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Applied Silences in Artificial Intelligence in Education: A Five-Dimensional Framework and the Case for Audible AIEd

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الصمت التطبيقي في الذكاء الاصطناعي في التعليم: إطار عمل خماسي الأبعاد ودراسة جدوى الذكاء الاصطناعي المسموع في التعليم

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Abstract:
Artificial intelligence (AI) has moved rapidly from the periphery of educational technology to the centre of pedagogical, administrative, and assessment practice. The dominant discourse surrounding AI in education (AIEd) emphasises personalisation, efficiency, scalability, and inclusion. This manuscript argues that alongside these celebrated affordances, AIEd produces a less visible but consequential phenomenon: applied silences. Applied silences are the systematic quieting of voices, knowledge forms, pedagogical processes, and critical questions that are either deliberately designed away or structurally rendered inaudible by AI systems in education. Drawing on a synthesis of recent scholarship across IEEE learning technologies, critical pedagogy, ethics of automated assessment, and surveillance studies, the manuscript develops a five-dimensional framework of applied silence in AIEd: algorithmic epistemic silence, pedagogical silence, dataveillant silence, structural and policy silence, and cognitive and affective silence. For each dimension, the mechanisms, evidence, and educational consequences are examined. The manuscript then proposes a counter-framework of audible AIEd, centred on preserving productive uncertainty, redistributing epistemic authority, enforcing genuine human oversight, and designing governance for voice rather than compliance. The conclusion argues that the legitimacy of AI in education will depend not only on what these systems enable, but on what they allow to remain heard.

Keywords: artificial intelligence in education, applied silences, pedagogical silence, algorithmic opacity, dataveillance, epistemic injustice, human-centred AI

الملخص
انتقل الذكاء الاصطناعي بسرعة من هامش التكنولوجيا التعليمية إلى صميم الممارسات التربوية والإدارية والتقييمية. ويركز الخطاب السائد حول الذكاء الاصطناعي في التعليم على التخصيص والكفاءة وقابلية التوسع والشمول. وتجادل هذه الورقة البحثية بأنه إلى جانب هذه المزايا البارزة، يُنتج الذكاء الاصطناعي في التعليم ظاهرة أقل وضوحًا ولكنها ذات أهمية بالغة: الصمت التطبيقي. ويُقصد بالصمت التطبيقي التهميش المنهجي للأصوات وأشكال المعرفة والعمليات التربوية والأسئلة النقدية، إما بتصميمها عمدًا أو بجعلها غير مسموعة هيكليًا بواسطة أنظمة الذكاء الاصطناعي في التعليم. بالاستناد إلى توليفٍ من أحدث الدراسات في مجالات تقنيات التعلّم التابعة لمعهد مهندسي الكهرباء والإلكترونيات (IEEE)، والتربية النقدية، وأخلاقيات التقييم الآلي، ودراسات المراقبة، تُطوّر هذه الورقة البحثية إطارًا خماسي الأبعاد للصمت التطبيقي في التعليم المدعوم بالذكاء الاصطناعي: الصمت المعرفي الخوارزمي، والصمت التربوي، والصمت القائم على مراقبة البيانات، والصمت الهيكلي والسياسي، والصمت المعرفي والعاطفي. وتُفحص آليات كل بُعد، وأدلته، ونتائجه التعليمية. ثم تقترح الورقة إطارًا بديلًا للتعليم المدعوم بالذكاء الاصطناعي المسموع، يرتكز على الحفاظ على عدم اليقين البنّاء، وإعادة توزيع السلطة المعرفية، وفرض رقابة بشرية حقيقية، وتصميم حوكمة تُتيح التعبير عن الرأي بدلًا من الامتثال. وتخلص الورقة إلى أن شرعية الذكاء الاصطناعي في التعليم لن تعتمد فقط على ما تُتيحه هذه الأنظمة، بل أيضًا على ما تسمح به من إمكانية للتعبير عن الرأي.

الكلمات المفتاحية: الذكاء الاصطناعي في التعليم، الصمت التطبيقي، الصمت التربوي، الغموض الخوارزمي، مراقبة البيانات، الظلم المعرفي، الذكاء الاصطناعي المتمحور حول الإنسان.

Introduction

Artificial intelligence has become an infrastructural presence in education. Intelligent tutoring systems, automated assessment engines, generative writing assistants, predictive analytics dashboards, and AI-mediated proctoring tools are no longer experimental curiosities; they are embedded in learning management systems, institutional workflows, and classroom routines across the educational lifespan [1]. The systematic literature reviewed by recent IEEE studies confirms that AI in education offers demonstrable advantages in individualised learning, automated evaluation, and administrative efficiency, while simultaneously introducing persistent challenges related to algorithmic bias, ethical ambiguity, and limited pedagogical insight [1], [6]. The central claim of this manuscript is that the most consequential of these challenges are not always the ones that announce themselves. They are the ones that operate through silence.

Applied silence, as developed here, refers to the deliberate or systemic production of inaudibility in educational contexts through AI. It is not the absence of sound, but the absence of hearing, namely the quiet removal of certain questions, certain knowledges, certain pedagogical rhythms, and certain forms of human agency from the audible field of education. The concept draws on a growing body of critical scholarship that has identified silence as a structuring feature of digital education: algorithmic gatekeeping that silently regulates visibility, legitimacy, and circulation of knowledge [7]; the digital silence produced by algorithmic censorship that does not ban speech but ensures it is never heard [2]; and the erosion of pedagogical silence in the always-answering classroom, where AI fills every hesitation before uncertainty can do its developmental work [9], [14]. These are not separate phenomena. They are interrelated expressions of a broader logic in which AIEd optimises for closure, compliance, and measurable output, and in doing so quiets the conditions that make education educative.

This manuscript synthesises recent evidence across these domains to develop a structured account of applied silences in AIEd. Section II clarifies the conceptual foundations of applied silence. Sections III through VII examine five dimensions of applied silence: algorithmic epistemic silence, pedagogical silence, dataveillant silence, structural and policy silence, and cognitive and affective silence. Section VIII proposes a counter-framework of audible AIEd. Section IX concludes with implications for research, design, and governance.

Ii. Conceptualising Applied Silence In Aied

Silence in education has traditionally been treated as a deficit: the student who does not speak is disengaged; the pause that lasts too long is a failure of instruction. Yet educational theory has long recognised that silence can be pedagogically productive. Silence is the space in which learners dwell with partial knowledge, tolerate ambiguity, formulate questions slowly, and engage in the cognitive struggle that durable understanding requires [9], [18]. The always-answering classroom described by Mariyam B. reveals the fragility of this productive silence under AI conditions: because AI systems are designed for instant responsiveness, they intervene precisely at the moment when uncertainty would otherwise function as a threshold state for learning. When a learner hesitates, the system answers; when silence emerges, it is filled [9], [14]. The result is not necessarily less knowledge, but a reconfiguration of what counts as a legitimate learning experience, one in which not-knowing becomes a problem to be eliminated rather than a condition to be inhabited.[9]

Applied silence, however, extends beyond the temporal dynamics of classroom interaction. It is also epistemic, structural, and affective. Algorithmic systems trained on dominant datasets can silence non-dominant ways of knowing by reproducing inherited imbalances in citation, language prestige, and domain coverage, presenting these imbalances through polished interfaces that appear neutral [3], [16]. Surveillance infrastructures can produce a chilling effect in which students and teachers pre-emptively

censor their own exploratory talk and intellectual risk-taking [10], [15]. Policy frameworks and commercial imperatives can silence questions of equity by framing AIEd as a technical solution to structural problems [5], [8]. And the cognitive offloading encouraged by frictionless AI assistance can quiet the internal struggle through which metacognitive capacity develops [12]. Applied silence is therefore not a single mechanism but a family of mechanisms that converge on the same outcome: the reduction of the audible, the contestable, and the human in education.

Iii. Algorithmic Epistemic Silence: Gatekeeping, Filtering, And The Quieting Of Knowledge

The first dimension of applied silence concerns the ways in which AI systems regulate what knowledge becomes visible, legitimate, and circulable in educational settings. AI does not merely mediate access to knowledge; it governs epistemic access [11]. Educational technologies, including learning management systems, generative AI tutors, and automated assessment engines, function as epistemic gatekeepers that silently filter, rank, and pre-select what reaches the learner [7]. This is not censorship in the traditional sense of banned books or prohibited curricula. It is a quieter form of exclusion: content that is down-ranked, demonetised, flagged as sensitive, or simply never surfaced by the recommendation algorithm [2], [7]. Joseph et al. describe this as digital silence, a condition in which speech is not prohibited but is made inaudible through invisibility.[2]

The epistemic consequences are particularly acute for learners whose knowledge systems diverge from the datasets on which AI models are trained. Large language models trained on web-scale corpora reproduce imbalances in language prestige, citation practices, and cultural representation; when these imbalances are delivered as fluent, authoritative answers, the knowledge of minority, indigenous, and Global South communities is quietly subordinated [3], [16]. Al-bannay identifies this as an automated Spiral of Silence: AI systems trained on biased media datasets perpetuate cultural misrepresentation and stereotypes, marginalising minority students and embedding dominant narratives into educational technologies and curricula [3]. The spiral is automated because the silencing no longer requires an active censor; it is produced by the ordinary operation of the system. The student whose epistemic resources are not represented in the training data does not encounter an explicit rejection. They encounter a silence, a gap in the system's fluency that is difficult to name and even more difficult to contest [3 ,[.[11]

This algorithmic epistemic silence is compounded by opacity. When an algorithmic system classifies a student as low risk or not proficient without that assessment being open to verification or discussion, the student cannot regulate their learning on the basis of criteria they are unaware of, and the educational institution cannot exercise its pedagogical function if its decisions are delegated to an opaque procedure [4]. The system speaks, but it does not explain; the learner is addressed, but cannot answer back. The silence here is not the absence of information but the absence of reciprocity, the dialogic condition in which knowledge claims can be questioned, contextualised, and revised [4.[11] ,[

Iv. Pedagogical Silence: The Always-Answering Classroom And The Erosion Of Productive Struggle

The second dimension concerns the quieting of pedagogical processes that depend on timing, hesitation, and dialogic relation. AI in education is frequently celebrated for its responsiveness: it answers instantly, reformulates endlessly, and generates alternatives without delay [6]. Yet this very responsiveness is pedagogically ambivalent. When uncertainty is resolved too quickly, it ceases to function as a productive pedagogical condition [9]. The always-answering classroom does not merely supplement the teacher; it alters the temporal and affective economy of learning. Learners may come to experience uncertainty not as a generative condition but as a problem to be eliminated as quickly as possible [9], [14]. The capacity to tolerate ambiguity, to formulate questions slowly, and to engage in sustained inquiry without immediate clarity is quietly eroded [13.[14] ,[

This erosion is closely connected to the fate of productive struggle. Educational theorists have long argued that appropriately calibrated difficulty is valuable: learners need to wrestle with confusion to build their own understanding [9]. When AI anticipates every step before a student even recognises a hurdle, it strips away the struggle on which learning depends [9], [12]. The student may produce correct answers, but the cognitive work that consolidates understanding, namely the effortful construction of mental models, the testing of hypotheses, and the experience of confusion followed by resolution, is bypassed. The silence here is the quieting of the learner's internal intellectual activity, masked by the noise of correct output.

Pedagogical silence is also relational. Teachers are uniquely placed to make pedagogical judgements that are more humanly than algorithmically traceable [11]. They read hesitation, adjust pacing, withhold answers strategically, and create the relational conditions in which students feel safe to risk a wrong answer. When AI assumes the role of the primary interlocutor, the teacher's epistemic authority is redistributed to the algorithm [11]. This is not simply a matter of role substitution; it is a transformation of the pedagogical relationship. If AI systems become the primary source of knowledge and feedback, they risk replacing the humanising, dialogic process of education with a dehumanising, transactional one [8], [11]. The teacher's silence, their deliberate withholding of an answer, their attentive pause, and their invitation to think, is a pedagogical art that the always-answering system cannot replicate because it is designed to eliminate the very condition that makes that art possible [9.[14] ,[

V. Data Veillant Silence: Surveillance, Chilling Effects, And The Quieting Of Autonomy

The third dimension is the silence produced by surveillance. AI in education is increasingly dataveillant: it monitors, records, predicts, and profiles learner behaviour across clicks, keystrokes, gaze patterns, emotional expressions, and physiological signals [10], [15]. The normalisation of classroom and workplace surveillance renders learners and teachers servile to algorithms designed to quantify and simplify that which is complex [10], [15]. So-called personalisation imposed by black-box algorithms is a diminishment of learner and teacher agency, restricting pathways to futures that are not built on statistics about the past [10]. But the most insidious effect of surveillance is not the direct restriction of behaviour; it is the self-silencing it produces. Students and instructors who know they are being watched may pre-emptively censor their exploratory talk, avoid intellectual risk-taking, and conform to what the algorithm appears to reward [10], [15]. This is the chilling effect: a kind of obeying in advance that diminishes agency and autonomy.[10]

The chilling effect is particularly troubling in educational contexts because education depends on a degree of vulnerability. Learning requires the willingness to be wrong, to ask a question that might seem obvious, and to advance a half-formed idea. When surveillance makes vulnerability risky, the classroom becomes a space of performance rather than inquiry. Students may still speak, but they speak strategically; they may still participate, but they participate in the register that the system recognises as legitimate [10], [17]. The silence here is not the absence of speech but the absence of candour, the quieting of the speech that education most needs to hear.[17]

Dataveillant silence also operates through passive consent arrangements in which students are categorised as a sensitive group susceptible to cognitive-behavioural influence while lacking adequate protective measures [10], [15]. Declining to participate in affective surveillance may implicitly risk academic penalties, creating a coercive framework in which silence becomes the only safe response [10]. The learner who opts out of emotion recognition, or who withholds authentic affect because it will be datafied, is not exercising freedom; they are managing risk. The system interprets this silence as consent, but it is better understood as a strategic retreat from a condition of asymmetric power [10 ,[.[15]

Vi. Structural And Policy Silence: Equity, Governance, And The Unasked Questions

The fourth dimension concerns the silences embedded in policy, governance, and political economy. AIEd is often promoted through a discourse of personalisation and precision that frames educational problems as technical problems awaiting algorithmic solutions [5], [8]. This technological solutionism silences questions about the structural conditions that produce educational inequality in the first place [5]. As of 2024, nearly one-third of the world's population, around 2.6 billion people, still lacked internet access, deepening the digital divide and potentially creating an AI divide [5]. Vulnerable groups, including girls, rural populations, persons with disabilities, and marginalised communities, are particularly affected [5]. When AIEd policy proceeds without addressing these material conditions, it silently writes these learners out of the future it claims to build [5.[8] ,[

Structural silence also operates through the political economy of educational technology. AIEd is increasingly shaped by commercial imperatives that prioritise scalability, data extraction, and market share over pedagogical values [8]. The risk is not simply that corporations influence education; it is that the questions that matter most to public education, including questions of equity, inclusion, teacher autonomy, and democratic accountability, are quietly displaced by questions of implementation, adoption, and return on investment [8]. UNESCO's 2025 report argues for a human-centred, rights-based approach that ensures innovations strengthen learning opportunities for all, rather than leaving anyone behind [5]. Yet the report also documents the persistence of governance gaps: data protection measures, ethical frameworks, transparent governance, inclusive access policies, and accountability mechanisms remain unevenly developed [5]. The silence here is the absence of robust public deliberation about what AIEd is for, who it serves, and what it should refuse to do [5.[8] ,[

Policy silence is particularly pronounced in relation to the Global South. Joseph et al. show that algorithmic censorship in the Global South does not need to ban books or imprison thinkers; it operates through down-ranking, demonetisation, and invisibility, quietly removing scholarship and perspectives from the audible field [2]. The scholar is no longer silenced by legislation, but by code [2]. In educational contexts, this means that knowledge produced in and about the Global South may be systematically under-represented in the very AI systems that are promoted as tools of inclusion [2], [3]. The silence is structural, built into the political economy of data and the geography of computational power [2.[7] ,[

Vii. Cognitive And Affective Silence: Deskilling, Passivity, And The Loss Of The Inner Struggle

The fifth dimension concerns the quieting of the learner's own cognitive and affective engagement. Several studies warn that excessive reliance on AI tools may erode critical thinking, writing competence, and problem-solving skills, a phenomenon termed cognitive deskilling [12]. When learners outsource cognitive processes to algorithmic systems, they may develop epistemic passivity: a disposition of accepting algorithmic output without the internal work of evaluation, synthesis, and critique [12], [16]. The silence here is the quieting of the inner dialogue through which understanding is constructed. The learner may be active in the sense of clicking, prompting, and receiving, but passive in the sense of not engaging in the effortful cognitive processes that education exists to cultivate.[12]

This is not an argument against AI assistance as such. AI can support learners in meaningful ways, particularly in contexts marked by uneven access to resources, linguistic barriers, or institutional constraints [1], [6]. The concern is subtler: it lies in the gradual reconfiguration of what counts as a legitimate learning experience [9]. When uncertainty is systematically resolved by external systems, learners may lose opportunities to develop tolerance for ambiguity and to engage in sustained inquiry [9], [14]. The affective dimension is equally important. Uncertainty is often accompanied by discomfort, curiosity, frustration, anticipation, and sometimes anxiety, affects that are integral to the learning process [13]. When AI intervenes too readily, it alters this affective economy, teaching learners that discomfort is a signal to seek immediate resolution rather than a condition to be explored [9], [13].

The silence here is the quieting of the learner's emotional relationship with not-knowing, a relationship that is foundational to intellectual courage [13.[14] ,[

Viii. Countering Applied Silences: Toward Audible Aied

If applied silences are produced by design, they can also be contested by design. A counter-framework of audible AIEd would rest on four interconnected commitments.

First, design for productive silence. AI systems in education should be designed to preserve, rather than eliminate, the temporal space of uncertainty. This means building in deliberate pauses, refraining from answering every question immediately, and creating interaction patterns that invite learners to dwell with ambiguity [9], [14]. An AI tutor that holds the answer back at the right moment may be pedagogically superior to one that answers instantly, because it protects the cognitive work that durable learning requires [9]. Designing for silence is not a matter of adding a delay; it is a matter of reorienting the system's objective function from closure to cultivation.[14]

Second, redistribute epistemic authority without abandoning it. The goal is not to reject AI or to return to a romanticised pre-digital pedagogy. It is to ensure that AI systems remain mediational tools rather than epistemic authorities. This requires genuine human-in-the-loop arrangements in which teachers and learners can question, contest, and override algorithmic judgements [4], [11]. It also requires what Kanoh calls transparent model mediation: AI outputs should be presented as claims to be examined, not as evidence to be accepted [11]. Teachers' professional judgement must be protected and resourced, not reduced to the role of passive assistants reviewing automated decisions.[11]

Third, govern for voice rather than compliance. Surveillance infrastructures that produce chilling effects cannot be countered by adding a consent checkbox. They require a fundamental reorientation of governance toward the protection of intellectual risk-taking, exploratory talk, and the vulnerability that learning demands [10], [15]. This means limiting the scope of dataveillance, prohibiting affective surveillance except under the most stringent safeguards, and creating meaningful avenues for students and teachers to contest algorithmic classifications [10]. It also means addressing the structural inequalities that make surveillance disproportionately burdensome for marginalised communities [5 ,[.[10]

Fourth, centre epistemic justice in AIEd policy and design. A human-centred, rights-based approach must go beyond access to include epistemic access: the right of learners to have their knowledge systems, languages, and ways of knowing represented and respected in the AI systems that mediate their education [3], [11]. This requires redressing the imbalances in training data, diversifying the teams that build AIEd systems, and creating mechanisms for community participation in governance [3], [5]. It also requires critical AI literacy for both teachers and students, not simply the ability to use AI tools, but the capacity to interrogate their silences [16].[18] [2], [5], [9], [10.[12] ,[

Ix. Conclusion

The promise of AI in education is real, but it is incomplete. The dominant discourse measures AIEd by what it enables: personalisation, efficiency, scalability, and inclusion. This manuscript has argued that a full evaluation must also ask what AIEd silences. Algorithmic gatekeeping quietly regulates which knowledges become visible. The always-answering classroom erodes the pedagogical silence in which uncertainty becomes understanding. Dataveillance produces a chilling effect that quietens candour and intellectual risk-taking. Policy frameworks silence structural questions of equity and governance. And cognitive offloading quietens the inner struggle through which learners become capable of independent thought

These applied silences are not accidental by-products. They are produced by design choices, governance arrangements, and political economies that prioritise closure over cultivation, compliance over contestation, and measurable output over human becoming [5], [8], [11]. The alternative is not to

abandon AI in education, but to build audible AIEd: systems and institutions that are designed to hear, to be questioned, and to leave space for the voices and the silences that education cannot do without [9], [11], [14]. The legitimacy of AIEd will ultimately depend less on what its systems can answer than on what they allow to remain heard.

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