Received: 25 April 2025 | Accepted: 31 July 2025

DOI: 10.1111/bjet.70007

ORIGINAL ARTICLE

British Journal of Educational Technology BERA

A topological exploration of convergence/divergence of human-mediated and algorithmically mediated pedagogy

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We explore a topological model that situates teachers' agency as a constituent element within the convergent and divergent dynamics at the intersection of human-mediated and algorithmically mediated pedagogies. Ubiquitous AI in education is designed to simulate, emulate and automate human processes and behaviours through datafication. Platformised AI and other applications like intelligent tutors use algorithmic mediation to connect patterns of un/desirable learning responses with optimised teaching pathways. But algorithmic emulations of pedagogic decision-making lack the rich perceptive and contextual data of human-mediated pedagogical interactions. Similarly, generative AI technologies imitate the outputs of social and cognitive processes of communication and meaning-making but are generated algorithmically via the statistical probabilities that drive large language models. While there are opportunities to exploit AI technologies to support pedagogical decision- or meaning-making, emulative processes, we argue, are not merely one way. There is a risk, conversely, of producing pedagogical atrophy as human pedagogic processes emulate and become increasingly dependent on AI. The original model we propose in this paper, examines how the convergence and divergence of algorithmic and human-mediated processes in education could provide a critical lens for developing teachers' agency.

KEYWORDS
algorithmically mediated pedagogy, human-mediated pedagogy, pedagogical atrophy

Practitioner notes

What is already known about this topic

- There is rapid growth in applications of Artificial Intelligence in Education (AIED) to imitate and rival human-mediated pedagogy.
- There is growing concern about the potential algorithmic replacement of humanly mediated pedagogies.
- Teacher (human) agency is vital for effective and ethical mediation of AIED.

What this paper adds

- A critical mapping of the mediating influences of AIED.
- A lens for critically evaluating the balance between algorithmically and human-mediated pedagogy.
- Consideration of how important qualities of human-mediated pedagogy could be at risk of deterioration and loss.
- An indepth analysis of current literature to advance thinking about the dilemma presented by the need to meld algorithmically and human-mediated pedagogies.

Implications for practice and/or policy

- The preparation of teachers should involve learning about the limitations and risks of AIED, as well as the potential.
- Strategies for developing teacher agency should include a critical understanding of the distinctive qualities of both human-mediated and algorithmically mediated pedagogy.
- Teacher education curricula and policy that develop understanding of a broad pedagogical repertoire is required for teachers to sustain a critical and professional stance in the context of AIED.

INTRODUCTION

Conceptual model building

Establishing rigour whether conducting or evaluating conceptual research is an acknowledged challenge (Heinonen & Gruen, 2024; Jaakkola, 2020; Prinsloo et al., 2024). Although there are no agreed types of conceptual research, Jaakkola (2020) groups different approaches to conceptual research by their main purpose and foci. That is: theory synthesis, theory adaptation, typology and model building. We adopt a model building approach which Jaakkola argues 'begins with a focal phenomenon or construct that warrants further explanation' (Jaakkola, 2020, p. 24) and delineates the relationships between the various concepts within the model.

Heinonen and Gruen (2024) map variations in methodological approaches to conceptual research along a continuum of low to high reliance on literature and a continuum of structured to more freeform synthesis of theories and connections through logical argument. While grounded in a critical reading of selected peer-reviewed literature in journals such as *BJET*, *International Journal of Artificial Intelligence in Education*, *Learning Media and Technology*, *Computers and Education*, *Postdigital Science and Education* and searches of Google Scholar, we also made use of more freeform synthesis of theory through logical argument (Heinonen & Gruen, 2024) and our own co-author dialogue. The mimetic

foundations of Artificial Intelligence (AI) (LaGrandeur, 2024; Lawtoo, 2024) led us to an analytical focus on the convergence and divergence of human-mediated pedagogy and AI. Beyond general search terms such as 'AI' plus 'education' and 'pedagogy', our analytical lens of convergence and divergence between human- and AI-mediated pedagogy led to searches of 'AI' and 'simulation', 'emulation' and 'automation' as well as 'datafication' and 'platformisation'.

Thus, selected literature is not the result of a systematic review. It was beyond the scope of this research to provide a comprehensive synthesis of literature. Instead, our intention is to invite a critical dialogue about the under-theorised convergence and divergence of human-mediated pedagogy and AI in education.

We draw on our knowledge of the field, academic judgement and a shared dialogic discussion of the research evidence to identify and analyse literature we judged most useful (Jaakkola, 2020) to explore the relationships between the conceptual components of the proposed model and develop a plausible argument (Figure 1). Our focal phenomena throughout this paper are the convergence and divergence of human-mediated pedagogy and AI and the interdependency of these phenomena with various mediating agents. But why is this focus warranted (Jaakkola, 2020)?

Focal warrant

A focal phenomenon of convergence and divergence of human/algorithmic mediation can be warranted, we believe, from critical posthuman (Barad, 2007) and postdigital (Fawns, 2022; Jandrić et al., 2018) perspectives that characterise humans and nonhuman entities such as technology as entangled. Jandrić et al. (2018, p. 893) argue that digital media and technology are not 'separate, virtual, "other" to a "natural" human and social life'. Wegerif and

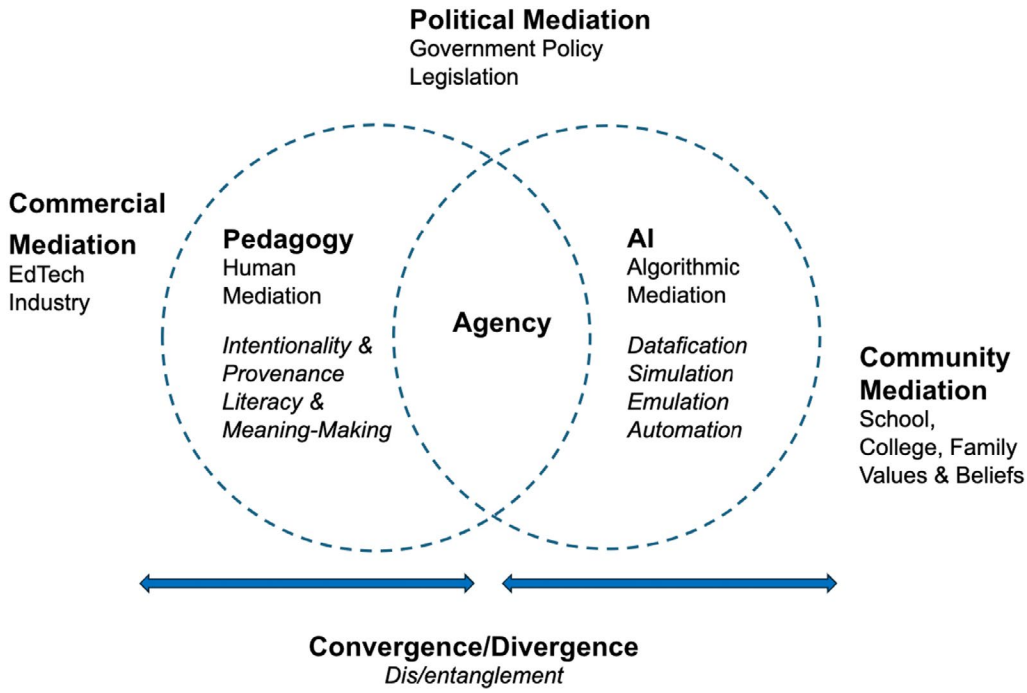

FIGURE 1 Topology of AI-pedagogy convergence/divergence.

Major (2023) similarly posit that entanglement between humans and technology has always been present drawing on the Greek root of 'techne' to argue that technology is not about devices but techniques which cannot be separated from human thinking about function and design. Such perspectives suggest the need for a better understanding of the processes underlying dis/entanglement and to consider wider assumptions about the conceptualisation and manifestation of agency in teachers' pedagogical practices.

Wegerif and Major (2023) argue that theorising of educational technology has been overlooked because research tends to focus on educational theory. Fawns (2022) also highlights the dichotomous 'pedagogy first' versus 'technology first' debate, which leads to isolated theories of pedagogy or technology that are either technologically or pedagogically deterministic. The posthuman concept of entanglement between humans and technologies challenges static human-centric conceptualisations of agency and accentuates a dynamic relationship between human and nonhuman entities (Sheridan et al., 2020; Sintonen, 2020). Cosentino et al. (2025, p. 623) characterise this dynamic entanglement between AI- and human-mediated pedagogy as 'hybrid teaching intelligence' or 'hybrid intelligence'. However, to coin such phrases is also arguably to imply that there exists a non-hybrid form of teaching and intelligence, a perspective challenged by posthuman perspectives that Barad argues 'allow matter its due as an active participant in the world's becoming, in its ongoing intra-activity' (Barad, 2007, p. 136).

Human agency is identified as a critical component within recent conceptualisations of AI and pedagogy (Cukurova, 2025; UNESCO, 2024). Sharples (2023) argues that distributed conceptualisations of agency between humans and AIs offer the potential for meaningful dialogic learning to emerge as AI is conceived as a 'conversational agent' enabling a merger of 'human empathy and experience with networked machine learning' (p. 166). Placani (2024, p. 694) suggests that it is a mistake to assign human-like agency to machines because it includes 'the capacity to act intentionally' (Figure 1), the origins of which lie in the distinctively human, sociocultural and affective mental states such as attitudes, values and beliefs. However, a dichotomous 'humans versus computers in control' conceptualisation of agency ignores human and technological entanglement. Fully automated applications of AI in education are not free from human intent as intent is designed into AI applications enabling various human agents beyond the classroom and school to both shape and surveil pedagogic relations and experiences (Pangrazio et al., 2023; Perrotta et al., 2021). The increasing marketisation of schooling has opened up the possibilities of entrepreneurial experimentation in the design and implementation of technocratic models of schooling. Algorithmic technologies and adaptive platforms can be exploited to redesign schools as spaces in which desirable outcomes and their associated values are encoded within the sociotechnical design of school systems and attendant processes (Williamson, 2018; Williamson et al., 2023).

Consequently, our model (Figure 1) is built on a definition of agency as a distributed and dynamic phenomenon negotiated between human and nonhuman entities, resonating with Barad's (2007) conception of agential realism. Barad's agential realism frames ontological units not as static 'things' but as intra-active phenomena that are 'dynamic, topological reconfiguratings/entanglements/relationalities/(re)articulations of the world' (Barad, 2007, p. 141). As Sintonen (2020) suggests, in agential realism 'human and nonhuman entities become agents only by way of each other' (p. 1325). Hence, the topological framework represented in Figure 1 is an attempt to represent the dynamic intra-activity between human and algorithmically mediated pedagogy as a 'material discursive practice' (Barad, 2007, p. 141).

After a critical analysis of the convergence and divergence of human and algorithmic mediation, we focus on datafication, simulation, emulation and automation as constituent and contingent processes underpinning agency. Finally, we discuss how wider factors such as political, commercial and community mediation are also significant within the model (Figure 1) and conclude with implications for policy and teacher education.

CONVERGENCE/DIVERGENCE: BEYOND IMITATION

We use the commonly understood meanings of convergence and divergence: The former meaning 'moving together or becoming similar' and the latter 'moving apart and becoming different'. AI's foundations in imitating human functions (Turing, 1950) resonate with what Barad (2007) argues is the historical dominance of mimetics where objectivity is dependent on capturing, 'copies that are homologous to originals, authentic, free of distortion' (p. 89). In contrast, Barad's posthuman perspective calls for more focus on the differences that matter as the boundaries between human and nonhuman entities, their properties and their meanings 'are differentially enacted' (Barad, 2007, p. 183) through the process of intra-action. Thus, in the context of this paper, we theorise the intra-activity of human-mediated and algorithmically mediated pedagogy as a constantly emerging process of divergence and convergence between these intra-acting entities.

Convergence and divergence between human and algorithmic mediation have historically attracted the attention of scholars. In his groundbreaking paper of 1950, Turing provides justification for the 'imitation game' devised to address the question of whether machines could be programmed to use language in a way that was indistinguishable from that of a human being and, give the appearance of communication with a sentient interlocutor. At its 50-year anniversary, Saygin et al. (2000) note that Turing's test had provoked a range of responses being lauded as the beginning of AI and critiqued as a harmful distraction. Seventy-five years on from Turing's test, it is now commonplace for humans to communicate with digital devices that simulate human-like responses such as chatbots helping with online transactions or conversations with digital assistants like Siri or Alexa, illustrating convergence of human-mediated and algorithmically mediated communication.

However, amidst the recent AI-driven burgeoning of apps offering computational imitations of human-like dialogue, thinking and behaviours, it is worth noting that Turing also reflected on the divergence of human and algorithmic thinking asking 'may not machines carry out something which ought to be described as thinking but which is very different from what a man does?' (Turing, 1950, p. 2). Turing's question might be interpreted as an acknowledgement that focusing only on machines' capacity to imitate and rival human thinking and behaviours is limiting and that delineating human and computational thinking from each other may also be significant. This ambiguity is also evident when considering the purpose of AI in education (AIED). For example, is the purpose of AIED to simulate teacher-like ways of being in order to augment teachers' pedagogical wisdom and capabilities, maintaining high levels of human agency and mediation (Cukurova, 2025)? Or, is the purpose of AIED to emulate teacher ways of being as is often seen in Intelligent Tutoring Systems (ITSs) where some of the functions of the human teacher are increasingly replaced by algorithmic mediation? Convergence and divergence, we argue, are of significant importance as teachers and policymakers consider the balance between human-mediated and algorithmically mediated pedagogy.

The UNESCO AI competency framework for teachers (UNESCO, 2024) advocates the iterative development of AI pedagogy that maintains high levels of teacher agency and human-centred approaches to ensure inclusive and ethical development. Cukurova (2025, p. 481) further elaborates suggesting an iterative process based on a model of 'tightly coupled human-AI hybrid intelligence' designed not to replace human-mediated pedagogy but to augment teachers' pedagogical competence. Current concerns about the balance between human and algorithmic mediation in AIED resemble historical debates about the potential of technologies to yield distributed models of pedagogy and cognition (Salomon & Perkins, 2005). Arguably, however, the potential for fully automated AIED challenges conceptions of agency as distributed and negotiated between human and non-human entities.

In terms of the acquisition of narrowly defined declarative knowledge, research on ITSs (eg, du Boulay, 2016) has shown fully automated systems can rival the effectiveness of human-mediated pedagogy. Despite this rivalry of some aspects of human-mediated pedagogy, Cohn et al. (2025, p. 600) point to important differences between fully automated algorithmic and human-mediated pedagogy, noting that collaborative models of AI-human mediation allow for 'varying degrees of human control' and can leave room for teacher interpretation and decision-making. Similarly, Peters et al. (2024) argue that in the context of AI and increased machine learning capabilities, it is important to distinguish between the unique contribution of human-mediated and algorithmically mediated pedagogy. That is, the ways in which algorithmic and human mediation diverge.

Arguably, the off-loading of some cognitive tasks to AI is neither inherently positive or negative. However, what pedagogic roles are ceded fully, partially or not at all to algorithmic mediation and how, may be critical as human and AI pedagogy converges. For example, Cukurova (2025, p. 480) states that 'over-reliance on AI could lead to the atrophy of critical competencies in the long term'. Other recent studies in a range of domains have also raised significant concerns with regard to the emergence of AI dependencies and atrophy (Fan et al., 2024; Macnamara et al., 2024; Vasconcelos et al., 2023). If teachers are to be equipped to avoid dependency and atrophy, we argue, they need to be able to identify and delineate clearly the convergent and divergent qualities of human-mediated and algorithmically mediated pedagogy (Figure 1). Without understanding how human and algorithmic mediation both converge and diverge, arguably teachers are less empowered to make critical decisions about how much agency to retain or cede and the potential implications of their pedagogic decisions. Indeed, Bauer et al. (2022, p. 5) suggest that 'understanding the resemblance or divergence of a simulation compared to the real-life practice' is an important aspect of simulation-based professional and vocational learning.

Morrison and Miller (2018, p. 441) state, 'machine intelligence… is not human intelligence and automated learning systems are not, in themselves, human contexts'. We concur and suggest that, in examining the impact of algorithmic technologies in education, blurring technological and human boundaries is problematic. Machines' capacity to mimic human intelligence and decision-making behaviours, however successful or imperfect, brings opportunities, but the convergence of technological and human mediation is also potentially regressive pedagogically if distinctive and important qualities of human-mediated pedagogy are lost to increasing algorithmic mediation. This begs the question, what distinctive and important human qualities are at risk?

Atrophy of pedagogical provenance

Teachers are uniquely placed and play a critical role in establishing the provenance (Figure 1) of particular aspects of pedagogical phenomena (Turvey & Pachler, 2020). The interrelatedness of learners' affective states and learning, matter in teachers' pedagogical decision-making and are currently more humanly than algorithmically traceable. For example, multimodal algorithmic detection of learners' affective states such as their motivations, emotions and interests poses significant ethical, child protection and technological challenges (Dai & Ke, 2022). Computers simulate meaning-making and interpretative judgements based upon statistical probabilities, diverging from human-mediated pedagogies in which Kalantzis and Cope (2025, p. 10) argue, 'interpretation based on the varied life experiences and interests of learning are of greater pedagogical significance'. This divergence between algorithmically and human-mediated pedagogy is not necessarily uncomplementary. Sharples (2023, p. 162) suggests that the challenge is respecting teachers' human expertise 'as initiators and arbiters of conversations for learning, as sources of specific knowledge,

and as nurturing and caring role models'. This also resonates with a 'postdigital ethics of care' (Costello, 2024) in which the inherently relational, dynamic and challenging nature of human/nonhuman entanglements call for sustained human attention to the detail and provenance of pedagogical intra-action.

Where human-mediated pedagogy diverges uniquely from algorithmic mediation is that teacher judgements and decisions relate to 'particular students at particular points in time in particular situations' (Biesta, 2020, p. 68). Drawing on historical and current perceptions of students, teachers are able to make evaluative judgements about students' intent, bringing into sharper focus 'questions about content, purpose and relationships' (Biesta, 2017, p. 28). Students respond in unique ways to curricula and partially or fully automating teaching impacts on how teaching and learning happens (Eynon, 2022). While it is acknowledged that teacher judgements can be biased and misinterpret students and situations, the integration of AI and algorithmic mediation into digital platforms cannot represent an objectified account of pedagogical reality (Prinsloo, 2019). Pangrazio et al. (2022) show that school platformisation of AI complicates rather than simplifies practices highlighting the increased importance of human mediation as data infrastructures impact on the socio-technical context of schooling.

Teachers are also uniquely placed to establish the pedagogical provenance in micro-level momentary pedagogical interactions involving the offloading of both lower and higher level cognitive interactions by learners. Research into higher education students' style of conversational engagement with Anthropic's AI assistant Claude used a four-quadrant taxonomy of direct or collaborative, problem-solving or output creation to gauge how far students delegated higher and lower order tasks to AI (Anthropic Education, 2025). While caution is advised over the interpretation of the results, there appeared to be a tendency to offload higher order tasks and problems to AI. This also echoes aspects of research by Fan et al. (2024) who speculate that the improvements in task performance but the absence of actual knowledge gains seen in their research results could be indicative of over-reliance on generative AI. While we should be cautious about generalising research from one phase of education, it is feasible that similar phenomena might be observed in other phases of education. It also suggests that pedagogical judgements about the extent to which particular learners may or may not be offloading cognitive tasks to AI are more difficult to determine algorithmically than via human-mediated pedagogy. Consequently, a challenge would appear to be how to avoid over-reliance on AI that leads to atrophy of pedagogical provenance, leaving teachers potentially less empirically aware of their students as learners or learners falling into habits of avoiding tasks that require them to think more deeply about problems or tasks.

Atrophy of social participation in meaning-making

The communicative processes of literacy in all its modalities are built on meaning-making (Figure 1) as a fundamentally human and social endeavour. Ceding increasing agency to generative AI could yield atrophy of participation in meaning-making. In his recent book *More than words*, Warner (2025) argues for the value of writing in the context of AI threatening to replace human agency in writing. He stresses the importance of seeing writing as a process and of recognising the significance of thinking and feeling in formulating and articulating ideas: 'Removing thinking from writing renders an act *not* writing' (p. 11). Warner (2025) also posits that writing is an experience that changes who we are: 'If writing is thinking—and it is—then it must be viewed as an act of our own becoming' (p. 73).

In contrast, as Kalantzis and Cope (2025) state, generative AI is a 'next-word predictor… placing after each word the statistically most probable next word' (p. 6) based on textual prompts. They also argue that 'generative AI mechanises the *production* of written text and

derivatively, multimodal meaning' (p. 6). For the authors 'derivatively' is the operative word as the computer has 'no capacity to mean' (p. 14) by which they draw attention to the fact that meaningful text can be created by computers only empirically and statistically but that

- semantics are only latent (p. 15);
- multimodal output is the result of applying textual labels only; and
- speech is transliterated text-to-speech in the process of which features of speech such as prosody, dialect, gesticulation, embodied context, redundancy, hesitation, circumlocution, etc., are lost (p. 16).

The mechanisms of text production of generative AI, therefore, are very different from human meaning-making, which Kalantzis and Cope (2025) consider to be design work that recognises the agency of the meaning maker and which they consider to be a social process of participation in meaning.

Kalantzis and Cope (2025) conclude that as a result of generative AI becoming pervasive, the frame of reference for literacy learning needs to change from a matter of utility, from being narrowly instrumental and functional, to a project of human growth: 'learning to write is learning to think' (p. 21). They advocate the use of generative AI to help learners 'develop the deeper cognitive processes and embodied capacities that underlie writing–the transposition of our representations-for-ourselves into communication-for-others and the empathetic interpretation of the varied social meaning we encounter'. Despite the unique divergence between algorithmically generated text production and human writers' meaning-making processes, Kalantzis and Cope (2025) suggest a complementary relationship between human and machine is nevertheless achievable through what they term 'cyber-social literacy learning' (p. 21). Kalantzis and Cope's (2025) conclusion is that generative AI need not lead to the atrophy of participation in meaning-making through literacy if literacy is framed differently at a systemic level to value its purpose and capacity for social and personal identity and meaning formation.

But how can a complementary relationship be established with 'black box' technologies such as AI in which algorithmic mediation and data are not legible (Hayes et al., 2023; Mortier et al., 2014)?

DEMYSTIFYING THE BLACK BOX—DATAFIED SIMULATION, EMULATION AND AUTOMATION

We posit that teachers' and policymakers' understanding of the interplay between simulation, emulation and automation, enabled by increasing datafication (Figure 1), is critical in developing an informed understanding of the convergence and divergence of algorithmic and human mediation. Such an understanding could arguably begin to mitigate concerns about the lack of transparency and comprehension of algorithmic mediation (Bearman and Ajjawi, 2023; Hayes et al., 2023; Mortier et al., 2014) and address concerns regarding atrophy of the distinctively human qualities of human-mediated pedagogy.

Datafication, simulation, emulation and automation are complex and closely related concepts within the field of computing and AI, but their definitions are also distinct both in computing and in etymology. Simulation and emulation are often conflated (Bowman & Grindrod, 2019) due to the interplay between them. For example, in the context of engineering and machine learning, Fagcang et al. (2022, np) state 'simulation is widely accepted to refer to the running of virtual models' using imitation to represent, model and explore systems. Emulation, however, refers to the running of systems 'that are fully or partly real'

(Fagcang et al., 2022, np) and can therefore function to some extent as a substitute for that which is being emulated.

This overlap between simulation and emulation is also evident in AIED. For example, in a systematic review of the use of simulated learners in AIED, Käser and Alexandron (2024, p. 547) found that there tended to be a focus on 'modelling only narrow aspects of learning' and recommend the development of 'more complete models' that offer authentic simulations. Another systematic review (Dai & Ke, 2022) highlighted concerns regarding the fidelity and authenticity of AI-simulated learning in education. Thus, emulation can be conceived as an extension of simulation being focused on the construction of a more equal or better functioning surrogate to the original system. That is, a realistic and authentic representation capable of functioning like, and to some extent replacing that which is being emulated. However, whatever form AIED takes (Chatbot, ITS, virtual classrooms) and however authentic its functioning might seem, it is an emulated surrogate based upon algorithmic as opposed to human mediation. In a recent study of an AI-powered virtual classroom (Zhang et al., 2025), pre-service teachers reported frustration in being unable to incorporate personal relevance into discussions with virtual students in the ways they would with real-world students. While understanding the boundaries between human-mediated and algorithmically mediated pedagogy is significant, blurring of the boundaries and conflating simulation and emulation can also manifest as hype.

Placani (2024) highlights the ways in which the capabilities of AI are often exaggerated through anthropomorphic language in which human qualities are projected onto AI. Similarly, Bowman and Grindrod (2019) identify two levels of hype relating to AI: first, exaggerated performance and operational capabilities and second, 'public performance level, concerning the future potential for the present AI to develop much further, with human thinking characteristics and not merely simply to simulate human decision-making' (p. 3). Such hype and anthropomorphism is often reflected in the commercial marketing (Figure 1) language of AIED applications. For example, 'No More Marking' is an AI-enhanced assessment platform offering several applications which use AI-enhanced comparative judgement to assess and grade children's writing (https://www.nomoremarking.com/). The hype of 'No More Marking' suggests the replacement of human mediation through the fully automated algorithmic mediation of the marking process. However, as is clear from the details of how 'No More Marking' actually works, human judgement and verbal feedback remain central. Such ambiguity and convergence between human-mediated and algorithmically mediated pedagogy has also arguably entered into school curricula.

Butler and Leahy (2021) note that, despite the rise in the teaching of computational thinking in international teacher preparation and school curricula, there is no consensus on its definition. It would appear the convergence and divergence of thinking as a human/computational process remains as ambiguous and problematic an area as it was for Turing (1950). Butler and Leahy (2021) acknowledge that the work of Papert (1971) was groundbreaking in its synthesis of computational processes and technologies with theories of mind and learning. The concept of computational thinking remains a contested and ambiguous term within the literature blurring the boundaries between human thinking and computational thinking as in Wing's (2006) definition which promoted a ubiquitous and universal conceptualisation of computational thinking. Wing (2006), for example, is keen to emphasise that computational thinking can be done by humans or machines but that 'thinking like a computer scientist is not trying to get humans to think like computers' (p. 35). In blurring the boundaries between human cognition and computing arguably, we risk reducing human cognition to that which is computational.

Tuomi (2024) highlights this risk of pedagogical atrophy. Teacher preparation programmes are based on the principle that the preparation of effective teachers requires them

to develop theories of the mind including a broad understanding of theories of learning. Käser and Alexandron (2024) highlight algorithmic mediation's tendency to focus on narrow aspects of learning. Tuomi (2024) argues that AIED has become trapped in an instrumental paradigm reminiscent of the teaching machine theories in the 1960s. Tuomi (2024) suggests an augmentation approach to AI could help to break the mould of operant conditioning (Skinner, 1965) in which AI is currently contained, suggesting that 'innovation should be called progress only when it expands human capability' (Tuomi, 2024, p. 28) beyond learners' epistemic competencies to include non-epistemic capabilities such as social, cultural and metacognitive capabilities.

In such a context, we argue that teacher agency is contingent on teachers being able to clearly and critically delineate algorithmic and technology-mediated pedagogical processes from different theories of mind and human-mediated learning in order to effectively exploit their differences and their complementarity. Without this capacity, there is a risk of convergence and the loss in particular of what makes human-mediated and technology-mediated pedagogies qualitatively different and distinct.

There is evidence of this in the recent pre-occupations by governments of anglophone countries with 'neo-trad' ideology at content, curriculum and pedagogy levels. Neotraditionalism can be seen as a reaction against perceived shortcomings of so-called 'progressive' educational philosophies as well as a response to the appeal of advances in the field of cognitive psychology and its advocates see themselves as true champions of science, reason and evidence, sometimes arguably with missionary zeal (see eg, Bennett, 2018). Ball (2003) coined the phrase 'policy technologies of education reform' as an analytical tool which he views inter alia as discursive interventions using vocabulary of performativity and which he sees governed by new 'regulative ensembles' (pp. 217–218). (For a more detailed overview, see eg, Pachler, 2025.) What we shall call 'neoconservative modernisation' here drawing on Neumann et al. (2020), according to Ball (1993) has advanced through two camps, neoliberal modernisers whose focus was on freedom of choice and the raising of standards through competition and marketisation, and the neoconservative 'cultural restorationists' (see Apple, 1998) committed to fighting progressivism through centralised regulation. In the field of teacher education, as Hordern and Brooks (2025) argue, this has led to a prescriptive model following a 'science-in-technology mode of knowledge production' which they consider to sit ill-at-ease with the 'values-rich, contextualised and holistic character' of the educational endeavour. Baird (2022) highlights a tendency in teacher education policies in England towards reductivist cognitive science and concepts of working memory, efficient encoding and storage in long-term memory and retrieval practices. Oversimplification of theories of learning and the overemphasis of evidence from cognitive science (Baird, 2022) arguably renders learning and theories of mind more imitative of computational and algorithmic components and processes than the messy, often unpredictable and affective reality of human learning.

The risk of pedagogical atrophy as the distinctive qualities of human-mediated pedagogy are ceded to algorithmic mediation is manifest, we argue, in the increasing range of historically human-centric teacher tasks being emulated and automated by AIED. AI-generated lesson planning is a specific example to which we turn now, as it also illustrates how wider political and commercial imperatives (Figure 1) are constituent influences on the ways in which unprincipled algorithmic mediation has the potential for pedagogical atrophy as algorithmically and human-mediated approaches converge.

AI-GENERATED LESSON PLANNING: WORKLOAD PANACEA OR THREAT TO TEACHER PROFESSIONALISM?

In England, as well as in many jurisdictions around the world (see eg, Pachler, 2024), teacher recruitment and retention are an important challenge in educational policy terms, with teacher workload being widely identified as a key contributing factor and driver of attrition. It is in this context that the use of AI for lesson planning is promoted as a potential 'silver bullet' by influential commentators and policymakers alike. Two arguments often made in support of AI by commercial EdTech providers and political policymakers are (1) that AI can accelerate and augment thinking processes; and (2) that AI frees up time that can be used for more advanced tasks (Roy et al., 2024). In relation to the former, Johnson (2025) notes the risks of abdication of thinking entirely to AI and, in relation to the latter, that of simply not moving on to more complex, thought-intensive tasks, leading to growing dependence on AI. An analogous argument can be made about the use of AI for lesson planning in that the unprincipled use of AI in this context can be seen to carry significant risks in terms of teacher de-professionalisation.

Professional atrophy and algorithmically mediated lesson planning

There is a small, but growing, body of empirical literature on the use of AI in lesson planning that highlights expectancies with regard to enhanced teacher performance and efficiencies (Acquah et al., 2024). But the literature also illustrates considerable weaknesses in the epistemic accuracy, appropriateness or reliability of AI for lesson planning (Flavin et al., 2025; Powell & Courchesne, 2024) as well as the need for teacher-led modifications and caution (Lammert et al., 2024; Van den Berg & du Plessis, 2023). Chen et al. (2025) examined pedagogical biases in AI-generated lesson plans and found reduced student agency as opportunities for 'productive classroom dialogue' (p. 5) were restricted. But what else is potentially lost in ceding greater agency to algorithmic mediation of planning?

According to Clark and Dunn (1991) 'planning is regarded as a psychological process of envisioning the future, and of considering goals and ways of achieving them' (Mutton et al., 2011, p. 401) and, as such, can be considered to be extremely important in the process of developing deliberate teacher practice and teacher professionalism. Acquah et al. (2024) note the importance of lesson planning in improving student learning outcomes and that it serves as a cornerstone for effective instruction. Teacher agency in the planning process in the form of evaluation, critique and discernment (see eg, Lammert et al., 2024, p. 168) ensures account is taken of important contextual factors about the social context that are classrooms and schools such as knowledge about individual pupils, envisioning of meaningful learning experiences for pupils, personal curriculum interpretations and the school ethos. Mutton et al. (2011, pp. 407f.) use the metaphor of 'planning as visualisation' by which they mean the capacity to anticipate the response of pupils and the flexibility to accommodate them, anticipation of what *might* happen rather than a determination of what *would* happen. Or, to use Schön's terminology (1987), the capacity to engage in 'reflection in action'. As such, lesson planning can be seen to help teachers 'think about things differently' (Guillaume & Rudney, 1993, p. 79).

From this perspective, outsourcing it to AI, therefore, risks the de-professionalisation of teachers unless appropriate safeguards are in place. By safeguards we mean due consideration to be given to contextual factors through a cognitive engagement and situation-specific decision-making by teachers in problem representation and mental trial (see Clark & Lampert, 1986, p. 28f.). Powell and Courchesne (2024), in a study exploring the potential of generative AI to support teachers in lesson planning in first grade science lessons, found

that 'teachers need to have a skeptical disposition regarding AI outputs' (p. 11) and, in addition, 'to ensure a rigorous examination of generative AI outputs'. Lammert et al. (2024, p. 173) undertook qualitative content analysis of outputs from AI lesson plan generators and found that 'in their current form AI-based lesson plans hold minimal value for experienced in-service teachers'. Malik et al. (2025), on the other hand, in a study of curriculum scaffolding in middle school mathematics posit that large language models have shown promise in generating educational content and supporting teachers provided that they are provided with additional context from the curriculum and provided they are prompted well.

Ninaus and Sailer (2022, p. 5) advocate an 'AI-in-the-loop' system where the teacher is in control of what is being sent to students. Flavin et al. (2025), in a study about the use of AI in mathematics lesson planning, draw attention to the importance of how teachers construct prompts and evaluate AI-generated outputs in real time. One key finding from their study is the critical role teachers' knowledge plays in effectively using ChatGPT: 'at times, participating teacher candidates were unable to curate relevant prompts or steer away from the conversations with ChatGPT due to their limited mathematical knowledge for teaching and their broader pedagogical knowledge' (p. 14).

Such findings underscore the dangers of outsourcing human agency to generative AI in terms of de-professionalisation. With Nückles (2021, p. 160) we want to question the notion that 'proficient teaching is the ability to react appropriately to the sudden and unforeseeable events occurring in a very complex and dynamic classroom' as it neglects the fundamental role of planning in teaching. With him we want to posit here that it is 'this planning (ie, selecting and sequencing learning content in line with the students' learning prerequisites, orchestrating cognitively challenging learning tasks and forms of social interaction [see Reigeluth, 2013]) that makes the complexity of classroom interaction predictable and manageable'. Outsourcing these processes wholesale to AI, we argue here, has a potential negative impact on teacher professionalism and needs to be guarded against.

Political and commercial mediation

Despite the problematic and inconclusive nature of the evidence, and the important role planning plays in the professional development of teachers, the Department for Education (DfE) promotes the use of AI in the English education system and has invested millions of pounds in developing large language models trained on curriculum-related government documents with the aim of reducing teacher workload (DfE, 2023, 2024a).

The Oak National Academy an arms-length national body (n.d.) whose board is chaired by the Chief Regulator of Ofqual is one of the recipients of government investment. One (of many) issue(s) arising with this model promoted by government is the need to critically explore the quality of the curriculum-related government documents used to train the AI. In a recent Special Issue of *The Language Learning Journal* (2022) problematising the OFSTED Curriculum Research Review for languages (OFSTED, 2021), Pachler and Broady (2022, p. 136) show how some such government documents may fail to take 'politics or ideology out of the policy process', even if they purport to adhere to evidence-based policymaking. In the case of modern languages, this can be seen to lead to a conceptualisation of language learning as a narrowly cognitive activity based on the so-called 'three pillars' of linear progression of phonics, vocabulary and grammar. Such a conceptualisation offers a limited interpretation of 'purposeful knowledge' in contrast to a view of language learning as a social practice and socio-culturally complex activity which is responsive to the language learner as an individual and recognises their language identity. Ignoring the importance of content and activities that are culturally and developmentally relevant and multilingual, intercultural, and cross-curricular in orientation leads

to a narrow representation of language learning. Invariably, these representations will find reflections in the lesson plans generated by AI trained on government documents.

In their annual report on the teacher labour market in England, the National Foundation for Educational Research in England and Wales (NFER), a charity seeking to provide 'actionable insights' relating to challenges faced by the education system, posits that AI-supported lesson planning could be a way of reducing teachers' workload (McLean & Worth, 2025, p. 27). Referencing work funded by the Education Endowment Foundation and evaluated by the NFER (Roy et al., 2024) they found that preparation time could be cut by around 30%—apparently with no detriment in the quality of materials according to an expert review panel and without a reduced sense of autonomy or creativity. The quality of lesson resources in Roy et al.'s (2024) study was measured on the basis of a ranking of lesson resources (see p. 25). Lesson resources submitted by a sample of 30 teachers were judged by a panel of '5 experienced teachers and leaders' who were 'blind' to the project aims and to group allocation (p. 20). The report does not give any details about the nature of the experience and expertise of the judging panel and concludes (p. 52) that there is no significant difference in ranks between lessons and resources provided by ChatGPT teachers and non-GenAI teachers.

The emphasis on teacher workload as well as the conceptualisation of quality in these two examples should give rise to considerable concern as they frame lesson plans as resources and don't appear to consider the process of lesson planning as an important and integral part of teacher learning, developing expertise and evidencing teacher professionalism, understood here as deliberate teacher practice that exerts educational judgement (see Frelin, 2013, p. 5). As Mutton et al. (2011, p. 399) very rightly in our view, and importantly, point out 'it is through planning that teachers are able to learn about teaching and through teaching that they are able to learn about planning'. A perspective of AI use solely for productivity gains in relation to the generation of lesson plans and of quality as product-orientated in our view completely misses the point of the importance of lesson planning as an integral part of teaching as a complex and cognitively demanding activity (see eg, Westerman, 1991, p. 292).

COMMUNITY MEDIATION: (POST)DIGITAL RESISTANCE AND BACKLASH

Through cross-sector and interdisciplinary research focusing on disadvantaged perspectives and postdigital inclusion, Hayes et al. (2023) introduce 'resistance' as a significant concept in how various stakeholder communities' engage with and mediate socio-technological contexts. Hayes et al. (2023) recently adapted the framework of Human Data Interaction (HDI) extending Mortier et al.'s (2014) dynamic model that foregrounds 'legibility', 'agency' and 'negotiability' as significant characteristics of the diverse and dynamic ways in which humans and data interact. In the updated HDI framework, 'resistance' is viewed from various perspectives and takes several forms (Hayes et al., 2023).

For example, Meechan (2023) uses the United Nations Convention on the Rights of the Child (UNCRC), (United Nations, 1989) to suggest the possibility of resistance to the digital profiling of children by behaviour management apps, encouraging schools and wider communities to consider their responsibilities as 'rights bearers', questioning whose agenda is really served by such profiling. Elliot and Pitchford (2023) argue that despite its increasing datafication and commodification, higher education still offers a space for resistance through the design of diverse pedagogies and students holding their institutions to account for how they gather and use their data. Similarly, resistance is framed as an opportunity by

Royle and Hawkins (2023) to reframe data ownership based upon more philanthropic cooperative models.

Indeed, the growing pervasiveness of datafication and AI-driven hyperconnectivity impacting on people's lives is also prompting what some call a digital backlash, which is defined broadly as 'a range of social and cultural practices of digital disconnection, as well as critiques of the impact of digital technologies and platforms in the world today' (Albris et al., 2024, p. 2). Lai and Cone (2024) map 'a day in the datafied life' of a primary school child and their teacher to illustrate the extent of hyperconnectivity and dataflow between teacher, child, school and third party commercial entities as they interact with various platforms both within school hours and beyond, raising concerns about the '(im)possibility of disconnecting' (p. 293). A digital backlash can be seen in the ways different stakeholder communities exercise agency to mediate digital technologies such as parental support for bans on mobile phones in schools and parents' instigating strategies such as 'times and spaces free of digital media' (Andelsman Alvarez, 2024, p. 236).

Albris et al. (2024) argue that we are in a new era where 'norms about digital behaviour, consumption, and habits are being questioned, and where the hype of the early digital era beginning in the 1990s is being challenged' (p. 11). Examples of a digital backlash can also be found at systemic policy level. For example, the Swedish government recently removed any expectation that pre-school teachers (1–5 years) will use digital media as pedagogical tools, in order to ensure education at this stage should be mainly screen-free (Government Offices of Sweden, 2023). However, Forsler et al. (2024, p. 92) argue that while the move represented 'a paradigm shift in the official education policy' in Sweden, the perspectives of experts in media literacy were marginalised as evidence from those representing the fields of psychology, neuroscience and paediatrics were given precedence.

Kalantzis and Cope (2025) capture the potential unease among different communities suggesting that AI can be perceived as a new 'colonialism, not of material space like the old colonisers, but the colonisation of social intelligence' reminding us also that 'Generative AI is an extractive industry and rent-seeker as it sells the human collective intellect back to us' (p. 8). However, Hayes et al.'s (2023) updated HDI framework frames 'resistance' not as a binary choice between connecting and disconnecting as already highlighted (Elliot & Pitchford, 2023; Meechan, 2023; Royle & Hawkins, 2023). Scott (2023), for example, suggests 'resistance' can be productive through increased 'digital vigilance' and teachers' better understanding of the consequences of 'producing and using data' and questioning 'the power behind the interface' (p. 290). That is exercising human agency over how we engage in socio-technological contexts. Arguably the issue of any digital backlash focused only on disconnecting is that it is 'a form of civic disempowerment' (Scott, 2023, p. 290) with the potential to widen disadvantage gaps further. In a postdigital world of complex socio-technological contexts 'apathy is not a choice' (Scott, 2023, p. 296). To simply disconnect, cedes further power and authority to commercial and political mediation.

So too we might argue in relation to AI. To not engage with AI is arguably to cede any influence in its use and further development. Technological innovations are mediated by wider communities (Figure 1) with their own attitudes and values towards technology and perhaps most pertinent to this debate is that 'resistance' (Hayes et al., 2023) is integral to an intra-active stance towards AI. That is, a means of intra-actively enacting divergence and drawing attention to difference so that 'differences come to matter' in the 'iterative production of different differences' (Barad, 2007, p. 137).

CONCLUSION

Our exploration of the convergence and divergence of human and algorithmic mediation of pedagogy provides some insight into the changing topological landscape of education. In a survey (Anderson & Rainie, 2025) of over 2000 experts from a range of fields, respondents were invited to predict changes and adaptations in human thinking, being and doing as AI develops. In response, Mark Schaefer questions how learning will change as more knowledge work is done by AI, suggesting a shift from knowledge workers, towards 'help[ing] young people build a life of meaning' (in Anderson & Rainie, 2025, p. 23).

While the pervading neoliberal model of education that prioritises productivity and efficiency (Biesta, 2010) is likely to yield more commercially driven emulation and automation by AI, human mediation of pedagogy lends itself to social and community participation in meaning-making. Teachers are vital to the development of communities of practice in which knowledge becomes meaningful, purposeful, contextualised, questioned, valued and critiqued (Biesta, 2010; Fawns, 2022). Such qualities of human-mediated pedagogy are unlikely to be effectively emulated by AI and, even if they were, this may not be desirable if education is to remain purposeful and meaningful. More convergence of human-mediated and algorithmically mediated pedagogy appears likely, as autonomous agents develop with the capacity to deliver specific knowledge and skills to rival or exceed the efficiency of humans. The emulative character of AI has the potential to dehumanise education if a lack of clarity about the unique qualities and value of teacher agency is not articulated. Without clarity and articulation of the distinct nature of human-mediated pedagogy, there can be no protection or promotion of teacher agency that is called for by Teräs et al. (2022).

The topological model (Figure 1) we have discussed in this paper has explored algorithmically and human-mediated pedagogy through a critical lens of convergence and divergence and we think it offers a useful model for debate by teacher educators. It is useful in developing teachers' understanding of the unique character and value of human-mediated pedagogy in the context of increasing algorithmic mediation. We consider this to be integral to postdigital teacher professionalism, which has a responsibility to critically understand and engage with the ongoing intra-active process of mattering; that is, to play their part in what differences between human-mediated and algorithmically mediated pedagogy are valued and come to matter and what differences can be safely excluded (Barad, 2007).

Despite evidence of the ongoing importance of pre-service teachers' 'digital identity formation' (Tondeur et al., 2025, p. 15), the Initial Teacher Training and Early Career Framework for England (DfE, 2024b) merely calls for teachers to make 'judicious use' of technology (p. 5). Exploring the convergence and divergence of algorithmically and human-mediated pedagogy within the wider contexts of political, commercial and community mediation (Figure 1) could help to move teacher digital and AI-literacies beyond a near-sighted focus only on effective and appropriate tool use, to also consider increasingly important 'issues of technology use and democratic citizenship' (Pachler, 2026, p. 13).

To conclude, this has implications for initial teacher education. While new teachers need to be prepared to exploit any potential opportunities that AI could yield, this should be taught alongside:

- learning about the limitations and risks of AI;
- learning about the processes of AI or demystifying the black box (datafication, simulation, emulation, automation);
- understanding the distinctive role they can play as teachers and human mediators in mitigating the risks from AI of pedagogical and professional atrophy; and
- developing a diverse repertoire of pedagogies and theories of mind.

Without an understanding of the diversity of pedagogical repertoire underpinned by a broad range of theories of learning and mind from which to delineate the distinctive value of both human-mediated and algorithmically mediated pedagogy—the differences that matter—teachers may well become bystanders as commercial and political mediators continue to prioritise productivity and narrowly defined efficiency over purposeful and meaningful education.

FUNDING INFORMATION
No funding was received for this study.

CONFLICT OF INTEREST STATEMENT
The authors have no conflicting interests to disclose.

DATA AVAILABILITY STATEMENT
Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ETHICS STATEMENT
The study did not involve human participants or the collection of new data. Under these conditions, ethical approval was not required by the authors' institution.

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How to cite this article: Turvey, K., & Pachler, N. (2025). A topological exploration of convergence/divergence of human-mediated and algorithmically mediated pedagogy. *British Journal of Educational Technology*, *00*, 1–20. https://doi.org/10.1111/bjet.70007