. The teacher can make the reasoning demand explicit instead: Which statement supplies the origin of the new material? Which statement names an energy source? Where could a class check either claim? The answer may be offered through a labelled image, a short spoken comparison or a written annotation. These are not interchangeable measurements of learning. They are alternative routes for making a decision available to scrutiny, particularly where writing fluency would otherwise obscure a pupil's grasp of the science.

3.4. Relational participation

Relational participation cannot be equated with speaking in front of the class. Requiring an immediate public answer may penalise learners who need more processing time or communicate more effectively through a partner, a drawing or assisted language. A private exchange with an AI system may serve as preparation for a contribution that becomes shareable later. Our criterion is therefore response-ability: can another learner or the teacher recognise and address the claim? This does not require a full transcript of the pupil's exploratory dialogue. Nor does it make sociability a prerequisite for every valuable form of learning.

3.5. Shared interpretive regulation

A change of criterion is easier to recognise than the amount of conversation preceding it. At first, the pair may choose whichever output reads more smoothly. After checking the source, they may agree that a satisfactory explanation must distinguish light as an energy input from carbon-containing matter incorporated through photosynthesis. The shift from readability to scientific adequacy is worth documenting. Yet the group could still adopt a faulty criterion, so its choice remains open to challenge.

Shared regulation should not be mistaken for agreement; it concerns the reciprocal adjustment of plans and judgements in relation to the task (Hadwin et al., 2018).

4. Pedagogical Implications for Hybrid Environments

4.1. From generated answers to shared objects of inquiry

The hypothetical science sequence begins with pupils' own representations of plant growth, recorded in words or drawings. Only afterwards does the teacher present two brief AI-generated explanations. One lists water, light and minerals without accounting for the carbon incorporated into new plant material; the other introduces carbon dioxide but still requires clarification. Pupils identify a disagreement, consult an age-appropriate science source, and annotate one change to their first explanation. The order is deliberate. An initial account gives the teacher something to compare with the revised one; a generated answer supplied at the outset would conceal that comparison. This is a design illustration, not a tested teaching intervention.

Three artefacts would remain after the activity: an initial drawing or statement, a selected correction, and the pupil's reason for making it. Even together, they would not constitute a validated measure of learning. They would, however, tell the teacher where further explanation is needed. A pupil who continues to describe sunlight as the material from which a plant's additional mass is made has not yet addressed the question posed. The relevant instructional response is to return to the scientific distinction, not to reward the fluency of the final paragraph.

4.2. A design and observation matrix

Table 1 contrasts weak proxies with traces that could justify closer pedagogical attention. Counting prompts, recording time online or rewarding frequent interventions is administratively simple, but such measures do not establish whether a scientific claim was examined. By contrast, a revision with a stated reason gives the teacher a specific decision to discuss. Even this is limited evidence: the reason itself must be evaluated against the subject matter.

Table 1. Interpretive criteria for AI-mediated relational engagement.

Not sufficient on its own	Potentially informative trace	Dimension
Number of generated responses	Pupil identifies a new question after checking a claim	Continuity
Fluent final wording	Pupil justifies accepting or re-jecting a claim	Accountable agency
Speaking frequently in a group	Peer response changes the in-terpretation	Relational participation
Compliance with an AI checklist	Group explains why its plan was altered	Interpretive regulation

Note. This matrix is an analytical aid proposed by the authors. It has not been validated as an assessment instrument.

The matrix is meant for professional interpretation, not pupil classification. A corrected arrow in a drawing may show what a longer essay obscures; a confident oral explanation may still repeat an error. Teachers must judge the disciplinary adequacy of a response while allowing pupils to communicate in different accessible forms. Collecting

complete chatbot histories would not remove that interpretive responsibility. It could instead produce extensive personal records of uncertain educational value.

4.3. Equity, digital educational poverty and care

Access and interpretive advantage should not be conflated. In the same class, one pupil may notice that a generated explanation has omitted a causal step, while another lacks the language needed to formulate the objection. An interface available to both does not give them equal power to examine its claims. Here we use digital educational poverty to refer to limited opportunities for supported interpretation and participation, not to a measured characteristic of pupils. Fabiano (2026) places AI literacy in relation to educational experience; this perspective directs attention to the teacher's mediation and to the resources pupils can actually use, beyond connectivity alone.6

There is a further limit to the demand for visibility. Private drafting may offer a pupil an opportunity to take intellectual risks that are difficult in front of peers. An educationally meaningful account need not disclose every exploratory prompt, irrelevant personal detail or unfinished idea. The teacher can request one selected proposition and the reason for accepting or changing it. Such a request is proportional to the disciplinary task and preserves a distinction between offering an explanation and surrendering a record of one's private exploration. Respect for this boundary is particularly important in inclusive settings.

5. Discussion: Propositions, Limits and Future Research

The countercases also prevent a circular definition. Correctness of the finished answer alone is insufficient: a pupil may have copied it. Discussion alone is insufficient: a group may reinforce a misconception. At the same time, a learner may privately verify an answer and revise a mistaken assumption without involving another person. We regard this last case as educationally valuable, although it falls outside the relational category proposed here. The concept is useful only if it marks a difference rather than describing every desirable learning episode.

The framework has implications for evidence and privacy. Asking pupils to submit every prompt would confuse comprehensive surveillance with an account of learning. A more proportionate request is to identify one claim, the source used to assess it, the revision chosen, and the opportunity for someone else to respond. This requirement may help a teacher see the intellectual decision at stake, but its suitability must depend on learners' age, needs and the disciplinary task. We do not present it as a universally effective procedure.

The argument remains bounded in several ways. Its references were selected for conceptual comparison, not by systematic review. The science lesson is constructed rather than observed, and the four interpretive questions have not undergone validation. A literary interpretation, for example, requires different criteria for warranted revision than an explanation of plant growth. More importantly, a distributed-cognition approach could ascribe a greater regulatory role to artefacts than our account does. We privilege reciprocal human accountability as a pedagogical criterion, but that choice is a theoretical position open to contestation.

6 Digital educational poverty is used here in an interpretive, not diagnostic, sense. It concerns unequal opportunities to evaluate information and participate in supported inquiry, beyond the possession of devices or connectivity alone. The article does not claim to measure its prevalence.

A classroom study could examine what becomes visible when pupils are invited to explain one revision rather than submit only a final AI-supported answer. It would need to observe interaction, inspect successive versions of pupil work, and evaluate the disciplinary adequacy of the reasons given. Comparisons should also consider cases where independent source-checking is more productive than group discussion. Any investigation involving children would require ethical approval where applicable, accessible participation and minimisation of personal data. No such observations or outcomes are reported in this article.

6. Conclusions

The central difficulty for AI-supported teaching is not simply that a system can generate an incorrect answer. It is that the fluent answer can make the work of inquiry less visible, even when pupils complete the assigned product. A teacher therefore needs grounds for distinguishing acceptance, verification and revision. Our hypothetical science task illustrates one way of reopening those differences by asking pupils to address a specific disciplinary problem and make a consequential choice discussable.

The proposal names a limited but important event: an AI-produced statement becomes an object of human judgement, and someone can respond to the reasons offered for accepting or changing it. This makes contact between Dewey's continuity of experience, AI literacy and collaborative regulation without treating an automated system as a teacher or peer. It does not suggest that valuable learning must always be collective. Nor does it claim that collective agreement is sufficient. The contribution is a set of conceptual distinctions and design questions to be disputed and tested, rather than evidence of an intervention's effectiveness.

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