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An Analysis of Actor-Network Theory and Its Implications for the Application of Artificial Intelligence in Education

Mohammad khosravi-Tanak

PhD Candidate of Curriculum Planning, University of Birjand, Birjand, Iran. E-mail: mohamadkhosravitanak@birjand.ac.ir

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ABSTRACT

This study seeks to explore the implications of Bruno Latour's Actor-Network Theory (ANT) regarding the integration of artificial intelligence into educational processes. The research employs a qualitative "theoretical essay" methodology, utilizing "document analysis" as the primary tool for data collection. the research data were mainly gathered through primary texts of Actor–Network Theory and secondary texts. Theoretical foundations and relevant literature on Actor-Network Theory were analyzed through a reflective and interpretive approach from an ANT perspective. Findings reveal that agency is no longer exclusive to humans but is distributed across unstable, multi-centered networks; meaning is not transmitted by teachers but is continuously co-constructed through interactions among human and non-human actors; and ethical responsibility no longer rests on any single individual, but is embedded within and interrogated by the opaque structures of algorithmic black boxes. In this context, humanity in education can no longer be defined in opposition to machines, but rather emerges through capacities of negotiation, interpretation, and regulation within technologically mediated networks. In conclusion, this article argues that the future of education lies not in resisting technology, but in consciously redefining the human role not as the sole possessor of agency, but as the network's regulator, interpreter of meaning, and architect of humanistic values amidst interactions with non-human elements. This perspective necessitates the design of interpretable AI systems, the cultivation of critical algorithmic literacy, and the establishment of multi-stakeholder ethical oversight mechanisms.

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Intruduction

Artificial intelligence, as of today, has been one of the most advanced and influential technological innovations, establishing its position in various social, economic, and cultural spheres. Among them, the education system, being a field related to the building of cognition, learning, and human generations' fate directly, has become one of the most vital areas where AI is being introduced at an accelerated rate (Stefania & Andrea, 2024). They are among others intelligent learning platforms, robot learning friends, personalized content sites, and performance assessment of students. They not only change the course of instruction and learning activities, but they also reconfigure the very dynamics of teacher-student and peer-peer relationships as well as student-educational tool relationships (Kumar, 2024).

In such a dynamic state of affairs, the question asked is: Are we merely witnessing a transition where technology is a tool at the disposal of humans, or is technology itself turning into a working, determinative, and even co-performing agent in the learning process? Though appearing to be simple, the question alludes to one of the most fundamental assumptions in philosophy of technology and sociology of science: the hypothesis related to the basic opposition between human and non-human agents.

Thus far, dominant technologies' theories following instrumentalist and voluntarist (e.g., Florman) or deterministic and essentialist (e.g., Ellul, Borgmann, and Heidegger) perspectives have relied on this dualistic vision, positioning human beings against technologies. Either human beings are in control of technology and utilize it as a tool, or technology takes control and traps human beings within its process (Sharifzadeh & Moghaddam-Heidari, 2015). This two-valued mind has resulted in the creation of analyses that situate technology as passive and weak, or, inversely, situate human beings as victims of an uncontrollable technological order. In either case, the dynamics between human beings and technology are thought to be grounded in domination, and one party always being better than the other.

However, in the case of experiences such as AI in teaching, such frameworks of analysis fall short. Artificial intelligence is not a passive tool deployed by teachers to offer learning, nor is it a deterministic power that keeps students within algorithmic frameworks. Rather, in fact, AI is an interactive, dynamic, and sometimes even decision-making agency in virtual and real-world classrooms: it personalizes learning material, manages temporal pacing and instruction sequencing, and occasionally provides feedback that even teachers may fail to notice. Under such circumstances, the distinction between "human agency" and "non-human agency" blurs. Teachers, learners, algorithms, user interfaces, learning data, and even virtual or physical classroom space get entangled in a rich web of interrelations, one where no single part overpowers the rest. Instead, knowledge, experience, and even pedagogical identity are continually reproduced through nested relations (Coleman, 2024).

Actor–Network Theory (ANT), eschewing the traditional human/non-human binary and giving equal analytical room to all the elements, whether human or material, allows for examination of dynamic nonlinear relationships in techno-social networks (Fenwick, 2011). An analysis of comparatively newer literature discovers a sharp divide: on the one side, like Zawacki-Richter et al. (2019) and Holmes et al. (2022), are interested in technical competence, ethical risk, or psychological impact of AI in education, in an epistemological framework that treats algorithms as black-boxed instruments or extrinsic factors. By contrast, while it is true that scholars such as Tattnall (2019) and Yoon (2024) have recently begun to use ANT in discussing educational technology, their descriptions barely scratch the surface of AI as a specific non-human actor with certain agential characteristics—i.e., adaptive learning, opacity, and self-generated decision-making. This theoretical lacuna not only constrains our knowledge about the workings of AI in learning but also restricts the development of intelligent learning systems well grounded in the dynamic interactions of such networks.

Current work aims to extend Actor–Network Theory to examine the building, stabilizing, and evolution of AI-driven learning networks. The fundamental research question is: In what ways and to what extent do human beings (learners, educators, system designers) and non-human beings (algorithms, tools, data, interfaces) interact with each other in today's learning environments, and through mutual actions, reproduce the learning process and network members themselves? In order to answer this query, this research goes back to the fundamental building blocks of Actor–Network Theory and presents an analytical agenda that not only enriches our vision of AI in education but also offers an entry point to the design of adaptive, nimble, and human-centered (albeit non-traditionally so) learning systems.

Literacy review

Theoretical Background

Actor–Network Theory (ANT) is a contemporary approach in sociology, with its roots in the field of Science and Technology Studies (STS) (Basco, 2006, 136). This theory, distinguished by its socio-philosophical perspective where both human and non-human actors (such as objects, tools, and technologies) are analyzed within the same conceptual framework, has attracted significant attention (Latour, 1999; Callon, 1986). Entirely European in origin, ANT was developed in the 1980s through the collaboration of thinkers such as Bruno Latour, Michel Callon, and British sociologist John Law. Within this framework, science and technology form the central focus of social analysis, grounded in the assumption that humans, objects, and environments (as human and non-human actors) interact within complex, multilayered contexts. Through these reciprocal interactions, both the actors themselves and our scientific knowledge of the world are continually reproduced. The primary aim of ANT is to understand how networks are formed in which social and material elements, both considered “actors,”

become interconnected, thereby generating scientific knowledge through processes of social construction and material resistance (Rydin, 2013, 24).

In ANT, there is no inherent distinction or hierarchy between human and non-human elements within technological systems. Every element, whether human, object, tool, or spatial environment, is considered an "actor" endowed with intentions, goals, and the capacity for action. These actors, through a process known as "translation," align their interests and objectives with others, constructing dynamic networks through mutual interactions. In this process, each actor strengthens its role in shaping collective order by overcoming resistances and forming new linkages. Some actors may ultimately achieve a dominant position, subordinating others to their aims, while others remain passive under the influence of stronger actors due to limited capacity or motivation.

The fundamental goal of ANT, particularly in Latour's perspective, is to demonstrate that human lives, objects, and surrounding spaces are deeply intertwined and inseparable: humans cannot be understood apart from their material and technological environments, just as objects lose meaning without human interaction. Objects and tools not only shape human environments but also constitute part of human identity and existence. Consequently, sociology cannot fully comprehend humans if it neglects their material and technological dimensions. Latour criticizes Cartesian science for its reliance on dualisms such as culture/nature, subject/object, and human/non-human, arguing that such dichotomies obscure a genuine understanding of human life in its complexity (Haji Shirazi, 2011, 62). The central premise of ANT is that socio-technological networks are formed not by humans alone but by heterogeneous constellations of human and non-human elements, including technologies, documents, laws, norms, tools, and other material and symbolic artifacts (Sharifzadeh, 2018, 198). This holistic outlook enables a more precise and realistic analysis of how socio-technological systems are formed, stabilized, and transformed.

ANT is thus a social theory centered on science and technology, premised on the participation of both human and non-human factors in a pluralistic field of interactive multiplicity. The theory seeks to explain how these mutually recognized actors' social and material connect to produce scientific knowledge through processes of social construction and material resistance. ANT employs concepts that fall into two categories: the first consists of novel concepts with no prior philosophical usage, such as actant, a term Latour introduced to describe both human and non-human entities. The second comprises existing concepts whose meanings are redefined, such as translation, which in Latour's framework goes beyond linguistic translation to encompass processes of connection, mediation, and alignment. Influenced by pragmatism and processual philosophies, ANT adopts a relational approach to phenomena, rejecting ontological divides between humans and non-humans. Instead, it focuses on heterogeneous human–non-human networks that are in constant motion. Humans and non-

humans mediate the definition and redefinition of one another; hence, the notion of purely human or purely non-human domains becomes untenable (Latour, 1994).

Philosophical Foundations of ANT

Ontological Foundations

From Latour's perspective, ANT rests on multiple ontological principles that reshape our understanding of reality. The Principle of Irreducibility holds that no entity can be reduced to another, as each phenomenon possesses independent existence while simultaneously evolving within networks of dynamic relations (Latour, 1988, 191). Thus, phenomena such as the ozone hole, AIDS, or cloned sheep cannot be explained solely as social, natural, or technological but must be analyzed within networked frameworks that dissolve traditional boundaries among nature, humans, and technology (Latour, 1993, 12). The Principle of Anti-Essentialism, influenced by post-structuralism, rejects any fixed essence or core for actors. Entities are defined not by intrinsic attributes but through relations and linkages with others, such that changes in those relations transform the actors themselves (Latour, 1988, 162). Accordingly, each actor is a unique event situated in time and space, with its identity arising from the network rather than from a pre-existing essence (Law, 1999, 4). The Principle of Hybrid Identities emphasizes that the world is populated by heterogeneous actors who transcend social/technical boundaries. No phenomenon is purely social or purely technical; instead, all acquire meaning within hybrid, networked constellations (Latour, 1998). The Principle of Symmetry posits that any entity, human or non-human, material or immaterial, qualifies as an actor insofar as it can effect change, with none considered more real or authentic than another (Latour, 2013, 247). Thus, the identity and power of actors arise from their networked relations rather than any intrinsic essence. Finally, the Principle of Alliance highlights that the power of any actor depends on its network of associations and allies. No entity is inherently strong or weak; its efficacy emerges from the alliances it forms (Latour, 1987, 162). An airplane component, for instance, gains meaning only within its network of interconnected parts, and each new alliance reshapes the very nature of the actors involved. Reality, therefore, is not based on isolated elements but constructed through the dynamics, expansions, and articulations of relational networks.

Anthropological Foundations

In contrast to traditional dualisms, ANT offers a new perspective on the place of humans in the world. First, it rejects Kantian distinctions between the thinking human subject and passive objects, advancing instead the principle of non-differentiation between humans and their world. From this view, humans possess no inherent superiority; like other entities, they are part of networks in which identity and power are distributed among actors. Classical binaries such as subject/object or society/nature thus lose their relevance, giving way to a networked perspective

with countless poles equal to the number of actors (Latour, 1992, 12). Second, drawing upon the principles of fluidity and relationality, ANT conceives human identity as neither fixed nor essential but relative and emergent from relations. Human capacities and attributes are shaped by linkages with other network elements, which are continuously redefined (Law, 1999, 5). Consequently, humans are hybrid, multifaceted beings whose identities form within diverse socio-technological fields. This stance not only rejects essentialist views of a unified human subject but also challenges the notion of autonomous human agency in shaping society. Third, within the framework of posthumanism, ANT highlights fundamental transformations emerging from the growing fusion of humans with intelligent technologies and environments. In this view, humans are no longer purely biological beings but are enmeshed with digital technologies that extend their physical, cognitive, emotional, and even spiritual capacities. Technology is not external or alien but an extension of human senses and existence (Van Loon, 2009, 153). Rooted in McLuhan's insights on media, this interpretation reframes humans as networked and hybrid entities whose identities and actions are continually co-defined with non-humans.

Epistemological Foundations

The epistemological foundations of ANT also critique classical approaches, emphasizing experience and interactive networks. First, ANT, while acknowledging positivist roots, locates knowledge not in abstract concepts or mental presuppositions but in the lived practices and observable interactions of actors. Latour's notion of "empirical metaphysics" asserts that entities can only be understood as they emerge within networks of action, with the role of theory being to describe these processes rather than impose normative judgments or a priori structures (Van Loon, 2009, 117; Latour, 1987, 123). Second, the principles of fluidity and relativity redefine truth and reality. For Latour, the truth of propositions depends not on correspondence with an external reality but on the extent of their support within networks of actors (Latour, 1999, 70). Reality is therefore not intrinsic or independent but a dynamic product continually constituted through reciprocal relations. In this sense, it is the power of the network that grants legitimacy and credibility to propositions, rather than any inherent essence .

Actor-Network Theory, developed by Bruno Latour, has richly enriched the field of science and technology studies as well as sociology, but is afflicted by several well-documented limitations. One of the most salient among them is that ANT goes out of its way to forgo significant descriptive analysis of how human and non-human actors are connected and a less theoretically-minded concern for critical inquiry into power, inequality, and social structures (Whittle, 2008; Mills, 2018). Although this descriptive approach is useful in the instance of network description, it is lacking in its capacity to explain political and ethical issues since it creates a "radical symmetry" among humans and non-humans and sometimes shies away from value-oriented critique or assessment of social effects (Shapiro, 1997). ANT's complete refusal

to judge and inability to make normative judgments may result in poor power and social structure analysis.

In addition, methodological flaws of ANT have been criticized by some scholars. For example, its application in some fields, such as music history, has revealed that an overemphasis on network relations might overlook explanatory or evaluative aspects and pertinent cultural and social aspects (Piekut, 2014). Apart from this, there has also been criticism regarding the use of language and terminology in ANT, i.e., that it is abstract and complex and hence not more suitable for practical analysis and policy-making. In general, while ANT is a useful device for understanding complicated interfaces between different actors, it is extremely restrictive when understanding power control frameworks, ethical and social implications, and also criticizing networks.

Empirical background

In the current research literature, Actor-Network Theory (ANT) has been by far the predominant theoretical framework for understanding the dense entanglements of human beings and technology in educational settings. Studies such as Moradi and Zarqami Hamrah (2019) and Farastkhah (2011) have applied ANT in deconstructing the long-held presumption of technological neutrality in learning, demonstrating that learning technologies, be they online platforms, digital textbooks, or even social media, are not inert intermediaries but active actors that reformulate learning processes, ethical responsibility, and even reconceptualize the learning goals. Internationally, writers like Tattnall (2019) and Yoon (2024) also developed this perspective by investigating key ANT notions to validate the argument that learning processes today are the emergent outcomes of complex networks with many human actants (learners, educators, policy-makers) and non-human actants (software, platforms, digital infrastructures, algorithms). This theoretical turn moves us beyond anthropocentric accounts of agency, learning, and responsibility, opening up new areas to critically examine the work of emerging technologies in education.

However, for all such valuable work, most existing research is still general theoretical or covering the overall categories of educational technology, many times covering artificial intelligence (AI), as a particular technological phenomenon characterized by machine learning, independent decision-making, algorithmic blackboxing, and with the possibility to become a "black box" in education networks extremely infrequently. Such a gap makes the present research even more valuable. By rigorously situating key ANT concepts, most prominently distributed agency, human–nonhuman symmetry, and the process of translation within the AI pedagogical setting, this research offers a novel interpretive lens. Unlike earlier research that speaks of technology in general terms, the current research specifically asks how AI works not merely as a facilitator of learning, but as an active pedagogical node of education networks that, in its interactions with other actors, re-constructs knowledge, re-designs learning experiences,

and reconfigures the borders of pedagogical accountability. Thus, while this study draws on the theoretical contributions of previous research, it also extends the relevance of ANT to new boundaries of AI-based learning, filling a key conceptual and empirical gap in the literature.

Methodology

Given the aim of this research, which is the theoretical analysis of Bruno Latour's Actor–Network Theory (ANT), the elucidation of its elements, and reflection on its implications for the application of artificial intelligence in education, the qualitative method of "conceptual essay" or "theorizing through reflective inquiry" is the most appropriate approach for this study. This method, which arises from the researcher's deep study, extensive experience, and profound reflection on the subject matter, allows for the integration of existing theories, critique of prevailing structures, and the development of innovative frameworks. It is a kind of meta-analysis or research synthesis in which the researcher, instead of relying on statistical and numerical rules, uses studies and propositions as tools (Schubert, 1991).

According to Mehrmohammadi (2018), this type of research may take different forms, such as expanding an important but neglected idea in a specialized field; introducing a new and boundary-breaking concept to create conceptual breakthroughs; or offering a new and innovative formulation of long-standing issues and debates within a discipline or topic. By engaging in such approaches, the researcher can draw the scientific community's attention to innovative and fresh intellectual contributions, which may take the form of an essay or a monograph. Conceptual inquiry can, in fact, be seen as preliminary efforts to prepare the raw materials for theory-building. Schubert maintains that a conceptual essay cannot and should not be reduced to a manual for producing essays. Nevertheless, the analysis of data in the present research was conducted through a reflective method (conscious intellectual engagement) (Creswell, 2012).

Within this framework, the research data were mainly gathered through document analysis. The sources studied fell into two categories: (1) primary texts of Actor–Network Theory (Latour, Law, and Callon), and (2) secondary texts, including scholarly articles, dissertations, and books that, in recent years, have addressed the application of ANT in the domains of technology, education, and artificial intelligence. These texts were selected through purposive sampling, meaning that the main criterion was theoretical richness and the ability of the text to contribute to theory-building, rather than statistical generalizability.

The process of data analysis was carried out in three stages: first, through multi-stage reading of the primary texts, the key concepts of Actor–Network Theory were identified and extracted. Next, these concepts were reinterpreted in the discourse of artificial intelligence in education, that is, the researcher reflectively examined the question of how, according to ANT, the application of AI in education takes place. Finally, by synthesizing the findings of conceptual analysis and theoretical reconstruction, an interpretive framework was presented that clarifies

the implications of ANT for the use of AI systems in education (In this study, we have used artificial intelligence tools solely for linguistic editing and improving the fluency of the text).

Disscution

Actor

In Actor–Network Theory, the term "actor" is widened beyond the normal limits of anthropocentrism to be applied to describe anything that is defined solely in terms of the degree to which it can make a difference in an environment that is networked. This broadening in itself is more than a shift in conception of agency; it also subverts the theoretical constructions of education systems. According to this point of view, any actor a mindful and ethically driven instructor, an algorithm-based AI system based on machine learning algorithms, an interactive learning environment, or even an algorithm monitoring student activity if it can provide an active contribution to the network of teaching interaction and alter the flow of learning, qualifies as an acceptable "actor" (Sperling et al., 2022).

This perspective completely rewrites the traditional linear and hierarchical models of education, in which the teacher was the central figure of knowledge dissemination and the student a passive absorber. Education is not, in this perspective, anymore a top-down, one-way phenomenon, but a networked, dynamic, and multi-centered process where the difference between "educational actor" and "educational subject" becomes non-existent. Here human beings (parents, students, teachers), technologies (user interfaces, artificial intelligence, learning platforms), information (interactions, marks, learning behaviors), algorithms (adaptive engines, recommendation algorithms), and even physical and virtual spaces (virtual learning environments, intelligent classrooms) constantly interacting with each other are at the same time teacher and taught (Tao & Perez, 2025).

This multi-faceted strategy allows us to approach the application of artificial intelligence in pedagogy not as a passive tool or lifeless servant, but as an active and determining pedagogical force. Artificial intelligence, through such phenomena as big data analysis of learning behavior, real-time feedback, and individualized learning trajectories based on individual needs, not only reshapes the mode of learning but also disturbs the nature of the learning process. These systems, by their reproduction of the processes of education and alignment of the students towards specific learning paths, determine some of the deep structure of education and play an effective and irrefutable part in the significant context of human development (Tilpeguana, 2024). This necessarily means that education can no longer be decided on the absolute basis of "human conscious intention" or "unambiguous will of the teacher," but is situated within a network of multi-agencies, human, technological, institutional, algorithmic, and even biological (Karalas, 2025).

And this change doesn't mean eliminating or diminishing the role of the teacher; ironically, it takes it to an even deeper, human, and philosophical level. Here in this networked model, the

teacher is no longer a "transmitter of knowledge" but a "network manager." The teacher becomes a manager of, interpreter of, and guide through interactions in the educational network: as steward of human purposes, translator of values, and moral arbiter, facilitating algorithmic outputs and final educational purposes. Through his or her pedagogical insight, the educator interprets lifeless computer printouts and statistics into human, value-oriented, and pedagogical meaning. He or she navigates algorithms towards the formation of identity, personality, critical thinking, and intrinsic human values. Thus, the teacher's function changes from "content sender" to "ethical regulator of the network," a teacher who, aside from delivering content, contributes meaning, direction, and worth to the network (Czahajda et al., 2022).

The outcome of this change is the development from an authoritarian and centralized system in which the teacher was the only moral and cognitive authority to a multi-centered and distributed system in which responsibility for education is being transferred among human and nonhuman actors (Hussein & Islam, 2024). This transition raises profound philosophical and ethical questions, including whether education can still have human-centered and value-oriented purposes when part of its decision-making, such as identifying learning weaknesses, suggesting learning paths, or even evaluating performance, is delegated to machines that lack intention, conscience, and moral values. How is it even possible to ensure that the values encoded into algorithmic codes, which are often invisible, opaque, and even culturally or commercially skewed, coincide with the human, pedagogical, and philosophical values of the learning system? And finally, how is it even possible to preserve human freedom, autonomy, and moral responsibility, especially that of the student, in a network whose decisions are partly determined and even directed by nonhuman actors? In this model, learning is not only the transmission of information or technical skills, but leads to the reproduction of life experience, construction of human identity, and construction of meaning in dialogue with technology. And technology and artificial intelligence, in specific, are not a substitute for the teacher but a partner and co-performer who, alongside the teacher, constructs important pedagogic situations: situations where the human person, not losing his or her will, autonomy, and moral responsibility, in an evolving, critical, and creative relationship with technology, comes closer to human perfection.

Within Actor–Network Theory, the "actor" is released from the weight of conventional anthropocentrism and extended to incorporate any agency that can, within a network of multifaceted relations, make a difference to the flow of action or meaning. This very elementary extension reorients the idea of agency and challenges the theoretical foundations of educational systems. From this view, any actor, a virtuous teacher, a machine learning agent, or a learning-behavior analytics algorithm, should, if capable of taking an active part in the network of learning transactions and impacting the learning path, be recognized as an "actor" (Latour, 2005; Sprang et al., 2022).

However, the advent of artificial intelligence into the fold of education not only illustrates the adaptability of ANT but also raises an existential query regarding the concept of "agency" in the theory. ANT counts on the proposition that agency is decided through "effects within the network," and not through "intention" or "awareness." However, modern artificial intelligence, particularly deep learning technology, operates at a level of automation, obscurity, and scale whereby the concept of "effect" can no longer be traced or attributed in any apparent manner. Is the program that, independently, calculates the learning path of the student based on hidden patterns in the data an "actor"? Or are we that automaton process without agency which ANT incorrectly believes to be an "actor"?

This is a question to which ANT is vulnerable to a philosophical critique already put forward: does the universalization of agency to nonhumans entail a flat ontology in which qualitative distinction between an answerable human and a computer program is erased? (Archer, 2000). If both are "actors," then how do we assign moral responsibility? How do we distinguish between "ethical decision-making" and "statistical output"?

In order to understand this challenge concretely, it suffices to take smart learning systems like Duolingo. In Duolingo, adaptive algorithms, as a response to learner mistakes, not only adjust difficulty levels but also recreate exercise types, concept presentation order, and even feedback delivery time. This system, without the presence of a teacher, directly affects learning experience, motivation, and even learner self-efficacy. To ANT, this algorithm is certainly an "actor." But from the philosophical perspective, this agency is free of intention, conscience, and responsibility. Is this "agency without responsibility" what education needs?

To determine that, we need a more precise definition of the agency terms. The specific attributes of artificial intelligence, such as self-configuration, algorithmic inscrutability, and vast scalability, force us to make new distinctions. Traits such as practical efficacy (ability to change learner behavior), processual autonomy (ability to change internal rules independently of direct human intervention), algorithmic transparency (ability to decode and interpret system choices), and network scalability can be considered. Based on these traits, technological agency reflects a type of "algorithmic agency" that, though efficient and self-adaptive, lacks the meaning-making and moral responsibility abilities needed for teaching.

This is not a revival of traditional anthropocentrism, but a critical expansion of ANT itself: the "actor" is not just something or someone that "makes a difference," but something or someone capable of remembering and interpreting human intentions in the network. From this perspective, artificial intelligence broadens the theoretical horizons of ANT and forces us to introduce "the becoming of agency," "epistemic opacity," and "technological accountability" into ANT's toolkit. It is only through this that the theory can both describe the reality of networks in modern education and provide a basis for their philosophical and ethical critique.

Network

In Actor–Network Theory, "network" extends beyond a group of things, but an active, meaningful arrangement that organizes relations, flows of influence, meaning, and resources between human and nonhuman actors (Latour, 2005). Not only is the network where actors are located, but also the shape that regulates how interaction, distribution of influence, and even the making of "educational reality" takes place (Nopas, 2025). Educationally, this network is bio-social in its potential: a rich mesh of teachers, students, algorithms, data, platforms, cultural norms, and institutional silences that enable and limit the learning process (Sprang, 2022).

But ever since artificial intelligence came into education, the stability and traceability of the network itself are uncertain. One of the most stringent requirements imposed by ANT is traceability, that is, we must be able to track the chain of associations, translations, and associations leading to an outcome (Law, 2009). But in AI-based systems, especially those using deep learning, that is no longer feasible. Algorithms make decisions, but their criteria for decision-making are hidden within a "black box" even to their designers. Can we still speak of a "network" under such conditions? Or are we faced with non-network configurations closed and manipulable in their interior?

In order to better grasp this question, let us consider the example of the platform Coursera. It proposes tailored learning paths based on users' behavior (clicks, view time, test results) via recommendation algorithms. These algorithms choose not just content, but actually redefine "valuable knowledge" for a user, yet neither student nor teacher is in the know about it. We are not aware of why a specific course is being recommended and another one is not; we are unaware of what cultural or commercial biases are baked into these recommendations. It is where the network has forfeited its role as "a dynamic and adjustable structure," but rather an institutionalized and inflexible structure, which has taken power out of human hands and invested it in inaccessible codes.

This leaves ANT in front of an easy question: if one network is not traceable, is it still a "network"? Or was ANT, which was interested in the "dynamism" and "reconstructability" of the network, intended to study systems where algorithmic opacity has substituted for human dynamism?

Philosophically, the transformation does not eliminate education from the realm of classical individualism but moves it to supra-individual and uncontrollable structures in which all learning is not a product of interaction but the result of choices being made out of sight. In that arena, "co-production," the core of networking in ANT, no longer applies, as one of the actors of the interaction (the algorithm) is uncontrollable but also cannot participate in the debate.

Therefore, an artificial intelligence network cannot be conceived as the mere "structural framework." Rather, it has to be conceived as the area of tension among transparency and obscurity, control and automatism, and responsibility and accountability. Any change in the

character of this network, algorithmic or institutional, will have deep impacts on the identity of the learner, on knowledge, and even on that of the "full human" in the academic community. But these impacts, if the network is imperceptible, will be irresistible and irrevocable.

In this perspective, the network is not just the space of education but the being-space of growth of the modern human person, where human persons, exchanging with machines, information, and buildings, build themselves, but will only realize this building as "education" if the network, however complicated, makes sense, is criticizable, and submits to human mastery.

Translation

In Actor–Network Theory, "translation" is an essential process whereby actors, human or nonhuman, redefine and relocate their goals, meanings, and positions in attempting to build a stable and meaningful network (Callon, 1986). This is action, as contrasted with mechanical information transfer, which is interpretive, ethical, and creative action in which each actor reconstructs reality from his or her perspective and places it in the service of common ends. In the classroom context, such an activity is generally designed as a collaboration between the teacher and the teaching machines: the teacher interprets the techno-products and directs them toward human ends.

But contemporary artificial intelligence ruins this utopian image of "translation." Translation, in ANT, is grounded upon the twin potential for understanding and accommodation, that each agent ought to have the power of responding, changing, and becoming a member of the coordination process. Artificial intelligence, especially deep-learning-based machines, lacks meaning-making potential, responsibility, or intentional accommodation. Algorithms "respond," but not "speak." They "produce outputs," but have no "intention." Such being the case, do we still speak of "translation"? Or is it a surreptitious one-sidedness of technology that only simulates collaboration?

To render this possible failure of translation more transparent, let us look more closely at artificial intelligence systems in internet school classrooms. Here, algorithms come to learn to adjust the learning path based on student behavioral data (response time, attempts, error patterns). The teacher is now compelled to "translate" these results: project them onto the student's emotional, cultural, and moral needs. But most frequently, the hidden reasoning of the algorithm, i.e., why the student is "weak" and why a certain subject has been hidden from him, is completely inaccessible. The teacher doesn't know which standard the choice relies upon: data bias? Site commercial preference? Calculating glitch? Without this layer of access, "translation" is no longer a shared constitution but an asymmetrical act of imposition of meaning upon meaningless computation.

This opens ANT up to a ground-level critique: does the "translation" idea of ANT rely on the unstated assumption that human or nonhuman actors all share at least some measure of

"responsiveness"? If this premise is shattered by the black-boxing of artificial intelligence, then "translation" can no longer be the point of networking. Indeed, artificial intelligence shows that not everything is equal to everything: some (like us) can be part of the process of translation; others (like black-box algorithms) provide outputs and say not a word.

Philosophically, this breakdown of translation makes what was previously a co-creative place of meaning an emergency place of interpretation. The teacher is no longer an "architect of meaning," but an interpreter with computational silence, an interpreter who must construct meaning and worth in outputs the provenance of which is foreign to him. This is not synergy but enforced recovery of moral responsibility for man, although decision-making has been taken out of his hands.

Therefore, translation nowadays, within the context of artificial intelligence, cannot be regarded anymore as a spontaneous and harmonious process. Rather, it must be read as an ethical space of tension where human subjects are compelled to mediate productions that are not only obscure but appear to pose as objectivity and neutrality. In this case, translation only works if it demands more than pedagogical instinct: algorithmic clarity, the right to be informed of the reason behind the choice, and the right of human functioning in network mode. Without these hypotheses, "translation" will be but an ethical desire, a desire which, faced with the black box, increasingly turns to silence.

Lastly, translation, as an intermediary among artists, can only guarantee learning stays away from crossing over to the human and value-oriented realm if the intermediary is two-way, but not if one end of it is closed in the darkness of inaccessible codes.

Mediation vs. Intermediary

One of the main models used to describe how change is accomplished in a network, in Actor–Network Theory, is the distinction between a " Mediation" and an " Intermediary." A " Intermediary," for example, a screen display or grade book, is simply a passive pipe for information transfer or storage; it lacks will, independent effects, or the capacity to reinterpret meaning (Fenwick & Edwards, 2013). In contrast, a "Mediation " is an active, transformatory, and sense-making process: a space in which devices not only transfer information, but also align goals, redefine meanings, and reshape habits in the middle of interactions. In education, this putatively fine distinction has significant implications: presupposing artificial intelligence to be merely a tool reinforces reductionism and instrumentalism, whereas presupposing it to be a Mediation enables one to think about education in terms of networks and sense-making (Nopas, 2025b).

But artificial intelligence today belies this fine distinction seriously. Most adaptive learning systems and intelligent education systems describe themselves as " Mediation" that individualize the learning process and maximize learning. However, in practice, they maximize the behavior patterns rather than constructing meanings. They guide the student through a

course with priority for efficiency over meaning, defined in terms of parameters like "response time" or "success rate." Are such systems "mediators" in this sense? Or are they more complex tools that, beneath the philosophical jargon of "dynamic interaction" and "personalization," come in the form of mediators?

In order to untangle this uncertainty, let us examine the Duolingo system more closely. This site, through adaptive algorithms, individualizes learning content to performance by learners and provides feedback in real time. On the surface, the system can be characterized as a "Mediation " with a role in the learning network. However, on a deeper level, we understand that its real purpose is to keep the user on the site (to maximize engagement and ad revenue), rather than to develop linguistic thinking or cultural understanding. The algorithms lead the user to minimally psychologically resistive exercises, rather than deepest learning ones. In this case, artificial intelligence is not a sense-making mediator but a high-degree behavioral optimization machine, disguising itself as a "Mediation " of the learning network.

This example illustrates how ANT's own distinction between "instrument" and "mediator" cannot survive technologies with a gloss of neutrality that tacitly imposes commercial or behavioral values. ANT assumes that if something "has an effect," then it is a "mediator." But under what conditions is this effect "meaning-making," and when is it "reductionist"? Is any behavior modification always a transformation of meaning?

Philosophically, this vagueness presents education with a serious risk: that of substituting human cultivation for behavioral engineering. When AI systems, unexplained, operationalize "successful learning" in terms of such open-ended parameters as response speed or cumulative success, they are not "mediators," but rather actual hindrances to human mediation. The teacher cannot so readily counter or amend these parameters.

Therefore, the distinction between "mere instrument" and "mediator" is not to be made in terms of "having an effect," but in terms of whether the effect is criticizable and of the nature of the effect. A genuine mediator not only has influence but an influence which is discernible, criticizable, and within human control. Otherwise, we are left with "complex instruments" that, beneath the philosophical rhetoric of ANT, pose as educational agents, but in fact boil down education to a simple set of manipulable inputs and outputs.

In such an understanding, naming artificial intelligence a "mediator" is more than observing its seemingly obvious role in the network. It calls for a critical interrogation of the values embedded in its algorithmic construction and in its capacity to join in meaning-making. Otherwise, ANT's "instrument" and "mediator" distinction can be invoked as an alibi to remove technology from moral responsibility rather than a tool for enhanced understanding of its role in education.

Black Box

In Actor–Network Theory, the "black box" is a metaphor for a process whereby the internal operations of an actor human or technological have been so stabilized, automatic, and uninterpretable that only their "input" and "output" are visible, but not the chain of decision-making, not the criteria of valuation, and not the hidden ethical reasoning backstage (Latour, 1987). ANT rests on the hypothesis that to know a network, we must be able to open the black boxes and trace the series of translations, collaborations, and compromises through which we have reached a certain outcome. Modern artificial intelligence, however, and most notably deep learning networks, not only generates black boxes but also makes them engineered to be impossible to open. This feature places ANT in front of an existential question: is it possible to study a network anymore if its heart, the algorithmic decision-making process, is systematically and irretrievably concealed from all other actors?

To get a better understanding of this crisis, let us take a closer look at automated grading student systems on websites like Coursera or EdX. In these systems, algorithms not only score the student responses, but they also adjust the difficulty level of subsequent questions, give pedagogical feedback, and even accept or reject the academic validity of learning. However, the teacher and the learner get no information regarding the real criteria for judgment. They cannot understand why an answer has been marked "incorrect" or why some path of learning has been closed off. Here, the black box is no longer a halfway house to making the network stable (as Latour desired) but a hard and impenetrable one that has wrested power from human action and invested it in codes impenetrable.

This is just one example of how artificial intelligence does not prove ANT but rather tests it to the limits of its epistemology. If ANT claims that "everything in the network is traceable," then how can it analyze systems whose internal logic is technically or legally untraceable? Is this a sign that ANT is not equipped to examine post-human technologies? Or does it mean that the "network" itself in ANT has to undergo a critical enlargement in which the "black box" is not the successful outcome of networking but the ethical failure of the network?

Philosophically, this crisis makes education a moral question: the educator, faced with outputs whose composition is no longer clear, is obliged to be a "moral reader" not just to accept but to re-read, correct, and orient them towards the creation of the free and responsible individual (Hussein & Islam, 2024). But this interpretation, when the tacit rationality of the algorithm conflicts with pedagogical goals, is itself susceptible to error and misreading. The educator can "interpret" results that are in fact based on data bias or market agendas.

In this manner, the black box in the teacher-artificial intelligence relationship validates that teaching in the age of intelligent technologies is no longer possible on the basis of complete transparency of mechanisms, yet it is possible on the basis of transparency of objectives, moral responsibility, and the right to human intervention. That is, smart learning systems should be

designed in such a way that, at least, their general decision-making algorithm is explainable, and the instructor can, if needed, shut them off or adjust them. Short of these safeguards, the black box will be less a technical aspect than a device for moral responsibility deflection from humans.

In this perspective, education is not about capitulating to the black box but about steadfast resistance to it resistance in which human beings, not ready to relinquish their will and responsibility, demand that the machine must be subservient to human beings, not their substitute. And this resistance is possible only if ANT, instead of capitulating to opacity, takes into account that opacity is a deficiency of networking, not the unavoidable outcome of technological sophistication.

Conclusion

This study, drawing on the ontology of ANT, has been seeking to make sense of artificial intelligence in education not as a passive technical entity or humanity-destructive force, but as an interactive, multi-nodal, and meaning-making process. Here, human actors (policy-makers, educators, students) and nonhuman actors (algorithms, data, platforms, systemic discriminations) interact in the production of "education" through unstable and endlessly reconfiguring networks. There, artificial intelligence is not a third party but an agential actor that reconstitutes the very foundations, bonds, and ends of teaching.

However, upon close examination, it transpires that modern artificial intelligence does not straightforwardly disqualify ANT but instead awkwardly cohabits with ANT's conceptual and ethical boundaries. ANT takes its stand on the basis of traceability of networks, co-participation in translation, and opening black boxes. But the deep-learning systems themselves are traceless, non-conversational, and unopenable. In that case, can we even speak of a "network"? Can we "translate" with the help of something that will never be able to answer? Is "agency" without moral responsibility what education is ultimately seeking?

These challenges reveal that while ANT is an effective explanation of the complexity of contemporary education, it is not sufficient for its ethical analysis. In fact, artificial intelligence requires us to make a critical addition to ANT itself, an addition in which:

- An "actor" is not merely someone who "makes something happen," but someone who is also able to take ethical responsibility.
- The "network" is no longer an arrangement that is simply energetic, but one where transparency and possibility for human action are guaranteed,
- "Translation" is no longer a transparent process, but a site of ethical struggle in which human beings must contend with outputs whose origin is not disclosed,
- And the "black box" is no longer the triumphant outcome of networking, but an exercise in failing to fulfill the ethical standards of learning.

This reconfiguration compels us to renegotiate fundamental principles. Moral responsibility is no longer the exclusive territory of the teacher but must be distributed throughout the whole network of algorithm designers, data policymakers, and ethical controllers. Student autonomy requires explainability of algorithmic thought and the possibility of appeal against system recommendations, not merely the capacity to choose between given ones. And human in education is no longer defined in opposition to the machine as negativity, but instead as the ability to read, resist, and produce before algorithmic form.

Practically, this view calls for change on four levels:

1. Developing intelligent educational systems not only technologically but also from a pedagogical interpretability standpoint, i.e., for simplicity of understanding and critical analysis of the rationale for system decisions,
2. Teaching educators and students' critical algorithmic literacy, the capacity to deconstruct, reprogram, and resist artificial intelligence output,
3. Placing control points at an institutional level, ethical standards for education algorithms, and multi-stakeholder fora,
4. Human-centered policy-making is no longer technocratic but driven by the politics of human, value-based, and existence-minded goals over computational logic.

At last, the simple fact of the presence of artificial intelligence in education is not a human essential crisis but an opportunity for a deep and responsible reinvention of education. But this opportunity will be productive only if we apply ANT not as a complete theory, but as an opening to philosophical research. Education today in the age of artificial intelligence can no longer be a controlled and linear process, but rather a networked and liquid process whereby value and meaning are embedded within interactions. This is not the end of man's control over education, but only the beginning of another era of diffused responsibility, an era in which the human subject, not as agent, but as interpreter, intermediary, and ethical governor at the center of the network, remains the ultimate designer of man in the educational process.

References

Bosco, F. J. (2006). In S. Aitken & G. Valentine (Eds.), *Approaches to human geography*. SAGE Publications.

Callon, M. (1986). Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St Brieuc Bay. In J. Law (Ed.), *Power, action and belief: A new sociology of knowledge* (pp. 196–223). Routledge & Kegan Paul.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson Education.

Czahajda, R., Čairović, N., & Černko, M. (2022). Live online education efficiency mediators from the actor-network theory perspective. *Frontiers in Education, 7*, Article 859783. https://doi.org/10.3389/feduc.2022.859783

Dong, X., & Aijing, C. (2025). Smart teaching in international Chinese education: A case study on the use of generative AI. In *Proceedings of the International Conference on Social Science and Humanity* (Vol. 2, No. 3, pp. 777–784). https://doi.org/10.61796/icossh.v2i3.163

Farasatkhah, M. (2011, May 29). *An idea of the future curriculum with an emphasis on the actor-network theory approach*. Paper presented at the Conference on Fundamental Transformation in the Curriculum System of Iran, Ferdowsi University of Mashhad, Iran.

Fenwick, T. J. (2010). (Un)doing standards in education with actor-network theory. *Journal of Education Policy*, *25*(2), 117–133. https://doi.org/10.1080/02680930903314277

Fenwick, T., & Edwards, R. (2011). Introduction: Reclaiming and renewing actor-network theory for educational research. *Educational Philosophy and Theory*, *43*(sup1), 1–14. https://doi.org/10.1111/j.1469-5812.2010.00667.x

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Hossain, M. E., & Islam, M. A. (2024). AI and the future of education: Philosophical questions about the role of artificial intelligence in the classroom. *International Journal of Research and Innovation in Social Science*, *8*(3S), 5541–5547. https://doi.org/10.47772/IJRISS.2024.803419S

Karaoulas, A. (2025). Supervision and teaching in education: Historical development and contemporary transformation in the digital age. *International Journal of Research in Education, Humanities, and Commerce*.

Kölemen, C. Ş. (2024). Digital transformation in education: Multidimensional effects of artificial intelligence-supported learning management systems. *Participatory Educational Research*, *11*(5), 102–124. https://doi.org/10.17275/per.24.66.11.5

Kumar, A. (2024). Artificial intelligence in education: Revolutionizing teaching and learning. *Journal of Asian Primary Education*, *1*(1), 63–67. https://doi.org/10.59966/joape.v1i1.1207

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard University Press.

Latour, B. (1988). *The pasteurization of France* (A. Sheridan & J. Law, Trans.). Harvard University Press.

Latour, B. (1992). One more turn after the social turn: Easing science studies into the non-modern world. In E. McMullin (Ed.), *The social dimensions of science* (pp. 272–294). University of Notre Dame Press.

Latour, B. (1993). *We have never been modern*. Harvard University Press.

Latour, B. (1999). On recalling ANT. In J. Law & J. Hassard (Eds.), *Actor network theory and after* (pp. 15–25). Blackwell.

Latour, B. (2013). *An inquiry into modes of existence: An anthropology of the moderns*. Harvard University Press.

Lee, K. M. (2025). A case study of high school music convergence project class using artificial intelligence (AI) based on actor-network theory. *The Journal of Learner-Centered Curriculum and Instruction*, *25*(9), 553–577. https://doi.org/10.22251/jlcci.2025.25.9.553

Mehromhammadi, M. (2018). *Review essays in education and training* (2nd ed.). Tarbiat Modares University Publications. (In Persian)

Mills, T. (2018). What has become of critique? Reassembling sociology after Latour. *The British Journal of Sociology, 69*(2), 286–305.

Moradi, A., & Zarghami, H. S. (2019). The status of massive open online courses (MOOCs) in breeding students' moral responsibility with an emphasis on actor-network theory. *(Journal information unavailable).*

Nopas, D. S. (2025a). Decentring the human: Actor-network theory and AI in Thai online learning communities. *Asian Education and Development Studies*, Advance online publication. https://doi.org/10.1108/AEDS-08-2024-0169

Nopas, D. S. (2025b). Algorithmic learning or learner autonomy? Rethinking AI's role in digital education. *Qualitative Research Journal*. https://doi.org/10.1108/QRJ-11-2024-0282

Piekut, B. (2014). Actor-networks in music history: Clarifications and critiques. *Twentieth-Century Music, 11*(2), 191–215.

Shapiro, S. (1997). *Caught in a web: The implications of ecology for radical symmetry in science and technology studies*. *(Unpublished manuscript).*

Sharifzadeh, R., & Moghadam Heidari, G. (2015). Leaving the dichotomy of autonomous technology and technology as intermediary based on Latour's point of view. *Philosophy of Science, 5*(9), 29–51.

Short, E. C. (Ed.). (1991). *Forms of curriculum inquiry*. SUNY Press.

Sperling, K. (2022). Machine (network) learning in K–12 classrooms: Exploring the state of the actual with actor-network theory. In *Proceedings of the 13th International Conference on Networked Learning*.

Sperling, K., Stenliden, L., Nissen, J., & Heintz, F. (2022). Still w(AI)ting for the automation of teaching: An exploration of machine learning in Swedish primary education using actor-network theory. *European Journal of Education, 57*(4), 584–600.

Stefania-Andreea, B. I. T. U. (2024). The impact of artificial intelligence in education: Transforming educational management in the digital age. In *Proceedings of the International Management Conference* (Vol. 18, No. 1, pp. 230–240). https://doi.org/10.24818/IMC/2024/02.13

Tao, H. B., & Pérez, V. R. D. (2025). Impact of artificial intelligence on educational actors (2015–2023). *Revista Colombiana de Ciencias Sociales, 16*(1), 240–276.

Tatnall, A. (2019). Researching computers and education through actor-network theory. In *International Conference on Sustainable ICT, Education, and Learning* (pp. 78–88). Springer.

Tilepbergenovna, U. A. (2024). The role of artificial intelligence in education. *International Journal of Pedagogics, 4*(10), 184–187.

Whittle, A., & Spicer, A. (2008). Is actor-network theory a critique? *Organization Studies, 29*(4), 611–629.

Yoon, O.-H. (2024). Exploring the educational implications of networking. *Korean Journal of General Education*, *18*(1), 67–78. https://doi.org/10.46392/kjge.2024.18.1.67

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education: Where are the educators? *International Journal of Educational Technology in Higher Education, 16*(1), Article 39.