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Ethical Implications of Generative AI in Collaborative Learning for Decision-Making in Circular Construction

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Abstract

Generative AI (GAI) is increasingly embedded in collaborative learning environments, shaping how students negotiate trust, authority, and responsibility in decision-making. This article examines how students in a circular construction course navigate the potential role of GAI during early-stage, value-laden design processes. Drawing on focus group interviews with interdisciplinary

student teams, the analysis is framed through a socio-material perspective that views GAI as an entangled actor rather than a neutral tool. Findings show that students often position GAI critically, engaging with it as a creative catalyst in early ideation phases, but maintaining professional distance when accountability, traceability, and domain-specific knowledge are at stake. Hesitation and non-use emerge as meaningful forms of ethical positioning, shaping collaborative dynamics as much as active use. The study highlights the need for pedagogical strategies that support students in critically navigating algorithmic authority and integrating GAI transparently and responsibly into collaborative design practices.

Keywords: Collaborative Learning, Socio-materiality, Generative AI (GAI), Ethical Decision-Making, Circular Construction

Introduction

Generative AI (GAI) is rapidly becoming a central actor in both education and professional practice. In learning environments and across industries like construction, GAI is not just supporting how problems are framed, how knowledge is shared, and who gets to decide; it is beginning to shape how problems are understood, how collaboration unfolds, and how knowledge is valued (Johri 2022; Orlikowski and Scott 2008; Cotton et al. 2023; Kasneci et al. 2023). Early-stage decisions in the construction industry about material reuse, life cycle design, and resource coordination, once grounded in humans' collaborative negotiation, are now increasingly co-shaped by algorithmic logic (Leonardi 2012). These early-stage decision processes are not merely technical calculations, but deeply collaborative and value-driven judgments made under pressure and uncertainty – conditions that make the presence of GAI even more consequential (Barad 2007; Jones 2014). In this evolving landscape, students are not merely learning about sustainability - they are learning through entangled processes of human-GAI decision-making that mirror the very complexities of the professional worlds they are entering (Barad 2003; Jensen et al. 2024).

From a socio-material perspective, this article examines how the presence and perceived role of GAI shape the conditions for dialogue, idea evaluation, and shared decision-making (Johri 2022; Orlikowski 2007; Barad 2007). GAI does not act as a neutral tool, but as

a potential actor whose authority must be negotiated, accepted, or held at a distance (Latour 2005; Callon 1999). Students thus learn not only through direct interaction with GAI, but also through the ethical and professional negotiations surrounding its use (Leonardi 2012; Tlili et al. 2023). The black-box nature of GAI, its biased training data, and lack of transparency raise critical ethical concerns (Haleem et al. 2022; Sharma and Yadav 2022). Rather than adopting GAI uncritically, students often question its legitimacy: Whose perspectives are represented, who controls the flow of insight, and under what conditions can its participation be trusted? (Barad 2003; Cotton et al. 2023). Hesitation and non-use can therefore be understood as ethical positioning, where professional judgment determines whether and how technologies are included in collaborative decision-making. Situated within a construction-oriented educational context, this study investigates how GAI tools are used by students to engage in collaborative exploration of circular design. The research question guiding this study is:

How do students professionally position themselves with an ethical judgment in relation to GAI when the technology has the potential to influence decision-making in early-stage circular design processes?

To address this question, the next sections outline two central foundations for the analysis. First, the concept of early-stage decision-making in construction is introduced, highlighting how this phase involves navigating uncertainty, value-laden trade-offs, and collective judgment. Following this, the theoretical lens of socio-materiality is presented to explore how technologies such as GAI are not simply neutral supports, but potential actors that learners may accept, resist, or hold at a distance (Johri 2022; Kallinikos et al. 2012; Barad 2007). Together, these perspectives provide the groundwork for examining how students' positioning toward GAI, including hesitation and selective engagement, shapes and reconfigures collaborative learning environments.

Early-stage decisions making in collaborative construction

When planning and designing buildings, many of the most important decisions are made long before any physical work begins.

These early stages, often called the design or concept phase, set the foundation for everything that follows. What materials should be used? How long should the building last? Can building components be taken apart and reused in the future? These are not just technical choices, they are value-driven decisions that influence environmental impact, financial cost, and social responsibility (Pomponi and Moncaster 2016; Asdrubali et al. 2024). Because buildings involve many stakeholders such as architects, engineers, sustainability experts, and contractors, these decisions must be made collaboratively (Kirchherr et al. 2018).

In recent years, interest in a *circular economy* in construction has grown, emphasizing design for reuse, recycling, and long-term resource efficiency (Ellen MacArthur Foundation 2013; Geissdoerfer et al. 2017). While often framed at a systemic level involving policy, markets, and supply chains (Raworth 2017; Kirchherr et al. 2018), circularity ultimately depends on early project decisions, when overall strategies are still flexible (Vázquez-Rowe et al. 2021). Early-stage construction decisions are not only technical and economic but also reflect underlying values and ethical priorities. Material choices, design strategies, and stakeholder involvement carry consequences for resource use, waste management, and broader social and environmental impacts (Pomponi and Moncaster 2016; Asdrubali et al. 2024). Students must therefore learn to navigate contested, value-laden, and situated decisions (Raworth 2017).

While research on GAI in construction education remains limited, studies in other fields offer valuable insights. Across contexts, GAI often enters early in collaborative processes, accelerating ideation, structuring discussions, and providing creative input, but also introducing new dependencies and tensions around trust, accountability, and epistemic authority Students tend to engage with GAI outputs critically, weighing their usefulness against issues of transparency and legitimacy. (Wei et al. 2025; Liu et al. 2024; Cress and Kimmerle 2023; Kaup et al. 2025). These dynamics resonate strongly with circular design, where early decisions shape long-term outcomes. If accepted uncritically, AI-generated suggestions risk obscuring the ethical stakes of design choices. Critical engagement is therefore essential to make visible the technology's role, its limits, and its implications for shared responsibility.

As GAI becomes increasingly embedded in early-stage construction decision-making, it can no longer be seen as a neutral support tool. A socio-material perspective allows us to examine how learning, agency, and professional judgment are co-produced through the interplay between human actors, technological systems, and material artifacts.

Framing the Socio-material Perspective

Socio-material perspectives challenge the assumption that learning is exclusively human-centered or technologically neutral. The social and the material are mutually constitutive, and learning emerges through ongoing reconfigurations among people, technologies, and artifacts (Johri 2022; Orlikowski and Scott 2008). Technologies do not merely deliver content or support activity, they actively shape what becomes possible to say, know, and do (Suchman 2007; Leonardi 2012). As Orlikowski (2007) emphasizes, everyday organizing is inseparably linked with materiality. Technologies shape actions, relationships, and knowledge in practice, not as external factors but as integral to the field of practice. Even seemingly individual acts, such as a Google search, are *"constituted by the performativity of computers, networks, software, algorithms, directories, databases, and infrastructure"* (Orlikowski 2007). This entanglement is also evident in GAI. Here, materiality is not only located in the interface, but in how the model generates language, suggests alternatives, and interacts dynamically with users. The phrasing, tone, and degree of confidence in each output carry epistemic weight and shape how authority is negotiated in practice. This reflects broader socio-material perspectives on how technologies co-produce meaning and agency (Jones 2014; Dourish and Mazmanian 2012), while recent research demonstrates how these dynamics are intensified in GAI due to the fluency and persuasive coherence of its output (Pelman et al. 2025; Kasneci et al. 2023; Cotton et al. 2023). In this sense, GAI actively participates in shaping how knowledge is accessed, interpreted, and legitimized (Johri 2022; Barad 2007; Latour 2005).

In collaborative learning environments centred on circular construction, these socio-material dynamics become particularly pronounced. Students navigate complex sustainability challenges in settings where agency is distributed across human actors, digital tools, and material artifacts. Following from the socio-material per-

spective, GAI is not a passive instrument in this process; it becomes entangled in knowledge production, sharing, and legitimation (Barad 2003; Orlikowski and Scott 2008), foregrounding design directions, amplifying sustainability framings, and subtly reorganizing the visibility of ideas. In doing so, GAI may shape who speaks, which ideas gain traction, and how collaborative reasoning unfolds (Callon 1999; Law 1992; Johri 2022), while participating in the emergence of meaning, authority, and judgment within the group (Barad 2007; Jones 2014).

Methodology

To explore how students position themselves professionally and exercise ethical judgment when using GAI in early-stage circular design decision-making, this study draws on a case-based learning context in a professional bachelor's program in architectural technology and construction management at a Danish University College. Students, working in interdisciplinary teams, developed circular design strategies for multi-storey buildings under realistic project constraints. The teaching approach was rooted in reflective practice-based learning (Horn et al. 2020), aiming to strengthen professional judgment and the ability to navigate uncertainty. Students applied decision-making models under time pressure and incomplete data, balancing technical options, client needs, and environmental concerns. Digital tools, including BIM platforms and GAI technologies such as ChatGPT and Microsoft Copilot, supported exploration, scenario simulation, and assumption testing without being presented as solutions.

Research Approach

The study was guided by an exploratory case study design, with a dual focus on how students experience early decision-making in circular construction and how GAI influences collaborative learning processes. Twelve student groups, each consisting of four to five students, participated in the course. From these, four groups were selected for in-depth focus group interviews to reflect diversity in project experiences. The selection considered differences in design strategies, collaborative dynamics, and the extent to which groups engaged with or reflected on the role of digital tools such as GAI. Each selected group worked on a shared design brief during the

design phase of the project. The four groups were interviewed separately, with all members of each group participating simultaneously in their respective sessions. Each interview lasted about an hour and focused on students' reflections on group decision-making, engagement with GAI tools, and how decision models shaped their handling of uncertainty and coordination. All participants gave informed consent, and anonymity was ensured. Interviews were recorded, transcribed verbatim, and analysed thematically (Boyatzis 1998; Saldaña and Omasta, 2016).

The analytical process proceeded in three stages that combined close reading with inductive thematic analysis based on a socio-material perspective (Saldaña and Omasta, 2016). **Stage 1**: The transcripts were first read and discussed to identify recurring elements related to trust, authority, and GAI's role, then coded line-by-line to capture how students positioned GAI in relation to professional reasoning, responsibility, and group dynamics. **Stage 2**: Drawing on the patterns identified in Stage 1, the analysis moved beyond line-by-line coding to a focused comparative coding phase, examining how these positioning practices varied across groups and contexts, and how they related to emerging themes of professional judgment. **Stage 3:** Codes were finally clustered to reveal patterns in negotiations of epistemic authority. Orlikowski's enactment lens (Orlikowski 2007) guided the analysis, tracing how agency, meanings, and roles were continuously configured through practices, tools, and interactions, rather than treating humans or technology as fixed entities.

Analysis of socio-material dynamics

This section presents insights from an exploratory case study of how students in a professional bachelor's program used GAI tools to navigate early-stage decision-making in circular construction. The analysis is organised around three interrelated themes that illustrate how collaborative early-stage design decisions are shaped not only by technical considerations but also by trust, traceability, and professional judgment. The students' interactions revealed tensions around authority, responsibility, and the ethics of digitally mediated decisions, highlighting the challenge of balancing GAI use with critical judgment in uncertain, value-laden contexts.

Circularity as an Ethical Learning Challenge

A substantial part of students' decision-making unfolded without actively using GAI. Many perceived its output as too generic, insufficiently traceable, or misaligned with the technical specificity required in early-stage circular design. As noted by Cress and Kimmerle (2023), students often negotiate the epistemic role of GAI critically, withholding full integration when transparency and context are lacking. Non-use thus became a deliberate part of their reasoning rather than disengagement. From a socio-material perspective, holding technologies at a distance is itself consequential, shaping which human, material, or technological actors participate in the design process (Kaup et al. 2025). This becomes evident in students' reflections on the role of materials themselves.

> "Well… we've chosen materials with a long lifespan—like 50 years plus in most places. And you could say we chose brick for the facade instead, because we had talked about whether it should be wood or something else. But then there's the maintenance and… operation and maintenance that comes into play instead."

Students thus recognized that early-stage design decisions in construction were not only technically significant but also entangled with ethical and material considerations. Their reflections highlight how materiality, both the properties of materials and the availability of data, actively shapes collaborative decision-making (Orlikowski 2007; Barad 2003).

This illustrates how material choices (materiality) and the information available about them participate in shaping discussion and decisions, rather than being passive objects of choice. The uncertainty surrounding durability and maintenance demonstrates that practice is co-constituted by both human actors and material/technological factors (Suchman 2007; Orlikowski and Scott 2008).

Generative AI and the Redistribution of Epistemic Authority

Students engaged with GAI tools such as ChatGPT and Copilot with a mixture of curiosity and skepticism (Kasneci et al. 2023; Cotton et al. 2023). Some used GAI to jumpstart creative ideation or explore unfamiliar design options, while others expressed concern

about relying on outputs they could not verify: *"But document it? I actually think that's hard with it. If you've just asked it. It's really about making sure we can document the decisions we make, not just 'because the GAI said we should."* This ethical hesitation highlights the socio-material entanglement of GAI in collaborative decision-making. When AI-generated content shapes group outcomes, questions of accountability and responsibility become distributed across both human and technological actors. One student critically reflected on the perceived objectivity of GAI:

> "Well, if you go and ask an GAI about fire safety compared to something else, you don't actually know. Because the data—or what it gives you—it's just to satisfy us. It's not like it actually got it from the updated B18 version from this specific date."

Students also described how GAI's confident tone could influence group momentum, even when information was incomplete or potentially misleading (Haleem et al. 2022; Hassan et al. 2022; Pelman and Zoran 2025). As one remarked: *"I don't know… I mean, I think we generally actually… like, we've always thought about what it is we're getting out. There's nothing we just directly take as it is."*. This indicates that GAI was experienced and negotiated as a socio-material actor that could influence which ideas gain legitimacy, and how knowledge is mobilized in collaborative processes (Orlikowski and Scott 2008; Barad 2007; Leonardi 2012; Suchman 2007). A similar effect is documented by Wei et al. (2025), who found that GAI can accelerate group creativity and problem-solving but simultaneously shift cognitive responsibility away from students. In this sense, GAI reconfigures epistemic authority within the group, influencing both the flow and outcome of shared decision-making (Johri 2022; Pelman and Zoran 2025). Students were acutely aware of these dynamics. They noted that the lack of traceability and transparency in GAI outputs posed barriers to trust:

> "It's about sources, references. If you had one [a GAI] that was only fed with valid sources… then you'd trust more what it comes up with."

Together, these reflections illustrate a pedagogically significant tension where students want GAI to support learning, but uncritical reliance risks blurring responsibility and weakening shared ethical accountability (Liu et al. 2024). From a socio-material perspective, these dynamics exemplify how learning and ethical judgment co-emerge through the entanglement of human actors, materiality (including GAI outputs), and collaborative practice.

The Temporal Dynamics of AI in Collaborative Design

While the socio-material perspective underpins the entire analysis, this section focuses specifically on how students positioned GAI during different phases of their collaborative design process. In particular, it examines how GAI entered as a creative catalyst in the early stages, how its influence persisted in subtle ways over time, and how students negotiated its role as they moved from ideation to more detailed decision-making. Whereas the earlier section focused on students' ethical positioning and concerns about GAI reliability, the present analysis highlights how GAI's role shifted during the collaborative process.

The way students used GAI was shaped by its perceived role in the group. For many, GAI acted as a starting point for brainstorming or visualizing concepts, particularly in the early phases of design (Kasneci et al. 2023). One group described how image-generation tools provided early aesthetic direction, but without deeply influencing the final decision-making:

> "Well, the competition or tender material we got—we just put it into ChatGPT and asked: 'Can you suggest a building expression?' and also shaped it in relation to what I had experienced. Then it came up with some different examples, and you could try out various things to focus on. It actually works quite well. Like, it kind of kickstarts your imagination about what you could do, I think."

Here, GAI functioned more as an inspiration generator than a decisive authority. Yet its presence still shaped the group's focus and introduced frames for exploration, illustrating the socio-material co-constitution of attention, creativity, and decision-making (Johri

2022; Pelman and Zoran 2025; Barad 2003; Dourish and Mazmanian 2012). As students moved from loosely structured ideation to more detailed analysis, GAI's influence often faded, but it lingered in subtle ways. One student reflected on the lingering effects of AI-generated visuals: *"Very subconsciously, I think maybe some of those image's kind of stuck with us when we moved into the decision-making phase."* This demonstrates how socio-material entanglements evolve through time. GAI may enter early as a creative trigger, but leave subtle imprints that shape subsequent human deliberation (Kaup et al. 2025, Barad 2007; Orlikowski and Scott 2008). At the same time, students began developing practical strategies to manage GAI's role over time. While their concerns about accuracy and hallucination relate to the epistemic issues discussed above, here the emphasis shifts to how they actively try to mitigate these uncertainties. Students expressed a preference for systems that integrate verifiable sources and align more clearly with the regulatory context of construction (Johri 2022; Pelman and Zoran 2025; Sharma and Yadav 2022; Cotton et al. 2023). For instance, the importance of a traceable GAI experience was emphasized:

> "It's about sources, references. Where you get your sources from. […] if you had one that was a bit more closed off from the internet and only fed with valid sources that you could trust – then […] you'd trust more what it gives you, when you're not yourself unsure if it's just making things up."

These reflections illustrate a shift from seeing GAI as a one-way information provider to conceiving it as a collaborative partner; one that must be explainable, reliable, and ethically embedded in the workflow. In socio-material terms, students negotiate with both the social (peers, roles, discussion) and the material (AI outputs, interfaces, generated content), co-constituting knowledge, attention, and ethical reasoning throughout the design process (Wei et al. 2025; Orlikowski 2007; Barad 2007; Leonardi 2012).

Conclusion

This study explored how socio-material dynamics involving GAI shape students' collaborative decision-making in early-stage circular design. Our findings show that GAI affects information flow and the negotiation of authority, responsibility, and ethical positioning within interdisciplinary teams (Johri 2022; Orlikowski 2007; Barad 2007). Students often used GAI as a creative catalyst in early ideation, but maintained critical distance when traceability and accountability were required. Hesitation and non-use reflected deliberate strategies to protect professional judgment and shared responsibility (Cress and Kimmerle 2023).

Through a socio-material and enactment lens, the analysis reveals how learning, ethical judgment, and epistemic authority emerge through the entanglement of human actors, GAI outputs, and material factors. Even subtle technological inputs redistribute attention, influence reasoning, and shape collective decisions, highlighting the co-constitution of social, ethical, and material elements in practice.

These insights point to the need for pedagogical strategies that integrate GAI as an active participant in collaborative reasoning rather than a neutral tool (Latour 2005; Orlikowski and Scott 2008). Structured opportunities to critically engage with GAI, support professional judgment and ethical reflexivity, preparing students to navigate black-box technologies responsibly while maintaining accountability and collaborative integrity (Jones 2014; Sharma and Yadav 2022; Wei et al. 2025).

Referencer

Asdrubali, Francesco, Andrea Fronzetti Colladon, Ludovica Segneri, and Dante M. Gandola. 2024."LCA and energy efficiency in buildings: Mapping more than twenty years of research."*Energy and Buildings*, 321, 114684. https://doi.org/10.1016/j.enbuild.2024.114684.

Barad, Karen. 2003. "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter." *Signs: Journal of Women in Culture and Society* 28 (3): 801–831. https://doi.org/10.1086/345321.

Barad, Karen. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke University Press.

Boyatzis, Richard E. 1998. *Transforming Qualitative Information: Thematic Analysis and Code Development*. Thousand Oaks, CA: Sage.

Callon, Michel. 1999. "Actor-Network Theory—The Market Test." *The Sociological Review* 47 (S1): 181–195. https://doi.org/10.1111/j.1467-954X.1999.tb03488.x.

Cotton, Debby R. E., Peter A. Cotton, and J. Reuben Shipway. 2023. "Chatting and Cheating: Ensuring Academic Integrity in the Era of ChatGPT." *Innovations in Education and Teaching International* 61 (2): 228-39. https://doi.org/10.1080/14703297.2023.2190148.

Cress, Ulrike, and Joachim Kimmerle. 2023. "Co-Constructing Knowledge with Generative AI Tools: Reflections from a CSCL Perspective." *International Journal of Computer-Supported Collaborative Learning* 18 (4): 607–614. https://doi.org/10.1007/s11412-023-09409-w.

Dourish, Paul, and Melissa Mazmanian. 2012. "Media as Material: Information Representations as Material Foundations for Organizational Practice." In *How Matter Matters: Objects, Artifacts and Materiality in Organization Studies*, edited by Paul Carlile, Davide Nicolini, Ann Langley, and Haridimos Tsoukas, 92-118. Vol. 3 of *Perspectives on Process Organization Studies*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199671533.003.0005.

Ellen MacArthur Foundation. 2013. *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*. Cowes, UK: Ellen MacArthur Foundation.

Faraon, Montathar, Kari Rönkkö, Marcelo Milrad, and Eric Tsui. 2025. "International Perspectives on Artificial Intelligence in Higher Education: An Explorative Study of Students' Intention to Use ChatGPT Across the Nordic Countries and the USA." *Education and Information Technologies* 30: 17835–17880. https://doi.org/10.1007/s10639-025-13492-x.

Geissdoerfer, Martin, Paulo Savaget, Nancy M. P. Bocken, and Erik J. Hultink. 2017. "The Circular Economy: A New Sustainability Paradigm?" *Journal of Cleaner Production* 143: 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048.

Haleem, Abid, Mohd Javaid, and Ravi Pratab Singh. 2022. "An Era of ChatGPT as a Significant Futuristic Support Tool: A Study on Features, Abilities, and Challenges." *BenchCouncil Transactions on Benchmarks, Standards and Evaluations* 2 (4): Article 100089. https://doi.org/10.1016/j.tbench.2023.100089.

Hassan, Rohayanti, Aida Ali, Chan Weng Howe, and Azlan Mohd Zin. 2022. "Constructive Alignment by Implementing Design Thinking Approach in Artificial Intelligence Course: Learners' Experience." In *AIP Conference Proceedings* 2433 (1). https://doi.org/10.1063/5.0072986.

Horn, Line H., Camilla Gyldendahl Jensen, Thomas Kjærgaard, Niels B. Lukassen, Ingrid M. Sørensen, Camilla Valbak-Andersen, and Stine B. Bundgaard. 2020. *White Paper on Reflective Practice-Based Learning*. Aalborg: University College of Northern Denmark.

Jensen, Camilla Gyldendahl, Susanne Dau, and Peter Gade. 2024. "The Role of AI Chatbots in Scaffolding: Linking Learning Outcomes with Assessment." *Learning Tech* 9 (14): 73–97. https://doi.org/10.7146/lt.v9i14.141213.

Johri, Aditya. 2022. "Augmented Sociomateriality: Implications of Artificial Intelligence for the Field of Learning Technology." *Research in Learning Technology* 30. https://doi.org/10.25304/rlt.v30.2642.

Jones, Matthew. 2014. "A Matter of Life and Death: Exploring Conceptualizations of Sociomateriality in the Context of Critical Care." *MIS Quarterly* 38 (3): 895–926. https://doi.org/10.25300/MISQ/2014/38.3.12.

Kallinikos, Jannis, Paul M. Leonardi, and Bonnie A. Nardi, eds. 2012. *Materiality and Organizing: Social Interaction in a Technological World*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199664054.001.0001.

Kasneci, Enkelejda, Kathrin Sessler, Stefan Küchemann, Maria Bannert, Daryna Dementieva, Frank Fischer, Urs Gasser, et al. 2023. "ChatGPT for Good? On Opportunities and Challenges of Large Language Models for Education." *Learning and Individual Differences* 103: 102274. https://doi.org/10.1016/j.lindif.2023.102274.

Kirchherr, Julian, Denise Reike, and Marko Hekkert. 2018. "Conceptualizing the Circular Economy: An Analysis of 114 Definitions." *Resources, Conservation and Recycling* 127: 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005.

Kaup, Camilla F., Anders Kalstrup Møller, Anders M. Boelt, and Kristine Bundgaard. 2025. "ChatGPT: Forstyrrelse eller Forandring? Generativ Kunstig Intelligens' Rolle i Kollaborativ Videnskonstruktion." *Tidsskriftet Læring og Medier (LOM)* 17 (31). https://doi.org/10.7146/lom.v17i31.148825.

Latour, Bruno. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press. https://doi.org/10.1093/oso/9780199256044.001.0001.

Law, John. 1992. "Notes on the Theory of the Actor-Network: Ordering, Strategy, and Heterogeneity." *Systems Practice* 5: 379–393. https://doi.org/10.1007/BF01059830.

Leonardi, Paul M. 2012. "Materiality, Sociomateriality, and Socio-Technical Systems: What Do These Terms Mean?" In *Materiality and Organizing: Social Interaction in a Technological World,* edited by Paul M. Leonardi, Bonnie Nardi, and Jannis Kallinikos, 25-48. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199664054.003.0002.

Liu, Jiangyue, Siran Li, and Qianyan Dong. 2024. "Collaboration with Generative Artificial Intelligence: An Exploratory Study Based on Learning Analytics." *Journal of Educational Computing Research* 62 (5): 1014–1046. https://doi.org/10.1177/07356331241242441.

Orlikowski, Wanda J. 2007. "Sociomaterial Practices: Exploring Technology at Work." *Organization Studies* 28 (9): 1435–1448. https://doi.org/10.1177/0170840607081138.

Orlikowski, Wanda J., and Susan V. Scott. 2008. "Sociomateriality: Challenging the Separation of Technology, Work and Organization." *The Academy of Management Annals* 2 (1): 433–474. https://doi.org/10.5465/19416520802211644.

Pelman, Barak, and Amit Raphael Zoran. 2025. "The Impact of Sociomaterials on Architectural Learning Processes in Virtual and Physical Design Studios." *Education Sciences* 15 (2). https://doi.org/10.3390/educsci15020240.

Pomponi, Francesco, and Alice Moncaster. 2016. "Circular Economy for the Built Environment: A Research Framework." *Journal of Cleaner Production* 143: 710–718. https://doi.org/10.1016/j.jclepro.2016.12.055.

Raworth, Kate. 2017. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. White River Junction, VT: Chelsea Green Publishing.

Saldaña, Johnny, and Matt Omasta. 2016. *Qualitative Research: Analyzing Life*. Thousand Oaks, CA: Sage Publications.

Sharma, Sudhansh, and Ramesh Yadav. 2022. "ChatGPT—A Technological Remedy or Challenge for the Education System." *Global Journal of Enterprise Information System* 14 (4): 46–51. https://www.gjeis.com/index.php/GJEIS/article/view/698.

Suchman, Lucy A. 2007. *Human–Machine Reconfigurations: Plans and Situated Actions*. 2nd ed. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511808418.

Tlili, Ahmed, Boulus Shehata, Michael A. Adarkwah, Aras Bozkurt, Daniel T. Hickey, Ronghuai Huang, and Brighter Agyemang. 2023. "What If the Devil Is My Guardian Angel? ChatGPT as a Case Study of Using Chatbots in Education." *Smart Learning Environments* 10 (1): Article 15. https://doi.org/10.1186/s40561-023-00237-x.

Vázquez-Rowe, Ian, C. Córdova-Arias, X. Brioso, and S. Santa-Cruz. 2021. "A Method to Include Life Cycle Assessment Results in Choosing by Advantage (CBA) Multicriteria Decision Analysis: A Case Study for Seismic Retrofit in Peruvian Primary Schools." *Sustainability* 13 (15): 8139. https://doi.org/10.3390/su13158139.

Wei, Xiaodong, Lei Wang, Lap-Kei Lee, and Ruixue Liu. 2025. "The Effects of Generative AI on Collaborative Problem-Solving and Team Creativity Performance in Digital Story Creation: An Experimental Study." *International Journal of Educational Technology in Higher Education* 22 (1): Article 23. https://doi.org/10.1186/s41239-025-00526-0.