



Journal of Tertiary Education and Learning (JTEL)

ISSN: 2994-4015 (ONLINE)

VOLUME 4 ISSUE 3 (2026)



PUBLISHED BY
E-PALIU PUBLISHERS, DELAWARE, USA

Postdigital Literacies beyond Digital Competence: A Relational Framework for Agency, Power, and Participation in Higher Education

Giovanni Vindigni^{1*}

Article Information

Received: July 27, 2026

Accepted: September 12, 2026

Published: September 14, 2026

Keywords

*Accessibility, Critical Literacy,
Participation, Post-Digitality,
Sociotechnical Relationality,
Tertiary Education*

ABSTRACT

Proceeding from the social-theoretical premise that digital and non-digital, material and symbolic, as well as human and technological world relations are not separate spheres but rather mutually constitutive elements of postdigital orders of reality, this article reconstructs postdigital literacies not as an additively extensible inventory of individualized competencies, but as a relationally situated capacity for reflexive interpretation, normative evaluation, and co-creative transformation of sociotechnically prefigured world relations. Methodologically, the study is grounded in a critical-integrative evidence synthesis drawing on 75 publications issued between January 2020 and August 2026 in the fields of media education, educational and literacy research, sociomaterial research, and research on data literacy, algorithmic literacy, and AI literacy. These findings are not cumulatively aggregated but relationally mediated with regard to their object constitutions, normative frameworks, and empirical scope. Within this analytical framework, it becomes evident that postdigital literacies cannot be adequately understood either as individualized, action-enabling knowledge or as a mere extension of digital competence. A relational heuristic is proposed instead, in which operational connectivity, infrastructural transparency, the capacity for reflexive distancing, distributed agency, and transformative participation mutually condition one another without forgoing their respective claims to validity. Within this architecture, competence refers to the situation-specific disposition to act; education, understood here in its transformative rather than merely instructional sense, refers to the reflexive transformation of relations to the self, the world, and technology; and literacies refer to the socially and materially situated practices, structured by relations of power, through which both are actualized, negotiated, and contested. On this basis, the synthesis provides a theoretical rationale for the claim that access, accessibility, and epistemic representation are not merely secondary implementation issues but rather constitute the conditions of possibility for postdigital educational and participatory processes. For research and media didactics, such a perspective implies the need to focus not primarily on technical performance, but rather on the reasoned capacities for relational interpretation, engagement with contradictions, and collective shaping within sociotechnically pre-structured contexts of action.

INTRODUCTION

In a context of profound societal mediatization, post-digitality refers neither to the chronological after of the digital era nor to a stage of development in which previously analog ways of life have been completely replaced by technology. Rather, it refers to a historical and sociotheoretical constellation in which the distinctions between online and offline, technical and social, material and symbolic, or human and nonhuman lose their self-evident organizing power, without thereby becoming irrelevant. Digital infrastructures emerge as socially effective precisely where, in the practice of everyday communication, education, work, and participation, they are no longer perceived as singular technologies but are taken for granted as prerequisites for perception, decision-making, and action. Therefore, in this theory-practice transfer context, Fawns (2022) conceptualizes entangled pedagogy through the interdependence of technology and pedagogical practice, a position that can be read alongside Jandrić and Knox (2022) and also

Jandrić and Hayes (2020) as requiring an examination of how educational purposes, institutional arrangements, and situated human action shape the significance of technical artifacts.

Drawing on Lacković et al.'s (2024) account of entanglement, digital materiality, and spatiotemporality, the present study takes this argument into tertiary education, where the analytical question concerns how these relations organize teaching, learning, and knowledge production, including the conditions under which particular practices become visible, count as achievement, and receive institutional recognition.

Particularly for media education, this shift presents a conceptual and normative challenge. On the one hand, competency models remain indispensable, insofar as pedagogical agency is to be translated into describable dispositions, learning objectives, and observable practices. On the other hand, such models often individualize problems whose origins lie primarily in platform architectures, institutional access regulations, data-

¹ Professor, Dean of Studies, Diploma Hochschule – University of Applied Sciences, Germany, and Doctoral Advisor, Global Humanistic University, Anguilla and Middlesex University, United Kingdom

* Corresponding author's e-mail: giovanni@vindigni.de

economic interests, and culturally unequal opportunities for representation. If a lack of participation is diagnosed solely as a deficit in personal abilities, the conditions under which certain abilities can be effectively exercised in the first place disappear from the analytical horizon. In contrast, approaches grounded in educational theory keep in mind the transformation of relationships to the self and the world, the openness of the starting point, and the resistance of the object; however, they remain underdetermined when the concrete infrastructural mediations of these transformational processes are treated merely as an external context. Between these two perspectives, the concept of literacies opens up a mediating frame of reference that is by no means free of tension, because it makes it possible to address skill, social practice, cultural coding, materiality, and power in their situational interweaving (Campbell & Olteanu, 2024; Markauskaite *et al.*, 2023; Pangrazio & Sefton-Green, 2021).

Further urgency is added to this reassessment by the current convergence of datafication, platformization, and generative artificial intelligence. Learning platforms not only record interactions but also shape their visibility; algorithmic recommendation systems direct attention; generative models prefigure linguistic plausibilities; automated decision-making systems translate heterogeneous educational trajectories into institutionally manageable risk profiles. However, the associated change is by no means limited to an expansion of available tools. Rather, it touches on the question of under which infrastructural, epistemic, and normative conditions references to the world emerge at all as relevant to learning, measurement, or decision-making. Within higher education, the significance of platform rules and data models becomes apparent when examining how student activity acquires the status of institutionally recognizable evidence. What can be recorded through a platform already depends on decisions about which activities warrant observation and how they are to be represented; subsequent evaluation therefore proceeds from a technically selective account of educational practice. Once universities rely on platform-generated representations to assess student activity, the selection decisions embedded in those representations acquire significance beyond the systems in which they originated. Deductively, what the platform renders observable can thereby become a basis for judgments about competence per se, while forms of participation that escape its categories risk remaining institutionally unacknowledged (Hartong, 2024; Nichols & Dixon-Román, 2024; Pangrazio *et al.*, 2022; Zomer, 2026).

In this context, a definition of postdigital literacies is inadequate if it simply incorporates new sub-competencies, such as data, algorithm, AI, information, or platform literacy, into existing catalogs. While such additive extensions may increase visibility within the curriculum, they easily reproduce the very segmentation that the postdigital analysis seeks to address. Data

criticism without an understanding of material and institutional infrastructures, AI literacy without reflection on its cultural systems of representation, media criticism without equitable access and participation, or design competence without insight into distributed agency remain factually fragmented. In contrast, what appears necessary is a conceptual framework that does not focus on individual technologies but rather centers on the ability to establish well-founded relationships within socio-technically prefigured relations to the world.

Accordingly, the present study examines how postdigital literacies can be conceptualized as a relational configuration of education, power, and participation in higher education, while preserving the distinct theoretical meanings of competence, education, and literacy, and what implications this conceptualization entails for the theoretical interpretation, empirical investigation, and pedagogical Gestaltung of sociotechnically mediated educational practices.

Four sub-questions will be addressed: First, it must be clarified which onto-epistemological shifts are associated with the postdigital departure from instrumentalist human-technology dualisms. Second, the relationship between competence, education, and literacies requires a definition that identifies overlaps without leveling conceptual non-identities. Third, we must examine the extent to which platformization, datafication, algorithmic mediation, and unequal conditions of access prestructure the possibility of literate practice. Fourth, criteria for research and media education design are to be derived from the reconstructed areas of tension.

As a scholarly contribution, this paper develops a relational heuristic of postdigital literacy. Operational connectivity, infrastructural transparency, the capacity for reflexive distancing, distributed agency, and transformative participation are conceived not as linear stages to be acquired but as interdependent dimensions of a situational and context-specific practice of judgment. What is new here is not so much the isolated identification of individual abilities as their systematic linking to the conditions that make them possible: Postdigital literacy manifests itself not only in the fact that subjects act successfully within technical environments but also in their ability to recognize the constitutive role of these environments, to reasonably challenge their claims to validity, to devise alternative frameworks of relation, and to politically assess the unequal distribution of corresponding opportunities for action.

LITERATURE REVIEW

Postdigitality as a Relational Diagnosis of the Present

From a historical-conceptual perspective, postdigitality challenges the view that technological innovations alter social reality from the outside and that educational practice must subsequently respond to this change. In place of such a model of succession comes a relational understanding, within which technological, social,

cultural, bodily, and ecological conditions operate in an interdependent and mutually constitutive manner through ongoing configurations. Determinatively, Jandrić and Knox (2022) identify the postdigital turn as a postdeterministic and postinstrumentalist reorientation of philosophy, education, and research, within which technological developments must be understood in terms of their social interconnections. As regards the pedagogical constitution of subject matter, this perspective is concretized in Fawns' (2022) work insofar as goals, values, methods, technologies, and contexts are examined in terms of their mutual interdependence, and the significance of individual design elements can therefore only be determined within the context of the respective educational arrangement. However, this perspective is followed by studies of post-digital learning spaces, which explore spatial quality as the result of material, practical, and institutional relationships (Gravett *et al.*, 2023; Lamb *et al.*, 2022): For the tertiary education setting, the question is therefore how physical arrangements, digital access conditions, data flows, and institutional expectations interplay and thereby help determine which forms of presence, exchange, and participation can actually be realized within a learning space.

Movement, change, and becoming, therefore, do not denote an external state of acceleration but rather a structural moment in the constitution of objects. Learners, teachers, and media do not interact as pre-established units; they acquire their respective concrete capacity for action within relational frameworks that change as they unfold. Therefore, this deduced phenomenon becomes particularly evident in the analysis of post-digital classrooms: the promises of a better future held by technical, here normative, and processual innovation become embedded in spatial arrangements, routines, and structures of expectation, while earlier practices persist and intended uses are reinterpreted depending on the situation (Forsler *et al.*, 2025; Giakoumakis *et al.*, 2025; Wilson *et al.*, 2025). In this regard, pedagogical reality thus appears to be neither technically determined nor arbitrarily socially constructible, but rather a contingent stabilization of heterogeneous relations.

From an analytical perspective, this leads to two clarifications. First, the dissolution of simple dualisms must not be confused with an indiscriminate merging of their poles. Digital and non-digital, human and technology, or materiality and meaning remain relevant as analytical distinctions when examining how their boundaries are established and take effect in concrete practices. Second, talk of interweaving has explanatory value only if it identifies the mechanisms through which relations are structured, rendered asymmetrical, or disrupted. Postdigitality, therefore, does not denote a harmonious interconnectedness but rather encompasses friction, exclusion, and conflict-laden interdependence. Here, Pischetola *et al.* (2021) indicate it is precisely breakdowns, barriers to access, and disruptive media shifts that reveal

the technical agency that remains invisible during smooth operation.

Building on the relational nature of pedagogical practice as previously explained, sociomaterialist and posthumanist works sharpen the question of how the capacity for action is constituted, insofar as sovereign human intentionality appears insufficient as the sole explanatory basis for the act of action. With the "circuit of agency," Hawley (2022) accordingly describes a relational circulation among individuals, things, discourses, and institutional arrangements, within which possibilities for action are brought about only through the interplay of heterogeneous participations; however, such a distribution of agency by no means implies a uniform distribution or even the abolition of human responsibility.

In the same way, it can be deduced that it is only through the inclusion of physical, cognitive, conative, and affective reciprocities, including nonhuman ones, that new materialist approaches currently advance a thesis that goes beyond a mere expansion of the field of learning research. This means that materials help determine the possibilities of perception, specifically regarding the interplay of representation, perception, reception, and expression; therefore, the respective taxonomy of learning processes must be examined to assess how their nature and arrangement influence the course of these processes (Lemieux & Rowsell, 2020; Sheridan *et al.*, 2020). In this context, the inconsistency of empirical operationalizations discussed by De la Calle Cabrera *et al.* (2024) regarding the empirical operationalization of post-humanist literacy research takes on particular significance; that is, with regard to the theoretical assumption of mutual constitution, the observations and criteria themselves, which can be used to reconstruct the interplay of subjects, practices, and materialities, have not yet been clarified. Furthermore, in the author's view, the methodology should also demonstrate how such a relationship can be identified in the research data in the first place and which results would, in fact, necessitate a revision of its theoretical definition. Otherwise, there is a real risk that the empirical-exploratory analysis will merely confirm the previously assumed conceptual relationships.

Movement, Spatiotemporality, and the Indeterminacy of Postdigital Mappings

Within postdigitality research, the recurring motif of movement refers to more than just the rapid pace of technological innovation cycles. Specifically, it denotes a transformation of the very relations through which presence, duration, reach, authorship, and context can be defined in the first place. Asynchronous communication can make institutional temporal orders more flexible while simultaneously giving rise to expectations of permanent accessibility; hybrid spaces can reduce spatial exclusion while simultaneously creating new dependencies on devices, bandwidth, and private learning environments. In this respect, postdigital spatiotemporality denotes neither the dissolution of boundaries per se nor the

simple superimposition of physical and virtual spaces. Based on this relational understanding, the exploratory research approach focuses on the question of under what sociotechnical conditions closeness and distance are produced and how the boundary between private discretion and public accessibility is negotiated on a situational basis. In addition to the work of Lacković *et al.* (2024) and Lamb *et al.* (2022), it is essential here to examine the temporal nature of participatory relationships per se, as their simultaneity or temporal displacement is influenced by media arrangements and institutional expectations; furthermore, the ongoing availability of contributions helps determine how they can be adopted and recontextualized beyond their original context.

From the perspective of media pedagogy, this processual nature is significant in two ways. On the one hand, the conditions of digital literacy practice are already changing as students are learning them. Therefore, curricula that treat current platform functions as a stable subject of competence risk producing a superficial competence that quickly becomes obsolete. On the other hand, change arises not exclusively from new technical functions but equally from the reconfiguration of existing routines. Through walking interviews, Wilson *et al.* (2025) explore in this respect the relationship between visions for the future of education, as well as traditional teaching practices, and the physical conditions of information-technologically equipped university spaces. Of particular interest here are the tensions that arise between institutionally designed uses and actual teaching practices, as these tensions reveal the conditions under which calls for pedagogical change are adopted, modified, or limited in everyday university life. In this regard, the transformation of higher education learning spaces can be understood as a process of negotiation, the course of which is shaped by existing practices and infrastructural conditions and therefore resists the seamless transfer of institutional visions of innovation into teaching practice. In this respect, post-digital literacy must therefore be directed less toward definitive mastery and more toward the reasoned ability to revise patterns of action and interpretation.

In this context, it is important to note that, given this backdrop, mappings of postdigital literacies have a performative character. For when research classifies certain practices as literacy, identifies others as mere use, and yet others as deficits, it does not merely categorize an existing field. Rather, it stabilizes representational, perceptual, and perceptive relevancies, addresses subjects, and contributes to the institutionalization of desired future competencies. Accordingly, every typology must reflect on its own modeling process: Which forms of engagement with the world are recognized as competent? Which social groups are primarily identified as the target audience for support? Which infrastructural conditions are reinterpreted as individual prerequisites? Which practices of renunciation, deceleration, or contradiction remain invisible because competence is operationalized exclusively through active and efficient use?

In this respect, it can be deduced that the programmatic openness of the post-digital does not, in and of itself, automatically protect against new universalisms. Messiness can denote a methodologically productive acknowledgment of irreducible heterogeneity, but it can also lead to conceptual immunization, insofar as contradictory phenomena are grouped under the same label without any criteria. A two-pronged approach therefore remains necessary: on the one hand, binary orders must be disrupted and neglected relationships made visible; on the other hand, the claimed connections must be examined in terms of their direction, empirical validity, and normative consequences. Postdigital mapping is thus open-ended but purposeful.

Competence, Education, and Literacies as Non-Identical Concepts

In current research discourse, the concept of literacy can be differentiated along at least three semantic fields, each of which, through its respective emphasis, reveals different prerequisites for appropriate action, cultural participation, and education-related transformation. While functional conceptions emphasize the availability of media-related and informational skills, socio-practical approaches situate literacy within culturally embedded, meaning-generating practices; transformative models, by contrast, incorporate the malleability of relationships to the self, knowledge, and the world into their conceptual framework.

Under postdigital premises, these approaches are not rendered irrelevant or superseded by a broader concept of literacy but are instead redefined in terms of their mutual interdependence: Operational mastery remains necessary but cannot, on its own, justify a sufficient educational claim, because proper use guarantees neither reflection on its prerequisites nor the ability to judge its purposes. In this respect, sociocultural situatedness must also be expanded to include those material, infrastructural, and algorithmic conditions of mediation through which meaning, visibility, and possibilities for action are pre-structured. Consequently, transformative literacy is not limited to individual changes in consciousness but also concerns the empowerment and the actual opportunities that are opened up to participate in the negotiation and transformation of precisely these sociotechnical conditions. Following on from this are trends that redefine critical thinking within non-instrumentalized digital socialities and develop post-digital alternatives to neoliberal educational logics (Bacalja, 2026; Kerruish, 2026).

To conceptually define postdigital literacy practices, one can draw on a framework in which entanglement, digital materiality, and spatiotemporality form interrelated approaches to the respective phenomena; the value of this framework lies in its ability to elucidate the practices under investigation based on their concrete conditions of emergence and execution (Lacković *et al.*, 2024). From the perspective of entanglement, the question is accordingly

how media mediation and physical performance intertwine within a given situation, while the consideration of digital materiality incorporates the technical and infrastructural prerequisites through which this interaction takes on its specific form (Lacković *et al.*, 2024). Linked to this framework is a spatiotemporal analysis that makes it possible to understand how presence and participation are organized beyond the immediately shared space and how media expressions remain available beyond their original context of creation (Lacković *et al.*, 2024).

Linked to this definition of the subject matter is the conceptual expansion of multimodal literacy, insofar as its text-centered and structuralist limitations are transcended in favor of a relational perspective on the production of meaning (Campbell & Olteanu, 2024). For pedagogical classification, however, it remains crucial to consider under which institutional conditions technically available means of expression may actually be utilized: School-based writing demonstrates that assignment requirements and assessment expectations can continue to limit the scope within which a form of expression is considered academically appropriate and worthy of recognition (Hawley, 2024). In this respect, the technological expansion of what can be represented does not in and of itself lead to pedagogical openness as long as the standards for its recognition in the classroom remain unchanged (Hawley, 2024).

Based on the distinction previously identified between technologically available means of expression and institutionally recognized forms of implementation, the relationship between competence, education, and literacies must also be defined in terms of their material, social, and normative conditions of mediation. In this respect, competence refers to a situation-specific disposition toward handling demands in a manner that is professionally, socially, and normatively appropriate, whereby the standards of such appropriateness themselves remain subject to justification rather than being legitimized solely by institutional validity. From the perspective of consensus theory, the focus is thus on the conditions under which demands and evaluation standards can be intersubjectively examined, contested, and negotiated; mere factual agreement does not in itself guarantee reasoned consent. The limits of competency definitions that can be operationalized in curricula are precisely here: Observable performance does not allow for the derivation of sovereign control over one's own actions or the justification of attributing infrastructure- or institution-generated constraints to individual deficits. In contrast, education emphasizes the reflexive transformation of those relationships to the self, the world, and technology, within which even predefined requirements and systems of recognition themselves become the subject of well-founded revision, without the outcomes of such educational movements being fully predictable or capable of being captured in standardized terms. From a practice-theoretical literacy perspective, both concepts are therefore not synthetically subsumed

but rather related to those concrete practices in which dispositions of competence, orders of meaning, and material arrangements interlock and educational processes are either initiated or constrained. The tension between these concepts remains productive because operational empowerment can enhance the practical effectiveness of reflexive scrutiny, while educational-theoretical openness prevents it from being reduced to mere adaptation to the system, and literacies expose the situational conditions of this reciprocal mediation.

Following on from the previously developed distinction between the fulfillment of operational requirements and the reflexive reexamination of their conditions, the discussion of professional digital competence builds upon this in that, here as well, the individual possession of technical skills is reevaluated in favor of a relational definition of possibilities for action and design. With their proposal of postdigital capabilities, Markauskaite *et al.* (2023) incorporate in this regard the sustainable shaping of human, technical, and natural contexts into the discourse on competence, thereby expanding its frame of reference beyond isolated, attributable user performance. Similarly, the concept of entangled learner agency developed by Code (2025) opens up an approach within which individual self-regulation can only be adequately defined by considering its spatial, collective, and shared prerequisites. Ball and Savin-Baden (2022) illustrate the educational-theoretical consequences of their framework using the example of liminal transitions: Here, irritation appears not merely as a disruption to an otherwise successful learning process but as a potential opportunity to question familiar interpretations and expectations of behavior. Taken together, these perspectives, as well as the pandemic-related redefinition of technological and pedagogical relationships in Rapanta *et al.* (2021), suggest that smooth performance should not be regarded as the sole educational standard, as successful use remains possible even within unreflectively adopted dependencies. Accordingly, it is not every interruption in and of itself that gains educational relevance, but rather its reflective processing, insofar as it contributes to enduring uncertainty, uncovering constitutive dependencies, and subjecting the validity of pre-structured courses of action to reasoned scrutiny and possible change.

Datafication, Platformization, and Algorithmic Orders of Plausibility

Under platformized educational conditions, practices are not merely digitally supported but are translated into technically and economically exploitable data relationships. Selection decisions regarding which interactions are recorded, which categories are formed, and which results are visualized shape the perceptibility of pedagogical processes. At this point, drawing on Pangrazio *et al.* (2022), the connection between datafication and platformization can be plausibly inferred from the fact that the infrastructure used already helps determine what aspects of educational activity can

be captured as data in the first place. In this respect, the study starts by outlining the prerequisites for data collection, as the technical conversion entails a selection process that makes certain processes accessible to institutional observation while excluding others from being represented in data form. There is a need to justify the selection decisions inherent in this conversion, insofar as they help determine which aspects of educational practice emerge as relevant for observation and which elude infrastructure-driven data collection. With regard to student engagement, this issue can be concretized in that recorded activity is only interpreted as participation on the basis of specific classification rules, and the resulting indicator consequently reflects a specific institutional conception of engagement (Zomer, 2026).

Precisely because such classifications become part of the infrastructural organization of everyday university life, their significance extends beyond the individual measurement operation: Through their mediation by actors and standards, the conditions under which educational processes are managed also change (Hartong, 2024). Therefore, against this backdrop, the power-political classification of platform governance takes on particular significance, insofar as decisions are also made within emerging EdTech ecosystems regarding whose conceptions of pedagogical practice are incorporated into the design of the infrastructures employed (Nichols & Dixon-Román, 2024).

For the definition of postdigital literacy, this implies the need to examine data in relation to the conditions under which social phenomena are considered quantifiable in the first place. Accordingly, the appropriate scholarly handling of data requires the ability to understand the decisions that lead to certain facts being assigned to a category, while others remain outside the chosen framework. It is precisely at this point that the limitations of a conception of competence that treats mastery of analytical methods as sufficient evidence of data-related judgment become apparent; research reviews point to corresponding narrowings of focus as well as inconsistent definitions and, to date, limited empirical validation of pedagogical approaches (Gebre, 2022; Ghodoosi *et al.*, 2023; Raffaghelli & Stewart, 2020).

From the perspective of critical data literacy, it therefore becomes necessary to justify whose perspective on a subject becomes decisive in its data-based representation and what consequences such a perspective has for those about whom decisions are made on this basis. In this regard, data-based judgment acquires a social dimension that transcends accurate evaluation, challenging the legitimacy of the representational and decision-making frameworks employed (Atenas *et al.*, 2023; Pangrazio & Selwyn, 2021; Sander, 2020).

Hereupon, the connection between constructionist and participatory approaches can be justified by the fact that learners are involved in the creation of those data representations whose underlying assumptions they are critically expected to evaluate. By developing their own

representations and comparing them with alternative models of the same subject, the concrete design process makes it clear how a changed classification decision shifts the visibility of what is represented and thus also influences its possible interpretation (Bilstrup *et al.*, 2022; Dangol & Dasgupta, 2023). From an educational perspective, what is significant here is the experience that data-based orders are based on decisions that require justification and that their malleability can be revealed through students' own active participation in their design (Bilstrup *et al.*, 2022; Dangol & Dasgupta, 2023). Such a practice requires, beyond technical data operations, the ability to address what has not been captured, what has not been made comparable, and what is normatively presupposed. In this respect, postdigital data literacy does not refer to the confident mastery of a transparent object but rather to a reasoned practice of judgment under conditions of partial opacity.

However, the issue discussed here becomes significantly more pronounced with algorithmic and generative systems. Considering the insufficient attention paid to algorithmic competence in existing frameworks per se, as described by Moylan and Code (2024), the author believes that, for professional digital education, particularly in the context of higher education, it remains to be clarified how its professionally recognized importance can actually be translated into well-founded curricular requirements. Further, defining such a theory-to-practice transfer is complicated by the scope of available research, as school-based studies have so far focused primarily on older learners under comparatively favorable resource conditions. It is becoming increasingly clear why further empirical research is needed to plausibly determine the feasibility of teaching concepts that are primarily based on the required learning taxonomies in higher education. Moreover, their application in this context is understood here as a theoretically grounded transfer rather than as a conclusion already substantiated by the school-based research examined by Magoge *et al.* (2025).

To determine AI literacy in a way that is tailored to the respective learning prerequisites, it must first be established or made explicit to what extent learners must understand the systems being used to independently evaluate their application within their own educational context. With regard to this issue, the decisive factor is what system knowledge is required to assess the specific pedagogical task and on what a judgment regarding the appropriateness of AI use can be based. Competency models offer a starting point, as they combine the evaluation of specific applications with the goal of preserving human autonomy in dealing with AI (Allen & Kendeou, 2024; Chee *et al.*, 2025). However, merely taking this requirement into account conceptually does not explain how it can be realized in the learning process, for between understanding a technical mechanism and making a well-reasoned decision about its pedagogical use lies an evaluative process whose prerequisites must be specifically identified.

In this regard, a further didactic question arises: how can acquired model-based knowledge be effectively applied to evaluate a specific use case without technical feasibility alone serving as justification for its deployment? The differences between technical knowledge and critical evaluation described in research reviews therefore point to a need for investigation into the conditions under which well-founded judgment is formed: It remains to be clarified how learners draw on their understanding of the system to determine the limits of a technically justifiable use of AI (Biagini, 2025; Ng *et al.*, 2024; Sperling *et al.*, 2024; Yim, 2024).

Based on the deductively derived distinction between determinants, indicators, and evaluation criteria, AI literacy can be defined within the postdigital framework as an exemplary distillation of the problem of relationality, the scientific exploration of which requires a systematic linking of observable actions to their constitutive conditions and normative evaluation standards. In this context, determinants to be considered include platform interests, the composition of training data, ecological resource dependencies, linguistic-cultural orders of representation, and institutional authorization practices, insofar as they structure the prerequisites for AI-mediated knowledge production and possibilities for action. Excerpts of this context become indicatively accessible, for example, in the well-founded design of prompts, the context-based examination of model outputs, and the explication of their conditions of origin and limits of scope; however, whether such practices can be considered an expression of critical literacy is measured only against established criteria of epistemic traceability, reflective judgment, and responsible design.

Accordingly, operational safety in and of itself does not guarantee a reflective understanding of the conditions under which system-generated statements acquire plausibility and institutional validity. In line with the distinction between system understanding and judgment competence outlined above, a concept of critical GenAI literacy holds that its requirements can only be determined based on the specific contexts of use and its socio-technological conditions (Rapanta *et al.*, 2025). For instructional design, this makes joint critical exploration by teachers and learners significant, because concrete applications allow one to understand the basis for judging the appropriateness of AI use and the conditions under which it requires revision (Dilek *et al.*, 2025; Walter, 2024). Therefore, and from a pedagogical perspective, it would be crucial for learners to be able to critically evaluate the approach they initially chose in light of recognizable model limitations, rather than assuming they have sufficiently mastered the prerequisites simply because an application was successful.

Criticism Between Immanent Examination and Transformative Transcendence

Starting from the deductive distinction between determinants, indicators, and evaluation criteria, the

conceptual heterogeneity of critical literacy must be traced back to the polycontextual conditions under which knowledge is produced and can claim validity. Which requirements become decisive in this context also depends on how culturally shaped interpretations take effect within institutional frameworks and how these relate to economic interests and technical prerequisites. To identify the determinants, it is therefore not sufficient merely to demonstrate the co-occurrence of such conditions; rather, it must be theoretically justified how each condition under consideration contributes to making certain forms of knowledge visible and eligible for recognition. Their interconnection alone does not allow one to infer either a uniform effect or a consistent weight within the context under examination. Under this premise, three analytically distinguishable dimensions of criticism can be related: the context-specific examination of the reliability of information, data, and technical outputs; the reconstruction of embedded power relations and cultural assumptions of normality; and the reasoned collective transformation of existing public spheres and infrastructures. Their postdigital intertwining stems from the fact that the objective assessment of a statement takes place under conditions that already pre-structure its accessibility and visibility, while the critique of these conditions, in turn, requires verifiable justifications. In this respect, source criticism without platform analysis remains inadequate in light of the conditions governing the selection of available knowledge; conversely, criticism of power without expert scrutiny risks blurring the distinction between well-founded doubt and generalized mistrust. Factually, then, transformative practice derives its normative claim to validity only through the context-specific justification of its goals and the reflective examination of its consequences; thus, the will to change alone does not constitute sufficient justification for the desired order.

Conceptually, it is therefore beneficial to distinguish between immanent and transcendent criticism. Immanent criticism evaluates a system against its standards: Does a platform that claims to be inclusive actually meet accessibility requirements? Does a data-driven recommendation comply with documented validity and fairness criteria? Are the promised choices effectively made available in the interface? Transcendent criticism, by contrast, questions the legitimacy of the established purposes and categories themselves. Rather, the question is whether learning activities should, in substance, be subject to continuous, i.e., iterative, interim measurement. Subsequently, we must ask to what extent algorithmic personalization can address structurally rooted educational inequality or whether it shifts the burden of addressing this inequality onto individual efforts to adapt, whereby the resulting changes in pedagogical relationships also require critical scrutiny.

Within this factual framework, however, postdigital distancing requires both approaches. As long as the investigation is limited to the operating conditions of

existing systems, any improvement to those systems remains bound by the very premises whose validity would first need to be debated. Conversely, a critique that points beyond this order requires a reconstruction of its concrete mode of operation if it is to justify where change can begin. Combined, these two approaches therefore hold promise for gaining new insights, insofar as the empirical investigation of technical interrelationships also subjects the normative standards of the critique to scrutiny and, at the same time, leaves open the question of whether a functionally improved system is pedagogically justified at all. Critical data literacy makes a significant contribution to academic productivity, provided that learners identify flawed visualizations and reconstruct the social genesis of categories, data gaps, and benchmarks (Atenas *et al.*, 2023; Sander, 2020). The same principle applies to probabilistic models, whose results are neither fully transparent nor independent of human acts of selection and authorization.

Critical literacy's self-reflexive turn follows on from the polycontextual conditionality previously explained, in that educational and scholarly actors participate in the very same platform and data structures whose selection mechanisms and conditions of validity they are examining. This constitutive embeddedness implies that the previously identified determinants must not be treated exclusively as conditions of the object under investigation but must also be reflected upon in terms of their significance for the constitution of the object itself, the selection of evidence, and the formation of judgment. In the absence of a completely unconditional epistemic vantage point from the outside, the validity of criticism is therefore also measured by the extent to which it subjects its material dependencies, institutional ties, and categorical presuppositions to a transparent examination. By no means does this self-reflexivity imply a renunciation of justifiable claims to validity in favor of mere plurality of perspectives; rather, it requires that the conditions of one's own cognition be disclosed and that their potential limiting effects be incorporated into the justification.

In contrast to a perspective that focuses solely on competent media consumption, postdigital education broadens the scope of judgmental practice to include the conditions under which one's own insights are generated, recognized as plausible, and translated into educational or scientific decisions.

Participation, Accessibility, and Digital Well-Being as Constitutive Conditions

For the normative assessment of a media literacy concept, the first crucial factor is whether it distinguishes between the provision of a technical offering and the actual prerequisites for its use. Substantive participation requires that an offering can actually be used under the respective living and learning conditions; in this context, accessibility for persons with disabilities constitutes a distinct requirement within the broader conditions of

effective digital access. Even when technical equipment is available, for example, it remains necessary to examine whether the design is suited to individuals' abilities to perceive and act and whether the necessary institutional support is guaranteed.

Findings on the continuing influence of educational level and social status on digital usage opportunities illustrate the significance of this distinction, noting that the pandemic-driven expansion of digital educational offerings has, in some cases, institutionally entrenched existing inequalities (Kaarakainen & Saikkonen, 2023; Timmis & Valladares-Celis, 2026). In this respect, the inclusive nature of an educational infrastructure is measured by the extent to which its design takes into account the prerequisites on which effective use actually depends. Thus, the potential for participation in personalized or location-independent educational offerings remains tied to an inclusive institutional framework, as access to these offerings continues to require prerequisites that are unevenly distributed across society. Nevertheless, if these prerequisites are treated in this context as propaedeutic, that is, assumed to be already in place rather than being institutionally supported, it is precisely the learners with disadvantages, whom digitalization is intended to help, who are least able to take full advantage of the new opportunities (Gottschalk & Weise, 2023).

With the concept of access conditionality, the difference between formally available access and substantive participation can be traced back to those institutional and sociotechnical prerequisites that an educational program requires its intended participants to meet. The program's design assumes certain usage possibilities, making access contingent on whether learners can independently meet these requirements or have access to appropriate support. Inequality thus also concerns the fit between individual prerequisites and the institutionally prescribed forms of use.

For the deductive determination of the determinants, it must therefore be established to what extent accessibility guarantees access to the respective program and under what conditions its usability supports self-directed engagement with the educational task. Within this context, human-centered design derives its methodological significance from the fact that it takes actual usage requirements as the starting point for development and ensures that these requirements are verifiably addressed in the specific context of use. In this respect, platform-based higher education infrastructures do not merely distribute functions but simultaneously structure dependencies, visibility, and alternative options; therefore, their educational legitimacy must also be measured by the conditions under which different groups of people can actually participate in them (Vindigni, 2024, 2026a, 2026b).

From a legal perspective, a distinction must be made between the European Accessibility Act and its German implementation through the Act to Strengthen Accessibility for the respective products and services

covered, as well as the digital accessibility regulations applicable to public bodies, which include the BGG and BITV 2.0 at the federal level and, in the context of higher education, the applicable state regulations (§ 12a Abs. 1 BGG; § 3 Abs. 1 BITV 2.0; § 1 Abs. 2 BFSG). The technical references to be used are EN 301 549 and the Web Content Accessibility Guidelines, including the updates provided by WCAG 2.2, taking into account their respective version status and legal integration (Directive (EU) 2019/882 of the European Parliament and of the Council, 2019; European Telecommunications Standards Institute, 2021; W3C Web Accessibility Initiative, 2026; World Wide Web Consortium, 2023). In addition, DIN EN ISO 9241-11 addresses usability in the specified context of use, DIN EN ISO 9241-110 addresses interaction principles, and DIN EN ISO 9241-210 addresses human-centered design of interactive systems (Deutsches Institut für Normung, 2011, 2018, 2020a, 2020b, 2022a, 2022b). Together, these reference points provide a foundation for incorporating accessibility, task-appropriate interaction, and consideration of heterogeneous usage conditions into the design and evaluation of digital educational arrangements from the outset (Vindigni, 2026c).

For instructional design, this gives rise to the requirement to reduce avoidable interaction-related complexity without simplifying the subject-matter complexity of the learning content. If the design-related prerequisites for use are not taken into account, there is a risk of misattribution, whereby difficulties caused in part by the infrastructure are mistaken for a lack of competence on the part of the learners. These individualization effects have far-reaching consequences in situations where successfully completing tasks requires technical equipment or paid access that not all target users have in equal measure. Furthermore, to the extent that the AI systems used favor certain linguistic and cultural forms of expression, existing barriers to access can persist within the context of usage because the expressions of those affected are represented only to a limited extent. To investigate AI-induced inequality, it is therefore necessary to reconstruct the conditions under which such selection effects interact and coalesce into a form of disadvantage whose infrastructural co-causation would remain unrecognized in an assessment of competence based exclusively on individual characteristics (Vindigni, 2025a, 2025b).

Beyond the mere distribution of resources, access conditions also affect the epistemic status of different experiences. Those who can use a platform only with increased cognitive, linguistic, or financial effort do not enter the educational process under the same conditions as those whose needs are already anticipated in terms of interface, language, and standard procedures. If the resulting disparities are subsequently measured as individual performance differences, infrastructure-induced disadvantage is transformed into evidence that appears to be person-specific. Postdigital literacy research must therefore not only determine whether access exists but also with what effort, under what disclosure

requirements, with what alternatives, and at what level of quality it can be realized.

Here, linguistic and cultural representation are of particular relevance. Data and AI systems operate on the basis of historically established corpora, categories, and evaluation frameworks. Underrepresentation, therefore, is not evident only in overtly discriminatory outputs but is already apparent in which bodies of knowledge are more readily accessible, which forms of expression are considered close to the standard, and which life situations are deemed statistically sufficiently visible. In this regard, methodological bias and epistemic injustice converge where marginalized voices are once again filtered through an infrastructure whose underlying framework represents them only to a limited extent. Critical literacy must therefore address not only error detection but also the question of whose experiential knowledge is recognized as suitable for modeling, measurement, and decision-making.

Consequently, from a normative perspective, this analysis leads to an expanded concept of substantive participation. Participation is not automatically guaranteed simply because a person is permitted to use a system. In consequence, this first gives rise to the requirement that terms of use be presented in a comprehensible manner and that support be made accessible in such a way that a formally offered choice can actually be exercised. Substantive freedom of choice requires that the use of a service be neither tied to the disproportionate disclosure of personal data nor effectively compelled by a lack of alternative procedures. At the same time, institutional safeguards must ensure that affected individuals can challenge burdensome decisions through accessible complaint channels and have them subject to effective review. Under these conditions, post-digital literacies do not compensate for deficient infrastructures. While they empower individuals to manage dependencies, they do not relieve institutions of their obligation to provide fair and verifiable conditions.

Following on from the previously explained intertwining of accessibility, usability, and institutionally guaranteed opportunities for participation, the question of digital well-being arises insofar as the quality of post-digital educational spaces must also be assessed based on the conditions under which their use supports a sense of belonging, self-determination, and controllable forms of social visibility. There is an ambivalence in the intersection of learning-related technologies and institutional expectations for their use that cannot be fully understood by considering the gains in temporal and spatial flexibility alone: What enables learners to shape their daily educational lives more autonomously and can support their identity development may, at the same time, become a burden under the expectation of constant availability. Here, the decisive factor is the extent to which the technical design allows those affected to regulate their visibility and to temporarily disengage from digital communication (Lister *et al.*, 2024; Roffarello & De

Russis, 2023).

For the deductive identification of determinants, it follows that well-being must already be related to the conditions under which technology is used. It thus becomes necessary to determine the extent to which institutional expectations and technical default settings contribute to the emergence of stress and to what extent learners can actually influence their impact. Only such an analysis allows us to identify limited scope for action as a possible contributing factor, rather than hastily attributing its consequences to insufficient individual adaptation.

For students in vulnerable life and academic situations, this problem is exacerbated when data-driven categorizations intersect with pre-existing institutional disadvantages and thereby influence the type of support offered to them or required of them. Interventions justified on the grounds of welfare can take on a paternalistic character if those affected cannot understand the classifications applied to them and lack effective opportunities to challenge them. To protect students' well-being, therefore, it is also necessary to consider the extent to which students retain influence over the use of their data and the measures derived from it (Prinsloo *et al.*, 2024).

Using the example of inclusive video conferences, this connection can be applied to the concrete design of pedagogical participation. Being technically connected does not in itself constitute adequate participation if the intended form of interaction does not meet individual usage requirements or requires the disclosure of personal circumstances over which those affected have little control. Here, accessibility derives educational significance from a design that opens up access to collaborative learning while simultaneously preserving individuals' control over their visibility (Heiser *et al.*, 2025).

Therefore, post-digital literacy encompasses not only the reflective examination of technical conditions but also their careful assessment and informed co-creation, whereby individual judgmental competence only gains practical effectiveness through institutionally guaranteed options for choice, objection, and withdrawal. This includes the ability to reject, modify, or supplement forms of use with suitable analog alternatives without incurring unreasonable disadvantages in participation.

MATERIALS AND METHODS

Research Design and Search Strategy

Methodologically, the study is based on a critical-integrative synthesis of evidence, the objective of which is not to aggregate the effects of a homogeneous class of interventions but rather to establish theory-guided connections among heterogeneous conceptual, empirical, and methodological contributions. These included peer-reviewed journal articles, systematic or scoping reviews, and empirical case and intervention studies, as well as research-based conceptual works, provided they substantively addressed at least one of the following subject areas: post-digitality and education, post-digital or critical literacies, sociomaterial or posthumanist agency,

platformization and datafication, data, algorithm, or AI literacy, digital participation, accessibility, or digital well-being. Time-wise, the primary publication period was limited to January 2020 through August 2026 to reflect the shifts that have occurred since the pandemic-driven consolidation of infrastructure and the widespread diffusion of generative AI.

Between August 1 and 31, 2026, the literature search for the critical-integrative synthesis comprised 30 author-reported semantically supported search events, which were organized into eight thematic research clusters to facilitate a structured exploration of the field of study. Supplementary Material S1 documents the recoverable search environment, 16 preserved query strings, their reconstructed assignment to the thematic clusters, and the retained candidate records. It explicitly distinguishes these recoverable elements from aspects of the historical search process that could not be fully reconstructed, including per-query dates, native filter settings, original result ranks, and precise selection cutoffs.

The preserved query strings linked the subject terms "postdigital education," "postdigital literacy," "sociomateriality," "posthumanism," "platformization," "datafication," "critical data literacy," "algorithm literacy," "AI literacy," "digital equity," "accessibility," "digital citizenship," and "digital wellbeing" with contextual terms from education and media pedagogy and contained the literal expression "year:2020-2026." The presence of this expression in the preserved query strings is documented in Supplementary Material S1; however, its successful enforcement as a platform-specific filter cannot be reconstructed retrospectively.

As a methodological point of reference for the supplementary bibliometric analysis, we draw on the study by Lyu *et al.* (2026), which focuses the analysis of scientific publication corpora, among other things, on their thematic structuring based on keywords.

In this paper, this reference is concretized in an independently specified, exploratory analysis of title word co-occurrence, based on the titles of the 75 external core publications (see Figure 1). The analysis captures the document frequency of individual words and their co-occurrence within the same publication title, with each word counted at most once per publication and the graphical representation limited to words with at least four document occurrences. Further, no stemming or synonym merging was applied. Publications by the author and other references used exclusively for contextual or methodological purposes were excluded from this analysis. The analysis fulfills its methodological function as a descriptive supplement to the critical-integrative synthesis of evidence by transparently identifying lexical condensations within the corpus whose subject-specific meaning can only be determined through interpretive analysis of the content (see Figure 2).

To descriptively analyze the conceptual interconnections within the corpus, the title-word co-occurrence matrix was processed in Python using NumPy and visualized

as a network with Matplotlib. Its spatial arrangement is based on a deterministic, force-directed layout algorithm and serves to clearly illustrate the identified connections. The font size and color indicate how many publication titles contain the respective word; the line thickness, on the other hand, indicates the number of titles in which the connected words appear together.

Both figures (see Figures 1 and 2) are based on the same title-word co-occurrence matrix and therefore provide complementary representations of a single descriptive analysis.

Their contribution lies in making lexical relationships within the corpus visible; neither representation, on its own, confirms the theoretical relationships proposed in the analytical heuristics.

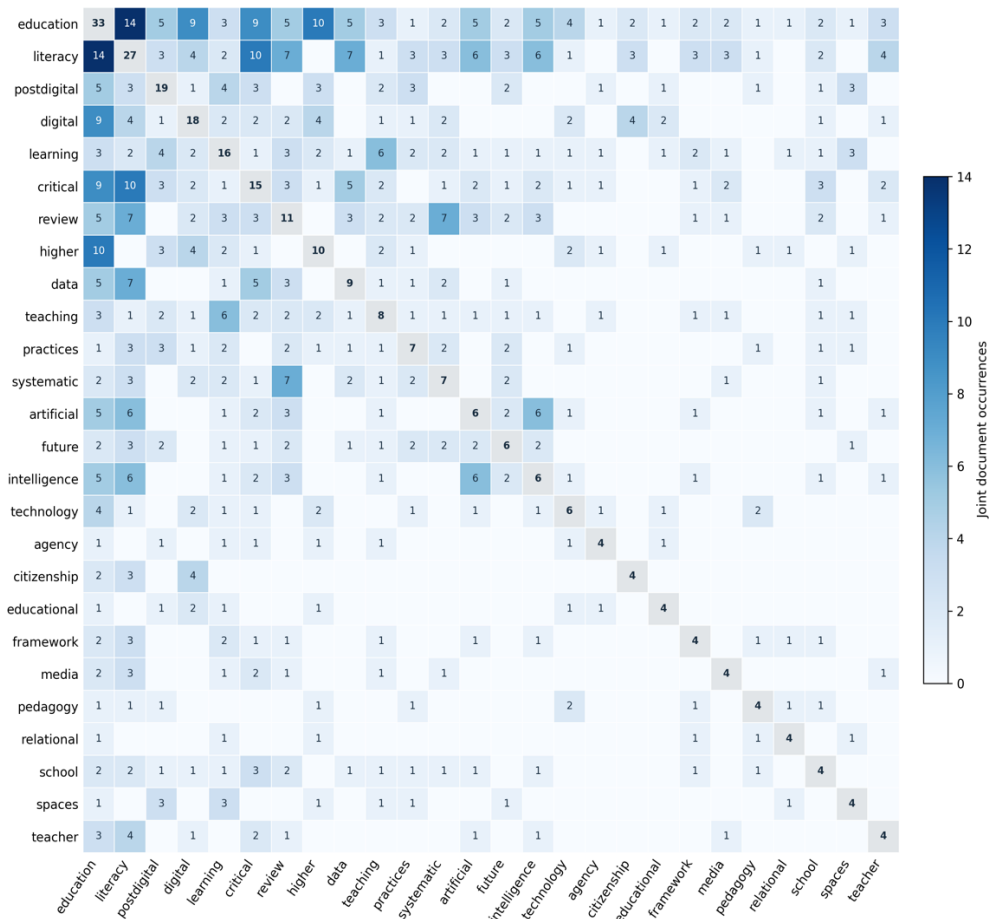
Supplementary Material S1 provides the publication-level corpus assignments and the exact title dataset underlying the bibliometric analysis, together with the

preprocessing rules, exclusion list, and executable analysis script specifying the software versions, layout algorithm, initialization, and parameter settings.

Supplementary title- and author-based comparisons were used for bibliographic verification and the prioritization of published versions. After deduplication, relevance checks, and full-text analysis, 75 external publications were included in the core analytical corpus. Additional references were used for theoretical contextualization, methodological justification, or clarification of the relevant regulatory and technical frameworks; these include publications by the author and were excluded from both the core analytical corpus and the title-word co-occurrence analysis. Supplementary Material S1 identifies the publications constituting the analytical corpus and distinguishes them from references serving these supplementary functions.

Title-word co-occurrence in the external literature corpus

75 publications | 26 title words occurring in ≥ 4 documents | binary counting per publication



Gray diagonal: document frequency of each word. Blue cells: co-occurrence within publication titles.
Blank cells: 0. Original English words; no stemming or merging of word forms.
Basis: saved manuscript-development corpus; five author publications used for context excluded.
Exploratory title-word analysis; no citation or full-text analysis; no claims about the entire research field.

Figure 1: Title-Word Frequencies and Co-occurrence Patterns in the Analytical Core Corpus.

Source: Author (2026)

Note. Underlying title dataset and computational procedures: see Supplementary Material S1.

Title-word co-occurrence network

75 external publications | 26 title words occurring in ≥ 4 documents

Node label size and color: document frequency • Edge width: co-occurrence frequency

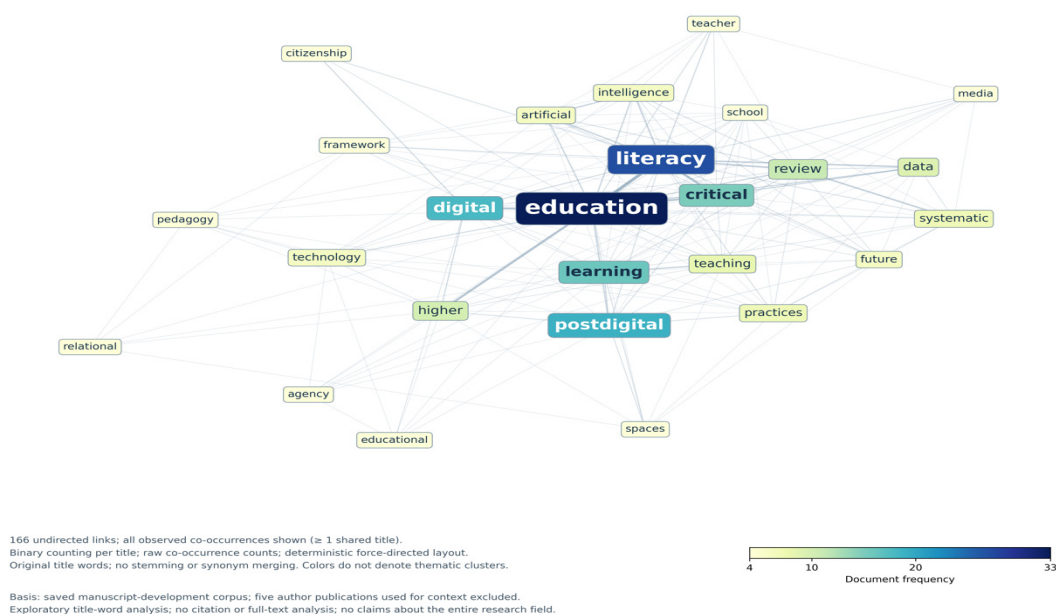


Figure 2: Relational Structure of Title-Word Co-occurrences in the Analytical Core Corpus.

Source: Author (2026)

Analysis and Methodological Limitations

Systematic analysis of the most important publications was conducted using a three-step process. First, a structuring coding was performed based on subject matter, understanding of competence, education or literacy, the underlying human-technology relationship, conceptualized agency, and empirical or theoretical forms of evidence, as well as explicit references to power, justice, and participation. Subsequently, recurring convergences, conceptual differences, and productive contradictions were reconstructed both within and across the clusters. In the third step, a meta-relational analysis informed by philosophy and the social sciences was conducted, from which the five dimensions of the proposed heuristic were derived and contrasted with the entire corpus.

Within this analytical framework, determinants denote theoretically specified conditions under which literacies are constituted or constrained, whereas indicators identify possible empirical manifestations through which these relations become accessible to investigation. Assessment criteria, in turn, specify the grounds on which the observed practices can be judged as appropriate or problematic. This distinction does not imply that the proposed determinants have been causally established or that the illustrative indicators constitute validated measures.

No claim is thus made regarding a statistical distribution of the entire research field. Semantic ranking procedures generate a platform-mediated order of relevance within which English-language, visible, and bibliographically well-documented publications may be structurally

favorable. Likewise, the heterogeneity of the included research designs does not allow for direct comparability of their claims to validity. In interpreting the included publications, empirical findings must be distinguished from conceptual arguments and secondary commentary; publication type alone does not establish evidentiary quality, which also depends on the methodological basis and scope of the claim under consideration.

Methodological control was therefore ensured not through a fictitious homogeneity, but through the explicit distinction between empirical findings, conceptual argumentation, and the theoretical synthesis undertaken here. Accordingly, the resulting dimensions should be understood as analytical heuristics rather than as a psychometrically validated competency model.

Supplementary Material S1 documents the coding rules and provides worked examples tracing source passages through their analytical categorization to the five heuristic dimensions, while distinguishing source-based findings from the interpretive propositions developed in this study.

RESULTS AND DISCUSSION

From Additive Competence Logic to Relational Literacy Architecture

Across the research strands examined, a common negative definition can be established: Postdigital literacy cannot be reduced either to an autonomous subject's sovereign control over external tools or to an arbitrarily extensive list of individual technical, communicative, and critical skills. First, the empirically and theoretically demonstrated role of platforms, spaces, interfaces, data

models, and institutional rules in the creation of concrete possibilities for action argues against such a reductionist view. Second, literate practices are subject to unequal social, cultural, and infrastructural distribution. Third, the evaluation of competent action itself is based on normative visions of the future regarding which forms of autonomy, productivity, criticism, and participation are pedagogically desirable (Macgilchrist *et al.*, 2024; Pischetola, 2021).

As a positive definition, postdigital literacy is therefore understood here as a situation-specific ability and a socially distributed possibility to actively engage with sociotechnically mediated relationships to the self, the world, and knowledge; to reflexively distance oneself from them with regard to their material and power-related conditions; to evaluate their claims to validity in a reasoned manner; and to help shape their future development both individually and collectively. Ability and possibility are deliberately juxtaposed here. Individual dispositions remain ineffective if institutional or technical arrangements prevent their exercise; conversely, accessible infrastructure alone does not generate the capacity for judgment. In this respect, literacies denote a relational actualization of skill, interpretation, materiality, and the right to participate, not just a subject-specific trait or a form of practice.

Consequently, five dimensions structure this interrelation (see Table 1). It must be noted, however, that no dimension has the status of a linear stage of

development. The reason for these findings is that operational connectivity can, without infrastructural transparency, degenerate into mere adaptation; reflexive distancing remains inconsequential without distributed agency; transformative participation loses its relevance to the subject matter without subject-specific connectivity. In this regard, it can be inferred from the current context that their context-sensitive interconnection fundamentally paves the way for a coherent educational movement. This, in turn, implies that, on the one hand, technical interdependence and distributed agency are recognized, while, on the other hand, an asymmetrical human and institutional accountability is also maintained.

Using the term heuristics also highlights a methodological limitation. However, such a definition is by no means intended to postulate five latent characteristics that could be measured independently of one another and aggregated into a single overall literacy score. Rather, it refers to analytical perspectives that allow for the examination of specific situations in various ways. Their relative importance and observable manifestations vary depending on the subject matter: In a school-based research assignment, source verification and plausibility checks may dominate; in a university learning analytics system, data provenance, the right to object, and institutional accountability come to the fore; and when dealing with generative AI, probabilistic variance, cultural representation, and the documentation of human selection decisions gain in importance.

Table 1: Relational Heuristics of Postdigital Literacies

Dimension	Insight and Action Function	Key Research Question	Risk of Reductionism
Operational Connectivity	Appropriate, accessible, and context-sensitive action in hybrid media and data environments	Can a person use and switch between the relevant configurations and remain capable of acting in the event of disruptions?	A focus solely on operational competence and visible performance
Infrastructural Transparency	Reconstruction of platform rules, data flows, materialities, interests, and access requirements	What invisible conditions create visibility, choice, and dependence?	A technocratic fiction of transparency without an analysis of power
Reflexive Distancing to Take a Step Back	Disruption of pre-structured plausibilities and reasoned examination of evidence, norms, and self-relationships	Under what conditions can a result, interface, or proposed course of action be considered valid?	Criticism without consequences or blanket skepticism toward technology
Distributed Agency	Exercise of relational agency while maintaining human accountability	How do sociotechnical arrangements configure possibilities for action, and which human or institutional actors remain accountable for the decisions made within them?	Anthropomorphization of technical systems or shifting responsibility away from human actors
Transformative Participation	Individual and collective co-creation of legitimate sociotechnical orders	Who can change conditions, object, choose alternatives, and help shape visions of the future?	Innovation rhetoric without an assessment of accessibility, equity, and consequences

Source: Author (2026).

Note: The dimensions and guiding questions constitute an analytical heuristic, not a validated measurement instrument. Worked examples of their derivation are provided in Supplementary Material S1.

In the author's view, the criterion of quality for such a heuristic is not internal scale homogeneity but rather the ability to differentiate based on the subject matter. It must be able to demonstrate why two outwardly identical acts of use are to be assessed differently from an educational theory perspective and why the same technical offering generates different opportunities for participation depending on infrastructure, social position, and institutional regulations. Likewise, it must account for situations in which deliberate non-use, switching media, or the demand for an analog alternative represent expressions of high post-digital literacy. Herein lies the difference from models of progress that implicitly equate greater digitalization with higher competence.

Operational Connectivity and Infrastructural Transparency

Within the relational heuristics developed earlier, operational connectivity must be defined as a course of action that can be generated situationally, the realization of which depends on the extent to which individual prerequisites are compatible with the specific task at hand and the conditions of use granted by the institution. The significance of technical design in this context becomes particularly evident when existing skills cannot be applied due to an inaccessible interface or can only be put to practical use with appropriate support.

To define the substance of this dimension, it is therefore necessary to establish what operational knowledge is required to tackle a subject-specific task and how learners can apply this knowledge under the given conditions. Information evaluation and data analysis derive their pedagogical significance from a well-founded engagement with the subject matter; accordingly, the choice of a medium of expression must also be assessed based on whether it facilitates its appropriate processing and understanding. In this respect, autonomy is also evident in the ability to reassess the suitability of the chosen method when requirements change and, if necessary, to switch to a technical or non-technical alternative. For the deductive identification of determinants, it is therefore necessary to specify prior experience, task structure, interface design, linguistic accessibility, assistive support, and institutionally permitted alternatives in terms of their respective contributions to the development of agency.

Against this backdrop, observable performance does not allow one to directly infer the existence of a context-independent competence, nor can its absence be unquestionably interpreted as an individual deficit: Comparable results may stem from different levels of support, while failure caused by technical barriers does not adequately reflect existing technical competence. Therefore, indicators of operational connectivity must always be considered in the context of their terms of use to avoid misrepresenting infrastructural selectivity as a difference in individual performance.

Related to this connection is infrastructural transparency, defined as the ability to reconstruct the prerequisites for

one's own scope of action to such an extent that their interdependencies, limitations, and malleability become accessible to a well-founded assessment. Here, the goal is not the complete disclosure of all technical processes, the accessibility of which remains limited, particularly in the case of proprietary, dynamic, and highly complex systems, but rather a subject- and decision-specific understanding of those structures that prefigure usage and the genesis of results. These include clarifying which data is collected and processed, the categories through which content and individuals gain visibility, how economic or institutional interests are incorporated into architectural and design decisions, and under what conditions standards support interoperability or reinforce dependencies.

It is also necessary to examine which groups of people are excluded by prescribed forms of access and what possibilities exist for challenging or changing such conditions. According to Pangrazio *et al.* (2022), the pedagogical significance of infrastructural orders must be determined at the level of object constitution, insofar as the translation of educational practices into data requires that certain actions be identified as worthy of recording and translated into technically processable categories. Additionally, the accessibility and user-friendliness of these measures must be assessed based on applicable legal requirements and relevant ergonomics and accessibility standards in accordance with DIN EN ISO 9241, EN 301 549, WCAG 2.2, the European Accessibility Act (EAA) and German *Barrierefreiheitsstärkungsgesetz* (BFSG), and the BITV 2.0 [Barrierefreie-Informationstechnik-Verordnung; German Ordinance on Accessible Information Technology] (§ 3 Abs. 1 BITV 2.0; § 1 Abs. 2 BFSG; W3C Web Accessibility Initiative, 2026; World Wide Web Consortium, 2023; Vindigni, 2026c; European Telecommunications Standards Institute, 2021; Directive (EU) 2019/882 of the European Parliament and of the Council, 2019; Deutsches Institut für Normung, 2011, 2018, 2020a, 2020b, 2022a, 2022b. Building on Hartong (2024), this raises the governance-related question of how such definitions, through infrastructural mediation, acquire institutional binding force and thereby also shape the conditions for pedagogical assessment. Nichols and Dixon-Román (2024) expand this context to include the power-political nature of platform governance, which raises the question of which actors can inscribe their conceptions of legitimate educational practice into the design of the underlying systems. As a result, the study pursued here aims to reconstruct infrastructural decisions in terms of their epistemic scope: it remains to be explored how a technically enabled form of data collection gives rise to an institutionally recognized standard against which pedagogical activity is assessed.

In the context of generative AI, the interdependence of these two dimensions can be illustrated as follows: while carefully crafted prompts can improve the task-appropriateness of an output, this alone does not provide sufficient justification for its epistemic validity. Without considering probabilistic generation, data-dependent

representation, and the framework of platform economics, it is unclear under what conditions the result is produced, which perspectives are favored, and within which limits its adoption is justifiable.

Conversely, knowledge of potential model biases remains insufficient for professional judgment as long as it cannot be determined how such a bias can be identified in a specific application and what consequences this has for the use of a result. Such knowledge gains substantive meaning when the evaluation draws on professionally grounded references and also allows for a revision of the chosen approach. Target-group- and domain-specific approaches to AI literacy relate the acquisition of systemic knowledge to the ability to independently evaluate its use in the respective disciplinary context, while taking ethical requirements into account (Allen & Kendeou, 2024; Ayanwale *et al.*, 2024; Chee *et al.*, 2025; Stolpe & Hallström, 2024). For a target-group-appropriate digitization of educational practice, this approach gives rise to the didactic requirement of making different learning prerequisites the starting point for individualized learning paths and justifying their level of difficulty based on a taxonomy of learning objectives. A key consideration here would be how learners can progress from understanding a system's function to its subject-appropriate application and, ultimately, to a well-reasoned judgment regarding its technical and ethical acceptability.

Under postdigital premises, it also remains to be examined to what extent such a concept of competence captures the conditions under which model use is institutionally considered legitimate. This would involve considering which culturally shaped bodies of knowledge are recognized in the generated representations and which are represented only to a limited extent. Likewise, dependence on ecological resources requires explicit consideration, because the concrete application draws on material prerequisites whose consequences extend beyond the immediate context of use. Only such an expansion takes into account the fact that appropriate application and infrastructural understanding remain interdependent within the same polycontextual constellation of action.

Reflexive Distancing as a Corrective in Educational Theory

As previously explained, the intertwining of operational connectivity and infrastructural transparency is complemented by reflexive distancing as a corrective in educational theory, insofar as neither proper application nor knowledge of its conditions alone guarantees that prescribed purposes, interpretations, and evaluative standards will be subjected to independent scrutiny. Under postdigital premises, however, such distancing cannot be defined as a return to an external position free of presuppositions and untouched by technical mediations, since even non-use and conscious media abstinence take place within social conditions whose infrastructural constitution is not thereby abolished.

Rather, it refers to the possibility of disrupting the taken-for-granted nature of existing relationships and making the conditions of their validity the subject of reasoned debate. Educational significance arises from this disruption when it extends beyond the optimization of already established courses of action and opens the way to a reevaluation of one's own relationship to knowledge, technology, other people, and oneself. In this respect, the ability to maintain distance is also measured by whether alternative interpretations and forms of action are not merely perceived but can be weighed against one another in terms of their premises and consequences.

Epistemic contradiction is of particular importance in giving concrete form to this claim, because information, media, and AI systems are involved in the production of those orders of visibility and plausibility within which statements appear, in the first place, to be worth examining, compatible with other knowledge, or authoritative. Although experimental findings support the effectiveness of media education measures for verifying information against disinformation (Adjin-Tettey, 2022), critical literacy is therefore not limited to establishing factual accuracy. Furthermore, it is equally necessary to reconstruct the power dynamics through which certain sources are recognized, other perspectives are marginalized, and uncertainty or ignorance may be viewed as insufficient (Madrid-Morales & Wasserman, 2024; Trust *et al.*, 2022).

From this contextualization arises a twofold requirement for justification. Here, we must examine both the evidence and scope of a statement and the sociotechnical conditions of its selection, dissemination, and institutional effectiveness. These two research approaches remain interrelated. The background to this is that identifying interest-driven visible content does not, in and of itself, refute the content of a statement; conversely, factual accuracy does not, in and of itself, justify the legitimacy of its dissemination through the media infrastructure.

It is precisely this distinction that prevents reflexive distancing from turning into generalized mistrust, whose blanket rejection of established sources of knowledge offers no sufficient safeguard against manipulation. Studies on disinformation accordingly highlight the difference between cynical rejection and critical judgment, such that skepticism only acquires epistemic value through its objectivity and justifiability (Madrid-Morales & Wasserman, 2024). Following the deductive distinction between determinants, indicators, and assessment criteria, institutional authorization, algorithmic visibility control, and cultural orders of plausibility can be examined as conditions of this judgmental practice; their reflexive processing becomes indicatively accessible, for example, in the explication of presuppositions, the consideration of counterevidence, and the reasoned revision of initially accepted interpretations.

By contrast, the criteria for their validity include the transparency of the reasoning, openness to conflicting evidence, and reflection on one's own positionality.

For generative AI, this implies that neither is linguistic coherence sufficient to validate an output, nor does its technical origin justify its rejection. More important is the extent to which the appropriateness of the subject matter, reference to sources, omissions, alternative explanations, and cultural preconceptions are examined, and whether the foreseeable consequences of incorporating the output into decisions can be substantiated justifiably.

Distributed Agency Without Diminishing Scientific and Pedagogical Responsibility

Socio-materialist approaches convincingly show that artifacts, bodies, spaces, data, and discourses both enable and constrain human action. Nevertheless, no symmetrical distribution of moral or epistemic responsibility can be derived from the relational distribution of agency, because participation in the coming about of an action does not, in itself, determine who is responsible for justifying it. To the extent that technical systems, through their configuration, help determine which options are even available and which interpretations emerge as plausible, they interfere with the preconditions of human decision-making; however, this influence does not give rise to an independent authority capable of vouching for the legitimacy of the pursued purposes vis-à-vis those affected.

Within the normative framework advanced here, distributed agency therefore entails no corresponding delegation of legal, ethical, or pedagogical responsibility to technical systems; responsibility remains attributable to human and institutional actors according to their respective obligations and decision-making authority. Such attribution must also reflect their actual capacity to shape or contest the conditions of use, lest institutional obligations be displaced onto learners who lack corresponding powers of intervention.

Conceptually, therefore, we must first distinguish between how a system causally influences the execution of an action or pre-structures its scope of possibilities and what role it plays in generating a claim to knowledge. Separate from this influence, normative attribution must be justified; its standard cannot be technical capability or factual influence alone, but rather the obligation of responsible individuals and institutions to justify decisions and to take responsibility for their consequences. While post-humanist-informed higher education pedagogy makes the participation of texts, bodies, and materialities visible, it nevertheless continues to require an explicit identification of the instances responsible for making decisions that must be justified and for which accountability must be assumed (Chappell et al., 2023; see also the review of Gourlay's work by Noteboom, 2021).

However, for post-digital literacies, this distinction constitutes a central educational element. Learners should neither underestimate technical agency nor anthropomorphically exaggerate it. Rather, what is required is the ability to reconstruct, within specific frameworks, who sets goals, selects data, provides models,

authorizes decisions, opens avenues for objection, and bears the consequences. Following Brod *et al.* (2023), here, the question of agency in the context of educational technology per se must be linked to the design of the conditions under which learners can make their own decisions. Therefore, an interdisciplinary perspective is necessary insofar as the pedagogical significance of a technical design decision becomes apparent only through an examination of the scope for action it opens up or limits in the concrete learning process.

In line with the relational pedagogy of Hickey and Riddle (2024), this connection can be further explored by recognizing that inclusive learning relationships require practical creation through interaction among the participants. For the heuristics developed here, the approach implies the need to also examine the extent to which intended forms of participation can be negotiated in the pedagogical process and adapted accordingly to different learning prerequisites.

Indeed, the posthumanist-oriented reflections of Gravett *et al.* (2023) and Gravett *et al.* (2024), in this regard, build upon this approach by incorporating the ethical significance of more-than-human relationships into the pedagogical framework of justification. Building on these ideas, the present argument must distinguish between the participation of nonhuman entities and the responsibility for shaping shared learning: A distributed production of educational events does not in itself entail an equal obligation on the part of the participating entities to justify its conditions to the learners.

But in this particular context, it is important to recognize that generative AI exacerbates the issue of assigning responsibility, because linguistically coherent suggestions can easily appear to be independent judgments. It is appropriate to speak of epistemic involvement only in a non-anthropomorphic sense: models alter the range of available formulations, comparisons, and plausibilities but possess neither biographically grounded understanding nor the capacity for responsible judgment. Critical Gen AI literacy thus also involves distinguishing between delegated operations, human acts of selection, and institutional authorization. To the extent that the use of generative AI speeds up the completion of a task, it remains to be demonstrated what role the technical pre-structuring plays in the production of the result; otherwise, the result could be regarded as an expression of independent human cognitive achievement without the conditions for such an attribution being transparently established (Rapanta *et al.*, 2025).

Transformative Participation and the Political Dimension of Literacy Modeling

Based on the previously developed interconnection between agency, reflective judgment, and infrastructural conditions for participation, it follows that even the conceptualization of literacies requires an examination of their normative premises. When desired skills are selected, social practices are not merely described; at

the same time, this process prefigures notions of which subject positions, forms of knowledge, and modes of participation are to be recognized in the future. In this respect, the very decision as to whether a model primarily captures efforts to adapt to existing platforms or also incorporates their purposes, rules, and malleability carries political significance. Thus, following Macgilchrist *et al.* (2024), it can be stated that transformative participation is measured by the extent to which a well-founded capacity for action can actually contribute to the collective shaping of the sociotechnical conditions under which learning and participation take place. In the context developed here, the approach presupposes that institutional decision-making processes provide a genuine opportunity for well-founded objections to influence outcomes and keep existing regulations open to revision. If the promotion of critical judgment remains without such institutional accountability, learners are required to engage with the preconditions of their actions, yet are denied the ability to influence their alteration.

Following in this regard Pangrazio and Sefton-Green (2021), the distinction between digital literacy and digital rights becomes significant for defining transformative participation insofar as the capacity for informed participation does not in itself establish an institutional obligation to actually grant that participation space and influence. In the context of the present argument, it follows that the promotion of competence must be linked to those rights and participatory processes through which learners can contribute their judgments to the shaping of the sociotechnical conditions that affect them; otherwise, the capacity for action sought through education remains disconnected from the conditions necessary for its social effectiveness. Furthermore, the concept of digital citizenship raises the question of under what conditions people are recognized as belonging and can influence the shaping of shared affairs. For the purposes of this argument, it follows that individual competence and effective participation are in a relationship that requires justification: even those who possess the necessary skills therefore do not necessarily have equal opportunities to publicly assert their interests.

This difference is the starting point for the intersectional perspective of Choi and Cristol (2021), which relates digital citizenship to social inequalities and thereby highlights its connection to participatory democracy and social justice. In this regard, it is necessary to examine how social positions overlap in the respective context and help determine whose voice is recognized and whose remains without effective resonance. A corresponding pedagogical implication can be derived from the pandemic-related considerations of Buchholz *et al.* (2020) as well as the teacher-education-related work of von Gillern *et al.* (2024). This means that digital citizenship requires instruction that enables learners to assess the legitimacy of existing rules and the consequences of their application. Its educational value thus extends beyond merely adhering to rules and also involves empowering

learners to make the conditions for social participation the subject of collective discussion.

In didactic terms, the aforementioned goal takes concrete form when learners examine data categories for their selection effects, critically analyze platform rules, design inclusive alternatives, and participate in decisions about technological futures. As potential indicators of transformative participation, however, such activities are meaningful only when their institutional leverage and the consequences of the desired changes are also taken into account. From this critical-integrative and deductive perspective, design must therefore be understood as a normative practice through which cognitive, political, affective, conative, and material relationships with the future are created (Macgilchrist *et al.*, 2024). It is only through postdigital eco-pedagogies that this perspective on consequences is supplemented by ecological interrelationships and the impacts of technical infrastructures on nonhuman life alike (Jandrić & Ford, 2022). Educational agency is thus measured by the informed participation in determining the purposes, conditions, and consequences of technological development; reducing it to the accelerated acquisition of ever-new tools would obscure precisely the mutability of established orders that transformative participation aims to address.

Methodological Implications: Relational Object Constitution and Multiscale Analysis

According to the proposed heuristic, empirical research must explore postdigital literacies through the relationship between individual dispositions and the situational conditions under which they are actualized. In this regard, self-reports on attitudes, self-efficacy, and reported practices remain just as incomplete as performance-related tasks, insofar as interface characteristics, institutional rules, social support, and conditions of access remain outside the scope of the study. Following the deductive distinction between determinants, indicators, and assessment criteria, observable performance must therefore be traced back to its infrastructural prerequisites and the quality of its justification. Consequently, the object of study must be the relationship between the individual, the task, technology, the institutional context, and the normative criterion of validity so that technically enabled courses of action are not prematurely interpreted as indicators of individual competence.

These subject constitutions correspond to multiscale designs, whose methodological connection is grounded in the specific relationships to be explored in each case. To empirically examine relationally defined learning spaces, the topologies described by Castañeda *et al.* (2024) provide a framework for comprehending how a learning activity is connected to other participants and physical arrangements beyond its immediate context. This perspective becomes methodologically significant when the spatial boundaries of a study threaten to obscure connections that are constitutive of the emergence of

the observed practice. Using walk-along interviews, it is additionally possible to determine the relationship between envisioned uses and the practices actually carried out and to identify where a discrepancy arises between the two that requires explanation (Wilson *et al.*, 2025).

Also following Wang and Canagarajah (2024), the methodological scope of postdigital ethnography already pertains to the constitution of the field of research, insofar as its delineation must be grounded in the practical contexts under investigation and cannot be predetermined by a presupposed separation of online and offline. For the present heuristic, this approach means following media transitions as far as they contribute to explaining the respective learning process; the relational openness of the subject matter in no way relieves us of the task of transparently demonstrating the scope of the investigation.

Building on the design-related considerations of Goodyear (2020) as well as Verster and Van den Berg (2022), this inquiry raises the question of how hybrid learning spaces are created through the interaction of participants and under what conditions a deliberate change in their configuration can be pedagogically justified. Within the framework of design-based research, empirical feedback thus becomes an integral part of the justification process itself, because it is only through the actual learning process that it becomes apparent to what extent a design decision fulfills the expectations associated with it. Discrepancies between intended and actual use should therefore be examined to determine whether they require an adjustment to the arrangement or whether they already call into question the theoretical assumptions from which its design was derived.

To integrate such findings, an explicit differentiation of levels is required, within which specific practices, tensions, and negotiations at the micro level are related to curricular guidelines, platform agreements, support structures, and assessment systems at the meso level. In this scenario, political regulation, market structures, data economies, and social inequalities constitute macrostructural conditions whose significance for each specific case remains to be theoretically substantiated and empirically examined. A cross-level meta-inference must therefore not derive connections solely from qualitative proximity to the subject matter or from quantitative scope but must demonstrate the mediating processes through which the findings can be related to one another.

In this regard, methodological triangulation offers an approach to this, provided that data, methodological, theoretical, and researcher perspectives are linked in a subject-specific manner and that even contradictory results are treated as findings that require further justification. If, for example, high levels of self-reported digital competence diverge from observed difficulties in making data protection decisions, it is first necessary to reconstruct which assumptions about competence structure the self-reported data and which situational requirements and infrastructural conditions shape the

observed behavior. Only this examination allows us to assess whether there are differences in the scope of the subject matter, limitations in the data collection, or substantial contradictions. In this respect, triangulation serves both to cross-check findings and to explain their different conditions of origin.

Consequently, units of analysis must be defined in such a way that the relevant mediating processes remain empirically traceable. Rather than assuming a limitation to individuals or platforms, the analysis can focus on episodes, constellations of practices, institutional-platform relationships, or temporally limited sociotechnical configurations. Their selection must be justified by the extent to which they reveal transitions, delegations, and interruptions: the assumption of operations, the translation of data, shifts in meaning at interfaces, and the reconnection of decisions to human actors. Relational precision thus rests on a clearly defined delimitation of the subject matter.

With this background in mind, this claim takes concrete form in research practice through the combination of contrast, disruption, and exclusion analyses. By comparing different platforms, languages, social positions, and conditions of support, differences first become apparent; the underlying conditions of these differences can then be reconstructed in greater detail based on media discontinuities, technical failures, or flawed translations. In addition, unrecorded individuals, inaccessible interfaces, discarded data, and missing alternative pathways must be taken into account, because their exclusion would replicate the selectivity of the arrangement under investigation in the research design. Deviations and non-participation thus gain research value as gateways to conditions that are often overlooked in routine practice.

Implications for Media Education: Well-Reasoned Contextualization Rather Than Visible Performance

Starting with the question of whose usage requirements are taken for granted in a digital offering, the reconstruction of access barriers can be justified as a pedagogical approach to understanding the selection effects of its design. When different social positions are applied to the same usage situation, learners can understand why a supposedly neutral requirement remains accessible to some while making participation more difficult for others. These discussions are complemented by construction-oriented approaches to critical data literacy, in which the development of one's own data models offers the opportunity to examine the consequences of self-made classification decisions on the resulting output and to subject its representational framework to a reasoned revision (Bilstrup *et al.*, 2022; Dangol & Dasgupta, 2023). Further educational significance is derived from this approach through its aim to combine critical digital literacy with social agency and self-directed design—an approach also highlighted in school-related syntheses (Ilomäki *et al.*, 2023). Critical co-discovery in working with AI can be followed by a collaborative investigation

in which, for example, the deliberate modification of an input or a change in language serves as an opportunity to explore differences between the generated outputs (Dilek *et al.*, 2025). For the didactic design, it would be crucial to trace such differences back to their possible conditions of origin through controlled comparisons and appropriate counterexamples so that the observed deviation gives rise to a well-founded question regarding the reliability and appropriateness of the model's use.

However, from a curricular perspective, such a practice requires the analytical distinction between three interrelated dimensions of performance so that task completion, epistemic justification, and assessment of societal consequences can each be evaluated appropriately. While the subject-specific, operational dimension concerns execution, the epistemic-reflective dimension focuses on evidence, limits of scope, and well-founded alternatives; the social-transformative dimension, by contrast, examines the extent to which impacts on different groups are taken into account and changes are collectively negotiated. For exam design, the approach implies that final products must be supplemented by process-related evidence, the validity of which is assessed based on explicitly stated criteria. Audit logs, documented decision-making processes, comparative case analyses, and oral defenses provide avenues for evaluation, provided they reveal why decisions were made, rejected, or modified. The focus of their evaluation is therefore the demonstrated quality of reasoning and not merely the completeness of retrospective documentation.

At the same time, the design of the learning and testing environment itself must be aligned with these requirements, because students' ability to provide reasoning can only be appropriately assessed under conditions that take into account diverse user needs. Accessibility and digital well-being must therefore be incorporated from the very outset of the instructional design process, for example, through multiple access routes, compatibility with assistive technologies, controllable visibility, understandable consent options, and suitable analog alternatives (Amjad *et al.*, 2024; Heiser *et al.*, 2025). Otherwise, there is a risk of interpreting infrastructure-related difficulties as individual underperformance and thereby reproducing the very selectivity that is supposed to be the subject of reflective analysis. Justified non-use should also be recognized as a legitimate option if the subject-specific learning objective can be achieved without the corresponding disclosure of data or reliance on a proprietary platform. Thus, substantive participation is realized through the combination of individual capacity with institutionally guaranteed opportunities for choice, dissent, and withdrawal.

Persistent Tensions and Theoretical Scope

Despite the reconstructed convergences, the heuristic must not be understood as a conceptual leveling. Competence, education, and literacies denote different epistemological concerns and claims to validity.

Competency models primarily focus on available capacity for action; educational theories on transformation and the relationship between the self and the world; and literacy approaches on socially situated practices of meaning-making and participation. While postdigitality reveals their interdependence, it does not negate their distinct identities. It is precisely this difference that protects against a totalizing model in which all educational processes would be reduced to measurable literacies or all competencies to undefined transformative movements.

Similarly ambivalent is the category of relationality. As an analytical perspective, it corrects individualistic and technology-deterministic oversimplifications; as an imprecise universal formula, however, it can obscure power differences. Not every relationship allows for mutual shaping, not every interconnection is symmetrical, and the distribution of agency does not, in itself, diminish human or institutional responsibility. Relationality must therefore always examine the direction, intensity, duration, mutability, and normative legitimacy of a connection. Only in conjunction with analyses of access, power, and consequences does it attain sufficient disciplinary precision.

Finally, within this referential framework, the available findings point substantially to significant gaps in research. When considering the research subject and corpus examined here, the scope of the available findings must, of course, be viewed in light of the distinction between conceptual approaches, time-limited empirical studies, and longitudinal studies of educational processes. The extent to which changing relationships with the self and the world, that is, in a reciprocal structure, develop beyond the specific context of the individual studies therefore requires further investigation, as does the question of under what cultural conditions the identified characteristics of post-digital competence are sustainable. Furthermore, research approaches in which those directly affected participate in the study under accessible conditions and can thereby also tap into opportunities for collective influence on the design of their educational infrastructure warrant further methodological examination.

At this causal intersection, with regard to AI competence, it should be noted that, particularly with its increasing use in higher education, this limitation takes on added significance insofar as the assessment of individual competencies and the measurement of usage-related attitudes shape the research approach (Biagini, 2025; Sperling *et al.*, 2024).

From the perspective developed here, it also remains to be explained how economic exploitation interests pre-structure the conditions of model use and what significance their material resource requirements hold for pedagogical assessment. Linked to this limitation is the question, which has received less attention to date, of the institutional procedures through which learners can challenge problematic usage practices and work toward changing them.. Therefore, future research should not only ask what people know about technologies but also

under what conditions they can recognize, evaluate, and effectively change sociotechnical orders.

A first line of research should conduct a longitudinal study to examine whether and under what conditions AI, data, or platform competencies observable in the short term translate into stable, reflexive judgment practices. Of particular interest would be whether learners transfer acquired evaluation routines to new models and contexts, how epistemic trust changes, and to what extent documented reasoning persists even without direct system support. A second line of research would need to conduct a comparative analysis of institutional infrastructures. Differences between open and proprietary platforms, local and cloud-based systems, or mandatory and optional usage settings allow us to draw conclusions about how governance prefigures literacy-related possibilities for action.

A third line of research concerns cultural and linguistic relationality. The extent to which the findings synthesized here are transferable across linguistic contexts and educational systems with different resource conditions remains to be examined. What is needed are research designs that do not merely translate pre-existing instruments but, in collaboration with local stakeholders, reconstruct which forms of critique, participation, and technical appropriateness are relevant in each specific context. Here, participatory and community-based approaches can prevent marginalized groups from being viewed exclusively as risk categories or populations with deficits. A fourth line of research should systematically incorporate ecological materiality: device lifecycles, energy requirements, reparability, and global supply chains are not external sustainability issues but rather integral components of the world-technology relationship that post-digital education aims to address. Finally, research is needed on the institutional effectiveness of critical literacy. Examining whether individuals recognize risks or change their attitudes does not, by itself, establish the institutional effectiveness of critical literacy.

What remains less clear is whether expressed criticism leads to changes in platform decisions, procurement rules, exam formats, or opportunities for participation. It can thus be concluded, with regard to the research subject under consideration here, that in the absence of institutionally binding feedback mechanisms through which students' well-founded objections are incorporated into the review of existing procedures, the promotion of critical literacy in terms of its transformative potential remains unfulfilled. Learners are then expected to identify problematic terms of use and cope with them individually, even though changing these terms lies outside their authority. Transformative participation therefore requires that institutions derive a well-founded mandate for review from such objections and transparently demonstrate what changes result from them or why existing regulations are being maintained. Only through this feedback loop does critical judgment

gain institutional effectiveness that extends beyond the ongoing efforts of individuals to adapt.

CONCLUSION

From this critical-integrative synthesis, it follows that postdigital literacies should not be defined either as a successor term to digital competence or as a terminological resolution of the relationship between competence and education. Rather, a relational architecture is proposed as an analytical heuristic, one within which operational connectivity, infrastructural transparency, the capacity for reflexive distancing, distributed agency, and transformative participation mutually presuppose one another. In this context, competence refers to the situation-specific disposition toward appropriate action; education, to the transformation of relationships to the self, the world, and technology, which cannot be fully standardized; and literacies, to the socially, materially, and power-related practices in which both aspects are actualized and become subjects of contention.

Consequently, the decisive question is not whether people are confronted with a world that can be defined as digital or non-digital. Rather, we must examine how concrete worldly conditions are related through platforms, data, interfaces, bodies, institutions, and cultural interpretations; what possibilities for action arise from these conditions; and to whom their use or modification is open. In this regard, postdigital embeddedness does not preclude reflexive distance; it alters its form. Distancing can no longer be conceived as a retreat into a technology-free exterior but rather as a deliberate interruption within the entanglement, through which rules of selection, dependencies, and alternatives become visible.

For media education, particularly in the context of higher education, this entails a threefold task. In terms of content, theoretical concepts must therefore be framed in such a way that they capture sociotechnical co-constitution without blurring the lines of responsibility. Methodologically, research designs must relate individuals, practices, and infrastructures across multiple scales and incorporate disruptions, exclusions, and non-participation as sources of insight. From a media didactics perspective, visible performance must be supplemented by practices of justification, contradiction, and design that are open to revision. Only under this condition does literacy cease to be a semantics of adaptation to permanent technological modernization and instead become a prerequisite for democratic educational and participatory capacity within sociotechnically pre-structured global conditions.

Declarations

The author has no acknowledgements to declare.

Conflict of Interest

The author declares that no conflict of interest or competing financial interest exists.

Funding

No external or earmarked institutional funding was received for the conduct or preparation of this study.

Ethics Statement

As a critical-integrative evidence synthesis based exclusively on previously published material, the study involved neither the recruitment of human participants nor the collection of new participant-related or personal data. Ethical approval and informed consent were therefore not applicable.

Author Contributions

The author assumed sole responsibility for the conceptualization and methodological design of the study, the literature search and critical-integrative evidence synthesis, the development of the analytical framework, and the preparation and revision of the manuscript.

Research Integrity Statement

The study was conducted and reported in accordance with the applicable principles of research integrity, methodological transparency, and accountable documentation, particularly the Guidelines for Safeguarding Good Research Practice: Code of Conduct issued by the Deutsche Forschungsgemeinschaft (DFG, 2025).

REFERENCES

- Adjin-Tettey, T. D. (2022). Combating fake news, disinformation, and misinformation: Experimental evidence for media literacy education. *Cogent Arts & Humanities*, 9(1). <https://doi.org/10.1080/23311983.2022.2037229>
- Allen, L. K., & Kendeou, P. (2024). ED-AI Lit: An interdisciplinary framework for AI literacy in education. *Policy Insights from the Behavioral and Brain Sciences*, 11(1), 3–10. <https://doi.org/10.1177/23727322231220339>
- Amjad, A. I., Aslam, S., Tabassum, U., Sial, Z. A., & Shafqat, F. (2024). Digital equity and accessibility in higher education: Reaching the unreached. *European Journal of Education*, 59(4), e12795. <https://doi.org/10.1111/ejed.12795>
- Atenas, J., Havemann, L., & Timmermann, C. (2023). Reframing data ethics in research methods education: A pathway to critical data literacy. *International Journal of Educational Technology in Higher Education*, 20(1), 11. <https://doi.org/10.1186/s41239-023-00380-y>
- Ayanwale, M. A., Adelana, O. P., Molefi, R. R., Adeeko, O., & Ishola, A. (2024). Examining artificial intelligence literacy among pre-service teachers for future classrooms. *Computers and Education Open*, 6, 100179. <https://doi.org/10.1016/j.cao.2024.100179>
- Bacalja, A. (2026). Postdigital English education: A productive narrative for resisting neoliberal logics. *English in Education*, 60(2), 106–121. <https://doi.org/10.1080/04250494.2026.2615429>
- Ball, J., & Savin-Baden, M. (2022). Postdigital learning for a changing higher education. *Postdigital Science and Education*, 4(3), 753–771. <https://doi.org/10.1007/s42438-022-00307-2>
- Barrierefreie-Informationstechnik-Verordnung vom 12. September 2011 (BGBl. I S. 1843), die zuletzt durch Artikel 1 der Verordnung vom 24. Oktober 2023 (BGBl. 2023 I Nr. 286) geändert worden ist. https://www.gesetze-im-internet.de/bitv_2_0/
- Barrierefreiheitsstärkungsgesetz vom 16. Juli 2021 (BGBl. I S. 2970), das zuletzt durch Artikel 2 des Gesetzes vom 19. Juli 2024 (BGBl. 2024 I Nr. 248) geändert worden ist. <https://www.gesetze-im-internet.de/bfsg/>
- Biagini, G. (2025). Towards an AI-literate future: A systematic literature review exploring education, ethics, and applications. *International Journal of Artificial Intelligence in Education*, 35(4), 2616–2666. <https://doi.org/10.1007/s40593-025-00466-w>
- Bilstrup, K.-E. K., Kaspersen, M. H., Lunding, M. S., Schaper, M.-M. A., Van Mechelen, M., Tamashiro, M. A., Smith, R. C., Iversen, O. S., & Petersen, M. G. (2022). Supporting critical data literacy in K-9 education: Three principles for enriching pupils' relationship to data. *Proceedings of the 21st Annual ACM Interaction Design and Children Conference*, 225–236. <https://doi.org/10.1145/3501712.3530783>
- Brod, G., Kucirkova, N., Shepherd, J., Jolles, D., & Molenaar, I. (2023). Agency in educational technology: Interdisciplinary perspectives and implications for learning design. *Educational Psychology Review*, 35, Article 25. <https://doi.org/10.1007/s10648-023-09749-x>
- Buchholz, B. A., DeHart, J. D., & Moorman, G. B. (2020). Digital citizenship during a global pandemic: Moving beyond digital literacy. *Journal of Adolescent & Adult Literacy*, 64(1), 11–17. <https://doi.org/10.1002/jaal.1076>
- Campbell, C., & Olteanu, A. (2024). The challenge of postdigital literacy: Extending multimodality and social semiotics for a new age. *Postdigital Science and Education*, 6(2), 572–594. <https://doi.org/10.1007/s42438-023-00414-8>
- Castañeda, L. J., Marín, V. I., & Villar-Onrubia, D. (2024). Relational topologies in the learning activity spaces: Operationalising a sociomaterial approach. *Educational Technology Research and Development*, 72(5), 2793–2815. <https://doi.org/10.1007/s11423-023-10296-z>
- Chappell, K., Natanel, K., & Wren, H. (2023). Letting the ghosts in: Re-designing HE teaching and learning through posthumanism. *Teaching in Higher Education*, 28(8), 2066–2088. <https://doi.org/10.1080/13562517.2021.1952563>
- Chee, H., Ahn, S., & Lee, J. (2025). A competency framework for AI literacy: Variations by different learner groups and an implied learning pathway. *British Journal of Educational Technology*, 56(5), 2146–2182. <https://doi.org/10.1111/bjet.13556>
- Choi, M., & Cristol, D. (2021). Digital citizenship with intersectionality lens: Towards participatory democracy driven digital citizenship education. *Theory*

- Into Practice*, 60(4), 361–370. <https://doi.org/10.1080/00405841.2021.1987094>
- Code, J. R. (2025). The entangled learner: Critical agency for the postdigital era. *Postdigital Science and Education*, 7(2), 336–358. <https://doi.org/10.1007/s42438-025-00544-1>
- Dangol, A., & Dasgupta, S. (2023). Constructionist approaches to critical data literacy: A review. *Proceedings of the 22nd Annual ACM Interaction Design and Children Conference*, 112–123. <https://doi.org/10.1145/3585088.3589367>
- De la Calle Cabrera, A. M., Leal-Bonmati, M., Guichot-Muñoz, E., & Balbás Ortega, M. J. (2024). Literacy practices in childhood from a posthumanist perspective: A systematic review. *International Journal of Educational Research*, 127, 102393. <https://doi.org/10.1016/j.ijer.2024.102393>
- Deutsche Forschungsgemeinschaft. (2025). *Guidelines for safeguarding good research practice: Code of conduct (Version 3)*. <https://doi.org/10.5281/zenodo.14281892>
- Deutsches Institut für Normung. (2011). *DIN EN ISO 26800:2011-11, Ergonomie – Genereller Ansatz, Prinzipien und Konzepte (ISO 26800:2011); Deutsche Fassung EN ISO 26800:2011*. DIN Media. <https://doi.org/10.31030/1775247>
- Deutsches Institut für Normung. (2018). *DIN EN ISO 9241-11:2018-11, Ergonomie der Mensch-System-Interaktion – Teil 11: Gebrauchstauglichkeit: Begriffe und Konzepte (ISO 9241-11:2018); Deutsche Fassung EN ISO 9241-11:2018*. DIN Media. <https://doi.org/10.31030/2757945>
- Deutsches Institut für Normung. (2020a). *DIN EN ISO 9241-110:2020-10, Ergonomie der Mensch-System-Interaktion – Teil 110: Interaktionsprinzipien (ISO 9241-110:2020); Deutsche Fassung EN ISO 9241-110:2020*. Beuth. <https://doi.org/10.31030/3147467>
- Deutsches Institut für Normung. (2020b). *DIN EN ISO 9241-210:2020-03, Ergonomie der Mensch-System-Interaktion – Teil 210: Menschzentrierte Gestaltung interaktiver Systeme (ISO 9241-210:2019); Deutsche Fassung EN ISO 9241-210:2019*. DIN Media. <https://doi.org/10.31030/3104744>
- Deutsches Institut für Normung. (2022a). *DIN EN 301549:2022-06, Barrierefreiheitsanforderungen für IKT-Produkte und -Dienstleistungen; Englische Fassung EN 301549 V3.2.1 (2021-03); Text Deutsch, nur auf CD-ROM*. DIN Media. <https://doi.org/10.31030/3352891>
- Deutsches Institut für Normung. (2022b). *DIN EN ISO 9241-20:2022-03, Ergonomie der Mensch-System-Interaktion – Teil 20: Ein ergonomischer Ansatz für die Barrierefreiheit innerhalb der ISO 9241-Reihe (ISO 9241-20:2021); Deutsche Fassung EN ISO 9241-20:2021*. DIN Media. <https://doi.org/10.31030/3325549>
- Dilek, M., Baran, E., & Aleman, E. (2025). AI literacy in teacher education: Empowering educators through critical co-discovery. *Journal of Teacher Education*, 76(3), 294–311. <https://doi.org/10.1177/00224871251325083>
- Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services, Official *Journal of the European Union*, L 151, 70–115 (2019). <https://eur-lex.europa.eu/eli/dir/2019/882/oj/eng>
- European Telecommunications Standards Institute. (2021). *Accessibility requirements for ICT products and services (ETSI EN 301 549 V3.2.1)*. https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf
- Fawns, T. (2022). An entangled pedagogy: Looking beyond the pedagogy—technology dichotomy. *Postdigital Science and Education*, 4(3), 711–728. <https://doi.org/10.1007/s42438-022-00302-7>
- Forsler, I., Bardone, E., & Forsman, M. (2025). The future postdigital classroom. *Postdigital Science and Education*, 7(3), 682–689. <https://doi.org/10.1007/s42438-024-00488-y>
- Gebre, E. H. (2022). Conceptions and perspectives of data literacy in secondary education. *British Journal of Educational Technology*, 53(5), 1080–1095. <https://doi.org/10.1111/bjet.13246>
- Ghodoosi, B., West, T., Li, Q., Torrisi-Steele, G., & Dey, S. (2023). A systematic literature review of data literacy education. *Journal of Business & Finance Librarianship*, 28(2), 112–127. <https://doi.org/10.1080/08963568.2023.2171552>
- Giakoumakis, E., Vicars, M., & Arantes, J. (2025). Educational illusion and collapse: Postdigital classrooms as places of entangled encounter(ing). *Postdigital Science and Education*, 7(3), 884–898. <https://doi.org/10.1007/s42438-025-00572-x>
- Goodyear, P. (2020). Design and co-configuration for hybrid learning: Theorising the practices of learning space design. *British Journal of Educational Technology*, 51(4), 1045–1060. <https://doi.org/10.1111/bjet.12925>
- Gottschalk, F., & Weise, C. (2023). *Digital equity and inclusion in education: An overview of practice and policy in OECD countries (OECD Education Working Papers No. 299)*. OECD Publishing. <https://doi.org/10.1787/7cb15030-en>
- Gravett, K., Baughan, P., Rao, N., & Kinchin, I. (2023). Spaces and places for connection in the postdigital university. *Postdigital Science and Education*, 5(3), 694–715. <https://doi.org/10.1007/s42438-022-00317-0>
- Gravett, K., Taylor, C. A., & Fairchild, N. (2024). Pedagogies of mattering: Re-conceptualising relational pedagogies in higher education. *Teaching in Higher Education*, 29(2), 388–403. <https://doi.org/10.1080/13562517.2021.1989580>
- Hartong, S. (2024). Governance by intermediarization. Insights into the digital infrastructuring of education in Estonia. *Research in Education*, 120(1), 91–109. <https://doi.org/10.1177/00345237241234613>
- Hawley, S. (2024). Finding an (ecological) niche in the

- postdigital taskscape: The role of strong literacy and poor pedagogy in primary school pupils' online literacy practices. *Postdigital Science and Education*, 6(3), 866–885. <https://doi.org/10.1007/s42438-024-00478-0>
- Hawley, S. T. (2022). Doing sociomaterial studies: The circuit of agency. *Learning, Media and Technology*, 47(4), 413–426. <https://doi.org/10.1080/17439884.2021.1986064>
- Heiser, R. E., Palalas, A., & Gollert, A. (2025). Digital well-being begins with inclusion: A systematic review of videoconferencing guidelines for equitable learning. *Australasian Journal of Educational Technology*, 41(1), 18–26. <https://doi.org/10.14742/ajet.9552>
- Hickey, A., & Riddle, S. (2024). Proposing a conceptual framework for relational pedagogy: Pedagogical informality, interface, exchange and enactment. *International Journal of Inclusive Education*, 28(13), 3271–3285. <https://doi.org/10.1080/13603116.2023.2259906>
- Ilomäki, L., Lakkala, M., Kallunki, V., Mundy, D., Romero, M., Romeu, T., & Gouseti, A. (2023). Critical digital literacies at school level: A systematic review. *Review of Education*, 11(3). <https://doi.org/10.1002/rev3.3425>
- Jandrić, P., & Ford, D. (2022). Postdigital ecopedagogies: Genealogies, contradictions, and possible futures. *Postdigital Science and Education*, 4(3), 692–710. <https://doi.org/10.1007/s42438-020-00207-3>
- Jandrić, P., & Hayes, S. (2020). Postdigital we-learn. *Studies in Philosophy and Education*, 39(3), 285–297. <https://doi.org/10.1007/s11217-020-09711-2>
- Jandrić, P., & Knox, J. (2022). The postdigital turn: Philosophy, education, research. *Policy Futures in Education*, 20(7), 780–795. <https://doi.org/10.1177/14782103211062713>
- Karakainen, M., & Saikkonen, L. (2023). Remark on digital accessibility: Educational disparities define digital inclusion from adolescence onwards. *Universal Access in the Information Society*, 22(4), 1279–1292. <https://doi.org/10.1007/s10209-022-00908-5>
- Kerruish, E. (2026). Postdigital teaching of critical thinking in higher education: Non-instrumentalised sociality and interactivity. *Postdigital Science and Education*, 8(2), 551–570. <https://doi.org/10.1007/s42438-024-00456-6>
- Lacković, N., Olteanu, A., & Campbell, C. (2024). Postdigital literacies in everyday life and pedagogic practices. *Postdigital Science and Education*, 6(3), 796–820. <https://doi.org/10.1007/s42438-024-00500-5>
- Lamb, J., Carvalho, L., Gallagher, M., & Knox, J. (2022). The postdigital learning spaces of higher education. *Postdigital Science and Education*, 4(1), 1–12. <https://doi.org/10.1007/s42438-021-00279-9>
- Lemieux, A., & Rowsell, J. (2020). On the relational autonomy of materials: Entanglements in maker literacies research. *Literacy*, 54(3), 144–152. <https://doi.org/10.1111/lit.12226>
- Lister, K., Riva, E., Hartley, A., Waterhouse, P., Moller, N., Downes, L., Coughlan, T., Kukulska-Hulme, A., McPherson, E., Macdonald, I., Jones-Tinsley, S., Brown, C., & Tudor, R. (2024). Positive digital practices: Supporting positive learner identities and student mental wellbeing in technology-enhanced higher education. *Journal of Interactive Media in Education*, 2024(1). <https://doi.org/10.5334/jime.831>
- Lyu, P., Liu, X., & Yao, T. (2026). A bibliometric analysis of literature on bibliometrics in recent half-century. *Journal of Information Science*, 52(2), 324–344. <https://doi.org/10.1177/01655515231191233>
- Macgilchrist, F., Allert, H., Cerratto Pargman, T., & Jarke, J. (2024). Designing postdigital futures: Which designs? Whose futures? *Postdigital Science and Education*, 6(1), 13–24. <https://doi.org/10.1007/s42438-022-00389-y>
- Madrid-Morales, D., & Wasserman, H. (2024). Cynical or critical media consumers? Exploring the misinformation literacy needs of South African youth. *African Journalism Studies*, 45(4), 327–345. <https://doi.org/10.1080/23743670.2025.2475761>
- Magoge, P. S., Sanusi, I., Suhonen, J., Pope, N., & Mwandosya, G. I. (2025). Teaching and learning of social media algorithms in the K-12 context: A systematic review. *IEEE Access*, 13, 199454–199473. <https://doi.org/10.1109/ACCESS.2025.3633584>
- Markauskaite, L., Carvalho, L., & Fawns, T. (2023). The role of teachers in a sustainable university: From digital competencies to postdigital capabilities. *Educational Technology Research and Development*, 71(1), 181–198. <https://doi.org/10.1007/s11423-023-10199-z>
- Moylan, R., & Code, J. R. (2024). Algorithmic futures: An analysis of teacher professional digital competence frameworks through an algorithm literacy lens. *Teachers and Teaching*, 30(4), 452–470. <https://doi.org/10.1080/13540602.2023.2263732>
- Ng, D., Su, J., Leung, J., & Chu, S. K. (2024). Artificial intelligence (AI) literacy education in secondary schools: A review. *Interactive Learning Environments*, 32(10), 6204–6224. <https://doi.org/10.1080/10494820.2023.2255228>
- Nichols, T. P., & Dixon-Román, E. (2024). Platform governance and education policy: Power and politics in emerging EdTech ecologies. *Educational Evaluation and Policy Analysis*, 46(2), 309–328. <https://doi.org/10.3102/01623737231202469>
- Noteboom, J. (2021). [Review of the book Posthumanism and the digital university: Texts, bodies and materialities, by L. Gourlay]. *Learning, Media and Technology*, 46(3), 366–367. <https://doi.org/10.1080/17439884.2021.1920977>
- Pangrazio, L., & Sefton-Green, J. (2021). Digital rights, digital citizenship and digital literacy: What's the difference? *Journal of New Approaches in Educational Research*, 10(1), 15–27. <https://doi.org/10.7821/naer.2021.1.616>
- Pangrazio, L., & Selwyn, N. (2021). Towards a school-based 'critical data education'. *Pedagogy, Culture & Society*, 29(3), 431–448. <https://doi.org/10.1080/146>

- 81366.2020.1747527
- Pangrazio, L., Stornaiuolo, A., Nichols, T., Garcia, A., & Philip, T. (2022). Datafication meets platformization: Materializing data processes in teaching and learning. *Harvard Educational Review*, 92(2), 257–283. <https://doi.org/10.17763/1943-5045-92.2.257>
- Pischetola, M. (2021). Re-imagining digital technology in education through critical and neo-materialist insights. *Digital Education Review*, 40, 154–171. <https://doi.org/10.1344/der.2021.40.154-171>
- Pischetola, M., de Miranda, L. T., & Albuquerque, P. (2021). The invisible made visible through technologies' agency: A sociomaterial inquiry on emergency remote teaching in higher education. *Learning, Media and Technology*, 46(4), 390–403. <https://doi.org/10.1080/17439884.2021.1936547>
- Prinsloo, P., Khalil, M., & Slade, S. (2024). Vulnerable student digital well-being in AI-powered educational decision support systems (AI-EDSS) in higher education. *British Journal of Educational Technology*, 55(5), 2075–2092. <https://doi.org/10.1111/bjet.13508>
- Raffaghelli, J., & Stewart, B. E. (2020). Centering complexity in 'educators' data literacy' to support future practices in faculty development: A systematic review of the literature. *Teaching in Higher Education*, 25(4), 435–455. <https://doi.org/10.1080/13562517.2019.1696301>
- Rapanta, C., Bhatt, I., Bozkurt, A., Chubb, L., Erb, C., Forsler, I., Gravett, K., Koole, M., Lintner, T., Örtengren, A., Petricini, T., Rodgers, B., Webster, J., Xu, X., Christensen, I., Dohn, N. B., Christensen, L. L. W., Zeivots, S., & Jandrić, P. (2025). Critical GenAI literacy: Postdigital configurations. *Postdigital Science and Education*, 7(4), 1296–1333. <https://doi.org/10.1007/s42438-025-00573-w>
- Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., & Koole, M. (2021). Balancing technology, pedagogy and the new normal: Post-pandemic challenges for higher education. *Postdigital Science and Education*, 3(3), 715–742. <https://doi.org/10.1007/s42438-021-00249-1>
- Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act), Official Journal of the European Union, L, 2023/2854 (2023). <https://eur-lex.europa.eu/eli/reg/2023/2854/oj/eng>
- Roffarello, A. M., & De Russis, L. (2023). Teaching and learning “digital wellbeing”. *Future Generation Computer Systems*, 149, 494–508. <https://doi.org/10.1016/j.future.2023.08.003>
- Sander, I. (2020). What is critical big data literacy and how can it be implemented? *Internet Policy Review*, 9(2). <https://doi.org/10.14763/2020.2.1479>
- Sheridan, M. P., Lemieux, A., Do Nascimento, A., & Arnseth, H. (2020). Intra-active entanglements: What posthuman and new materialist frameworks can offer the learning sciences. *British Journal of Educational Technology*, 51(4), 1277–1291. <https://doi.org/10.1111/bjet.12928>
- Sperling, K., Stenberg, C., McGrath, C., Åkerfeldt, A., Heintz, F., & Stenliden, L. (2024). In search of artificial intelligence (AI) literacy in teacher education: A scoping review. *Computers and Education Open*, 6, 100169. <https://doi.org/10.1016/j.cao.2024.100169>
- Stolpe, K., & Hallström, J. (2024). Artificial intelligence literacy for technology education. *Computers and Education Open*, 6, 100159. <https://doi.org/10.1016/j.cao.2024.100159>
- Timmis, S., & Valladares-Celis, M. C. (2026). Digital inequalities and the COVID legacy in higher education in the global South and North: Intersecting inaccessibilities and institutional assumptions. *Compare: A Journal of Comparative and International Education*, 56(3), 429–447. <https://doi.org/10.1080/03057925.2025.2483691>
- Trust, T., Maloy, R. W., Butler, A. T., & Goodman, L. (2022). Critical media literacy in teacher education: Discerning truth amidst a crisis of misinformation and disinformation. *Journal of Technology and Teacher Education*, 30(2), 167–176. <https://doi.org/10.70725/007235rcfely>
- Verster, B., & Van den Berg, C. L. (2022). Theorising with sociomateriality: Interdisciplinary collaboration in socio-technical learning environments. *Educational Research for Social Change*, 11(2), 39–56. <https://doi.org/10.17159/2221-4070/2022/v11i2a3>
- Vindigni, G. (2024). Enhancing human-computer interaction in socially inclusive contexts: Flow heuristics and AI systems in compliance with DIN EN ISO 9241 standards. *European Journal of Contemporary Education and E-Learning*, 2(4), 115–139. [https://doi.org/10.59324/ejceel.2024.2\(4\).10](https://doi.org/10.59324/ejceel.2024.2(4).10)
- Vindigni, G. (2025a). Data-driven disparities: How AI applications in education may perpetuate or mitigate inequality. *European Journal of Science and Modern Technologies*, 1(4), 4–54. [https://doi.org/10.59324/ejsmt.2025.1\(4\).02](https://doi.org/10.59324/ejsmt.2025.1(4).02)
- Vindigni, G. (2025b). Gender bias and cultural misrepresentation in AI: A critical inquiry into cross-cultural communication and algorithmic design. *European Journal of Applied Science, Engineering and Technology*, 3(3), 51–72. [https://doi.org/10.59324/ejaset.2025.3\(3\).06](https://doi.org/10.59324/ejaset.2025.3(3).06)
- Vindigni, G. (2026a). Beyond compliance: Future Skills 2030, digital accessibility and democratic participation in higher education—a scoping review. *European Journal of Contemporary Education and E-Learning*, 4(4), 56–137. [https://doi.org/10.59324/ejceel.2026.4\(4\).05](https://doi.org/10.59324/ejceel.2026.4(4).05)
- Vindigni, G. (2026b). Platformized private higher education institutions in the EHEA: Instructional infrastructure, access conditionality, and platform governance. *European Journal of Contemporary Education and E-Learning*, 4(4), 275–356. [https://doi.org/10.59324/ejceel.2026.4\(4\).13](https://doi.org/10.59324/ejceel.2026.4(4).13)

- Vindigni, G. (2026c). *UX Research und User Research: Theorie, Methoden und Anwendungsfelder der Nutzerforschung*. Springer Vieweg. <https://doi.org/10.1007/978-3-662-72235-0>
- von Gillern, S., Gould, H., Gannon, M., & Haskey-Valerius, B. (2024). Digital citizenship and its relevance for literacy education: Perspectives of preservice teachers. *The Australian Journal of Language and Literacy*, 47(1), 73–90. <https://doi.org/10.1007/s44020-024-00059-5>
- W3C Web Accessibility Initiative. (2026, May 26). *WCAG 2 overview*. <https://www.w3.org/WAI/standards-guidelines/wcag/>
- Walter, Y. (2024). Embracing the future of artificial intelligence in the classroom: The relevance of AI literacy, prompt engineering, and critical thinking in modern education. *International Journal of Educational Technology in Higher Education*, 21(1), 1–29. <https://doi.org/10.1186/s41239-024-00448-3>
- Wang, C., & Canagarajah, S. (2024). Postdigital ethnography in applied linguistics: Beyond the online and offline in language learning. *Research Methods in Applied Linguistics*, 3(2), 100111. <https://doi.org/10.1016/j.rmal.2024.100111>
- Wilson, S., Vallis, C. J., & Yeoman, P. (2025). Walking through the future in the present: Teaching practices in postdigital learning spaces. *Postdigital Science and Education*, 7(3), 813–833. <https://doi.org/10.1007/s42438-025-00569-6>
- World Wide Web Consortium. (2023). *Web content accessibility guidelines (WCAG) 2.2*. <https://www.w3.org/TR/2023/REC-WCAG22-20231005/>
- Yim, I. H. Y. (2024). A critical review of teaching and learning artificial intelligence (AI) literacy: Developing an intelligence-based AI literacy framework for primary school education. *Computers and Education: Artificial Intelligence*, 7, 100319. <https://doi.org/10.1016/j.caeai.2024.100319>
- Zomer, C. (2026). How ‘much’ engaged are you? A case-study of the datafication of student engagement. *Learning, Media and Technology*, 51(1), 166–180. <https://doi.org/10.1080/17439884.2024.2437547>