

Interrogating and Recoupling Learning and Knowledge with Networks and Power: Exploring Sociomateriality as a Foundational Theory for Research in the Learning Sciences

Michael M. Rook (organizer), U.S. National Science Foundation, michaelmrook@gmail.com
Tutaleni I. Asino (co-chair), Oklahoma State University, tutaleni.asino@okstate.edu
Scott P. McDonald (co-chair), The Pennsylvania State University, smcdonald@psu.edu
Lucila Carvalho, Massey University, l.carvalho@massey.ac.nz
Anna Keune, Technical University of Munich, anna.keune@tum.de
Vishesh Kumar, Northwestern University, vishesh.kumar@northwestern.edu
James Lamb, The University of Edinburgh, james.lamb@ed.ac.uk
Phil Tietjen, North Carolina State University, ptietjen@gmail.com
Mike Tissenbaum, University of Illinois Urbana-Champaign, miketiss@illinois.edu
Pippa Yeoman, The University of Sydney, pippa.yeoman@sydney.edu.au
Brian K. Smith (discussant), Boston College, b.smith@bc.edu

Abstract: With increasing understanding of the inextricable connections between learners and the tools that facilitate their learning within complex social systems, new theoretical and methodological developments have emerged to allow us to explore the materiality in learning environments. Sociomateriality (Fenwick, 2015) urges us to consider the interdependence of social and material elements in learning. Rather than viewing classroom spaces and educational tools as static, inert material objects, sociomateriality posits them as capable of exerting force by the way they are acted on or by. This approach has the potential to help respond to the global crises by interrogating and recoupling learning and knowledge with networks and the power relationships inherent in all learning. To this end, this symposium aims to bring researchers together around a common theme of unpacking how sociomateriality might be used as a theoretical foundation or analytical approach for Learning Sciences research.

Keywords: learning theory, sociomateriality, actor-network theory, postdigital, posthumanist

Introduction

In the spirit of ISLS 2024 which recognizes that learning is a cornerstone for healing, resilience, and community and that our Learning Sciences community must consider research and practice when responding to global crises in the face of COVID-19, racism, bigotry, war, climate change, and political oppression, we propose an ICLS symposium that investigates innovative pedagogies and learning environments and encourages us to interrogate and recouple learning and knowledge with the power relationships inherent to both. The goal of this symposium is to bring researchers together around a common theme of sociomateriality, an emerging theoretical and methodological development, and to invite the Learning Sciences research community to adopt the use of sociomateriality as a foundational theory for research in the Learning Sciences.

In the Cambridge Handbook of the Learning Sciences, Mitchell Nathan and Keith Sawyer (2022) list five intellectual traditions upon which scholarship in the Learning Sciences builds: American pragmatism, constructivism, sociocultural theory, situated learning, and embodied, extended, and distributed cognition (pp. 30-35). In 1994, Jan Nespore problematized these traditions and their psychological notions of knowledge and learning as compartmentalizing knowledge and learning in ways that leave out their connections to agency, power, and networks. Nespore suggested that prior learning theories, such as situated learning, artificially bounded learning within a “localized, pre-capitalist form of social organization” (1994, p. 132). In situated learning, the unit of analysis focuses on the setting, activity, participation, and identity of the learner (Nespore, 1994). Theories of situated learning are connected to the physical and social situations within which learning occurs (Nathan & Sawyer, 2022), but fail to include the power relationships inherent in the physical and social situations, knowledge, and learning (Nespore, 1994, p. 132).

In Nespore’s account, “face-to-face interaction is a misnomer: in addition to people and things in the immediate setting people are always interacting with distant entities that have been materially or semiotically transported into the encounter” and within these interactions, “questions of power become unavoidable” (1994, pp. 132-133). Sociomaterial perspectives such as actor-network theory (Latour, 2005; Callon, 1986) allow us to see individual learners as actor-networks with knowledge existing in relation to a power structure. Nespore provides some insight to explain this notion of an actor-network:

People don't participate as 'individuals' in pristine or local small-scale 'communities of practice' (Lave and Wenger, 1991), nor do they take on stable 'identities' by becoming 'full participants' in such communities. Such views ignore the fact that 'communities' aren't just situated *in* space and time; they are ways of *producing and organizing* space and time and setting up patterns of movement across space-time: they are networks of power. People don't simply move into these networks in an apprenticeship mode, they are defined, enrolled and mobilized along particular trajectories that move them across places in a network and allow them to move other parts of the world into that network. A 'community', if we still wanted to use the term, would have to be seen as composed of extremely heterogeneous and dispersed elements linked together in what, following Callon (1986), I will call 'actor-networks': fluid and contested definitions of identities and alliances that are simultaneously frameworks of power. (Nespor, 1994, p. 9, emphasis in original)

Recent research has called for the Learning Sciences community to explore emerging theories and new conceptualizations of learning and how they drive methodological developments (Damsa et al., 2023; Peppler et al., 2020). This symposium responds to this call by introducing four different approaches to thinking through how postdigital and posthumanist perspectives such as sociomateriality and actor-network theory might be used as a theoretical foundation or analytical approach for Learning Sciences research. The contributing papers include perspectives from Australia, Germany, New Zealand, Scotland, and the United States to further illustrate that learning and knowledge are not bounded but exist across an international network of power.

Tracing connections and following the action: How sociomaterial, and postdigital sensibilities help us appreciate the learning whole in action

Pippa Yeoman, Lucila Carvalho and James Lamb

We all have blind spots, and knowing where they are helps us guard against incomplete accounts of the phenomena we study—in this instance learning. Some are blind to the social structures that constrain or empower knowledgeable action, and others fail to see the ways in which materials participate in the development of skillful action. We argue that learning activity is indirectly influenced by complex nested relations between the conceptual, social, and material structures of learning and the practices they support (Goodyear et al., 2021). As such, our work aims to take in the broad landscape while affording us the opportunity to focus on particular aspects without losing sight of the learning whole.

This symposium contribution highlights how sociomaterial and postdigital sensibilities contribute to our understanding of how people learn by drawing on three chapters in a forthcoming edited collection exploring *Postdigital learning spaces: Towards convivial, equitable and sustainable spaces for learning* (Lamb & Carvalho, forthcoming). Each chapter offers a window into a different networked learning environment and foregrounds different aspects of the social-material-conceptual whole. As such, our remit is broader than actor-network theory, but it engages deeply with the sociomaterial and extends to include a postdigital sensibility as well.

To take a sociomaterial approach to educational research is to challenge the centrality of human processes in learning in favour of an approach that encompasses the social *and* the material, with the aim of supporting studies that ask *how* entities, knowledge, other actors, and relations of mediation and activity come together in learning. Sociomaterial accounts resist divisions between subject and object, nature and society, and matter and meaning. Because, from this perspective, both meaning and sense are the effects of assembled practice, providing grounds for explanation and not *a priori* categorisation. Above all, they commit to articulating the role of things, the relations between them, and their relations to time and space. They describe a world in which people and things acting in concert produce change, a constant series of transformations in which learning resides (Fenwick et al., 2011).

Much of what we would recognise as the conceptual underpinnings of sociomateriality also characterise a postdigital sensibility. In its very simplest form, the postdigital starts from a position that digital technologies and practices have become woven into the fabric of our everyday (and therefore educational) surroundings. It shares with sociomateriality an interest in the more-than-human, as it recognises a shifting and often complex entanglement of the biological with the informational and technological (Jandrić et al., 2018). From a research perspective, it similarly enables us to observe the messy and unpredictable reality of learning environments and events. Where a postdigital sensibility goes further, however, is in being more forthright in seeking to establish the presence and influence of digital actors, as we look to make sense of our educational surroundings and practices. This conceptual compatibility helps to explain why education researchers are increasingly combining

sociomateriality and postdigital thinking as they seek to understand learning and knowledge in a changing world. These sociomaterial and postdigital approaches are productively put to use as we explore diverse learning contexts. Drawing on the chapters presented we highlight how a mix of autoethnographic and visual methodologies reveal human and non-human elements at play whilst remembering that from a sociomaterial perspective images are never neutral, they are contingent on various human and technological biases. One chapter explores the informal learning networks of people living with Long Covid. Using an autoethnographic approach it traces knowledge sharing and knowledge creation through online support groups, the use of low cost networked medical appliances, and open access to medical preprint servers, revealing how the epistemic practices of ‘being ill’ and ‘treating illness’ have shifted. A second chapter reports on a short experiment conducted during a transcontinental rail journey between Scotland and Switzerland, as the author reflected on the educational activity they undertook while traveling to an academic conference. With implications for the wide range of informal spaces where a great deal of learning now takes place, the in-transit performance of teaching, writing and research was shown to depend on shifting patterns of social and material actors. In the postdigital setting of the train carriage, learning is contingent on technology, mobility, safety, sound and a multitude of other human and non-human resources and interests. And a third chapter explores sociomaterialism and postdigital thinking using photographic representations of learning spaces. These images and short accompanying commentaries were generated by contributing authors as they worked on their chapters for the edited collection. The editors drew on the images and commentary to introduce sociomaterialism and postdigital thinking and illustrate the value of visual methods in learning spaces research.

In exploring three diverse networked learning environments using a sociomaterial and postdigital sensibility, we foreground the mutually shaping nature of the materiality of learning and the power relations through which teaching and learning practices are enacted. Moreover, in tracing disruptions in traditional practices we highlight the value of understanding the complex nested sets of relations through which learners and communities develop resilience in the face of global challenges including post viral infection associated illnesses, balancing teaching and learning practices and sustainable participation in academic conferences, and the reality of hybrid work both in-transit and at home.

Capturing material-driven learning: Methods derived from taking on posthumanist perspectives for the study of learning

Anna Keune

As educational research, including the field of the Learning Sciences, grapple with participating actors in learning that are of structural, digital, and material nature (e.g., Eglash et al., 2020; Kuby & Rowsell, 2017; Taylor & Iverson, 2013; Sørensen, 2009), the field is experiencing a shift toward understanding learning as deeply materially-driven. Such a material turn includes viewing learning from actor-network and posthumanist perspectives to empirically base the idea of decentering humans in epistemological and analytical approaches (e.g., Barad, 2003) when studying learning. It is particularly relevant to capture how actors beyond humans contribute to learning, as semi-autonomous and artificial intelligence-based actors are entering educational spaces at lightning speed and with little to no regulation. Despite the timeliness of considering how non-human actors participate in learning, methods for capturing learning that are aligned with posthumanist perspectives remain under-documented. With this symposium contribution, I highlight methods to capture learning from a posthumanist perspective. Specifically, the work presented here takes on the idea of rupturing the traditional focus on humans to highlight the interplay between knowledge production and materiality (Kuby & Rowsell, 2017; Sørensen, 2009). The methods illustrate how posthumanist approaches can advance theoretical and practical insights into longitudinal learner trajectories as well as concept-relevant learning.

With this symposium contribution, I show methodological advances derived from two empirical research projects that were set in maker-centered learning contexts, which are learning environments where youth have access to low and high-tech tools and materials for creating personally meaningful and shareable projects and generating technological innovation (Peppler et al., 2016). Posthumanist philosophies informed the data collection and analysis in both studies. The first study investigated the spatial setup of a maker space and its influence on the longer-term learning trajectory of youths (Keune & Peppler, 2019). The data collection of this study happened through a focus on material movements in space, captured by 360 photographs of the maker space over several years as well as tracing social media artifacts to enable the analysis of relational reconfigurations of people and materials in physical and digital spaces. The second study investigated fiber crafts as a context for computational learning in a middle school context (Keune, 2022; 2023). The video data collection, including birds-eye-view data (Keune & Ruiz-Cabello, 2022) and close-up video, informed the development of two analytical approaches for illuminating material-driven aspects of computational learning. The studies from which the contributions are

drawn make it possible for me to offer details that were otherwise not included in the empirical publications that focused less on the methodological contributions.

Looking across these studies, two methods informed by posthumanist perspectives for the study of learning emerged that seem relevant to further explore in other contexts. The first study engaged in *longitudinal spatial mapping of the movement of youth-relevant projects and workstations* over the course of several years to better understand how locational and material changes related to the longer-term development of youths' trajectories and learning journeys to remain in technical fields. The method required close collaboration with the educators of the maker space and the development of detailed instructions for capturing 360 photographs of the space from particular angles at agreed upon intervals. The photographs were then also published online as part of a larger database supporting educator training on designing maker spaces. The analysis focused on traceable material and locational changes in the projects and workstations as well as on how this coincided with major events related to the youths in the space (e.g., public speaking events, employment). The data collection and analytical approach was informed by posthumanist perspectives that considered the person one part of a relational field among components that come together, and that produce new possibilities for learning and personal development (Hultman & Lenz Taguchi, 2010).

The second study employed the translation of youths' sewn and woven projects into pseudo-computer code to show how everyday practices, such as crafting, are a context for computational performance (Keune, 2022; 2023). The translation of crafts into pseudocode also made it possible to compare and contrast the production of projects over time across crafts to show material-specific approaches to learning domain ideas. The analysis was made possible by closely analyzing close-up photographs of craft projects. The analysis included reconstructing the projects to understand the material processes required to make them. Illustrating the material processes through pseudocode leveraged a STEM cultural representational form as a powerful means to relate non-digital and seemingly non-computational context to computational learning and produced an analytical method that showed that the possible computational learning was materially-driven (e.g., computing as automation in weaving and computing as 3-D modeling in sewing). The method was informed by a posthumanist analysis of intra-actions (Barad, 2003), that is, how routine ways of coming together of component parts change to produce a particular phenomenon of interest (i.e., computational learning moment). The approach led to considering whether and how youth could perform the translations themselves in future work. The study developed the method as an analytical move to illustrate learning and analyze over advancing a pedagogical tool to foster learning outcomes.

This symposium contribution shows that posthumanist perspectives can inform the design of methods for the study of learning that show longitudinal intersections of material spatial setups with learning trajectories as well as shorter-term implications of materials and domain learning possibilities. Through the presentation of the methods, this paper contributes to the larger effort of documenting ways to capture learning in theory-driven ways. This is contributing to strengthening the material turn within the Learning Sciences that advocates for the integration of additional theoretical perspectives in the already theoretical and methodological pluralistic field. Specifically, the methods presented here contribute to a better understanding of learning as materially-driven, highlighting how materials used in learning drive what is possible to learn conceptually and domain-specifically, whom to conceive of as actors in the space, and, more importantly, how to trace this in data. The next step is to investigate how the presented methods, which were developed for studies of learning in one context, could be used for capturing learning in other contexts, including networked algorithms, semi-automated robotics, and artificial intelligence-based settings of learning, where the active agents can easily get blurred.

Reinterpreting new technologies in a maker classroom to convey the dynamics of social technological interventions

Vishesh Kumar and Mike Tissenbaum

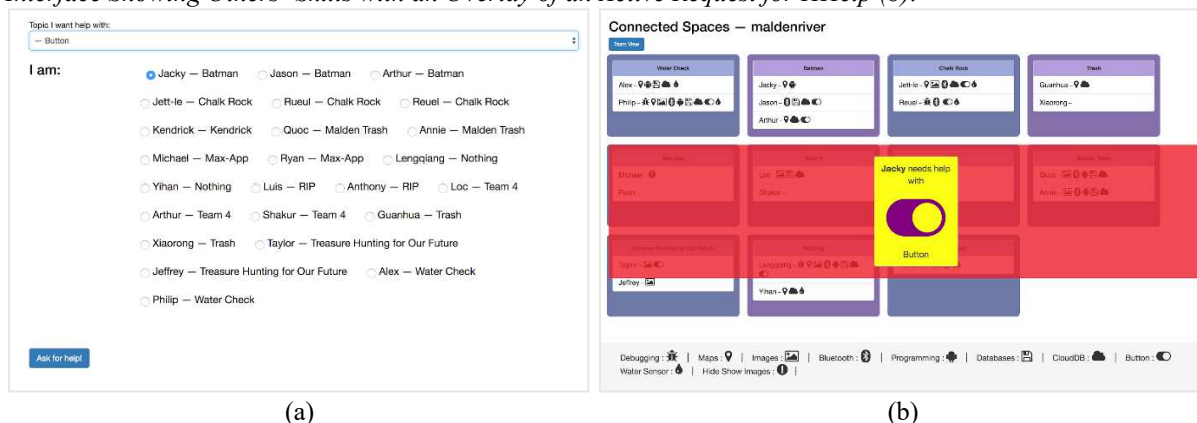
In this symposium contribution, we discuss how iterating on a newly introduced technology in a classroom and analyzing this iteration through actor-network theory (ANT) lenses (Fenwick et al., 2011) can inform how we engage in computer science education classrooms around the design and creation of community and use-oriented technologies. This analysis gives us insights about the necessity for, and also methods to discuss the impact of technology with youth in maker environments and engineering and technology classrooms. Specifically, how to expect and analyze the impact of interventions in society is not as one-sided as basic design education conveys, and that the impact of technology is co-constructed alongside how it is interpreted and adopted in the contexts it is deployed (Fischer & Herrmann, 2015). This relates to conceptions of thinking about design through the lens of design in use (i.e., how to expect differences from expectations and iterate on designs after seeing them in use)

but also adds a critical layer of paying attention to power relationships across users and deployers of technologies in different contexts.

Our work is situated in a project-based classroom centering the computational action framework (Tissenbaum et al., 2019)—orienting computing as a tool to engage in social impact on (computing) learners’ and practitioners’ communities and lives. Computational action proposes unique value around learner agency and engagement in designing computer science learning environments that center authentic social situations learners want to improve as a goal to address by learning different design and computing tools and methods.

We engaged in a design-based research (DBR) project in this classroom—in a large public school in a medium-sized city in the Northeastern United States—with a tool called Connected Spaces (CxS), aimed to promote inter-youth help seeking and offering. Our context had 15 high schoolers of mixed age, gender, and ability, and working on developing programming and mechanical engineering skills to develop products to solve problems they identified and designed solutions for, over a period of 8 weeks. We introduced CxS in the last week of this project creation when youth had completed the design and learning phase of the course and were focused on project creation. We base this analysis and work on data collected through field notes from the authors playing the role of teachers and observers simultaneously, highlighting instances of using CxS, and different help seeking and offering interactions in the classroom. CxS provided two interfaces to youth—a personal interface to declare needs of help in specific domains around the tool they were using; and a classroom wide central interface, which showed youth the skills everyone claimed to be proficient at, as well as ‘announcements’ of help needed by others (Figure 1). We designed this tool to organically promote youth in asking for and offering help to each other. After two days of an initial deployment, we noticed how youths’ proclivity to rely on help from teachers, and lack of pre-existing norms around helping each other led to them never reaching out to others, especially for offering help. While some youth did start using the help seeking interface—in particular those who found it hard to solicit teacher attention—students almost never looked up at the global interface to actually respond to a call for help. By the third day, we started using the global interface as a dashboard for our own awareness of who was looking for help and connecting them to peers who had relevant knowledge. When directly suggested by teachers (including us), youth eagerly responded and helped each other.

Figure 1
The Two Interfaces of Connected Spaces – Including the Personal Interface to Ask for Help (a), and the Global Interface Showing Others’ Skills with an Overlay of an Active Request for HHelp (b).



This analysis helped highlight how norms and power relationships around the desired behavior (of classroom collaboration) played a key role in co-creating a new interpretation of CxS for any successful usage (Kumar & Tissenbaum, 2022). The students who shifted to using CxS instead of directly soliciting teacher attention demonstrated a specific assemblage of becoming more capable help askers in the act of expression, even if the response of receiving help was limited for some time through this medium (Ryan et al., 2005). Students rarely used CxS to find opportunities to offer help without explicit prompting by teachers, which demonstrated how engaging in new behaviors in specific environments is often foreclosed without validation by the actors with relative power (Ares, 2008).

In conclusion, this symposium contribution drew from Fenwick’s (2015) ANT and Barad’s (2003) framing of intra-actions to highlight underemphasized aspects in DBR implementations of technologies in learning classrooms—the role played by the spatial design of the space, pre-existing norms and varying priorities of learners in the context of learning goals and outcomes, and most critically, the ways certain behaviors persist

and new behaviors are foreclosed without the active involvement of other actors in the space with different kinds of power. Exploring the underemphasized aspects in DBR is critically needed in Design Education across a variety of curricula, especially those that facilitate youth in imagining and creating tools for social change or use by others (e.g., those designed around Computational Action). We suggest that both researchers and practitioners consider the use of ANT and more specifically, an analysis of the material-discursive practices of youth engaging with new technologies, to make visible the different intra-action entanglements and layers of power within these rich learning environments.

Residue-learner-network assemblages across space and time

Phil Tietjen, Michael M. Rook, Scott P. McDonald and Tutaleni I. Asino

During emergent activity in learning environments, knowledge artifacts are created in situ to support learning. Examples of knowledge artifacts include personal notes, writing on physical white boards or in virtual spaces, and digital trails or traces of learning activity. These artifacts might be considered learning ‘residue’ or ephemera because historically many are not retained or preserved (i.e., the artifacts are erased). In some cases, residue may persist in the learning environment itself (e.g., in the Stanford d.School spaces only the author can erase writing on a white board) or may persist as a digital representation of the artifact (e.g., a photo of a white board).

Learning residue also may take the form of data trails captured from mobile devices. Possibilities exist for data collection that passively track learners across physical contexts and then find patterns across multiple learners with the help of artificial intelligence tools (Wise et al., 2023). Imagine maps of learners’ transit within and between locations that create nodes where residue can accumulate, helping designers better understand opportunity landscaping (Pinkard, 2023). The accumulation and collection of residue introduces new attention to issues of storage and ownership including the learner’s willingness to share ownership of their data with others (Agesilaou & Kyza, 2021).

This symposium contribution explores how actor-network theory (ANT) helps us to understand the role learning residue plays within learning environments and how residue exists within assemblages and networks of power. An assemblage is a construct that points to the entangled relationship among humans and materials in a learning context that is always co-evolving (Sørensen, 2009; Tietjen et al., 2023). Learning residue produced within a learning design studio at a large Northeastern U. S. University is used to answer two research questions (RQs): (1) *When and in what ways does learning residue contribute to material-learner assemblages across spaces and times?* (2) *How are these assemblages being acted on and by whom?*

A vignette helps illustrate the data used as evidence to answer the first RQ. Emergent activity within the learning studio involved graduate students working collaboratively to design a mobile app that would support learning among elementary-aged students. Learners used portable whiteboards to produce visual representations of group knowledge. The white board artifact existed as learning residue with a preservation end date (i.e., once the course session concluded whiteboards were erased). However, while collecting data the researchers preserved learning artifacts, and thus the residue was extended in video and image form. Residue then emerged in two multimodal transcriptions within an article (Tietjen et al., 2023) for future readers to engage with—the endeavor preserved learning residue and helped to form a residue-learner-network assemblage across space and time. The residue contributed to an assemblage because the life of the residue was preserved intentionally.

The vignette also helps to address the second RQ. The assemblage produced during the research endeavor was acted upon by the research team, the research community, and individuals that used/will use the digital form of the residue to inform future research or practice. Material affordances of the space enabled the residue to be acted upon. Policies regarding the preservation of learning residue helped to ensure the residue could be acted upon. In other words, learning residue is acted upon by the producer(s) of the learning residue and those who engage with the preserved representation(s) of the residue—we call this enactment. Notions of ownership and power emerge during enactment depending on who preserves the residue and for what purpose. Traditionally, institutional review board (IRB) documents are used to ensure learners are not harmed in the process of research. In the future, IRB also might consider future uses of learning residue and who owns residue across time.

The implications of this work are threefold: (1) space design, (2) teaching practice, and (3) research practice. First, the type of environment plays a role in the development of residue and mitigating power disparities around the ownership and preservation of learning residue. The environment used in this paper was a future learning space (Hod, 2017). Future learning spaces enable learners to have more agency over their residue than traditional spaces. When designing for student ownership of residue, we might borrow from the design principles typically inherent in future learning spaces, which call for a diversity of spaces that support social practices, provide individual and shared affective responses, and enable bring-your-own-device setups (Rook et al., 2015; Rook et al., 2020). Second, teachers can extend the use of residue to support learning by being intentional about

the preservation of crafted artifacts. Residue artifacts can live beyond the classroom walls and contribute to shared, group cognition. Third, the research endeavor contributes to the formation of residue-learner-network assemblages. These assemblages are acted upon by those engaging with the research in the future. Researchers should acknowledge that products produced during the research process might include residue and extend its life and thus, should consider issues of ownership and power inherent in preservation and curation of learning residue.

In conclusion, ANT provides insight into the power dynamics and micro-negotiations that lead to the formation and corresponding impact of a residue-learner-network assemblage and helps generate alternative conceptualizations of space that move beyond viewing classrooms as static, inert containers. Carvalho et al. (2016) argue that a sociomaterial perspective such as ANT problematizes common conceptualizations of space and place: "... the growing scale and variety of uses of mobile, personal, connected technologies raise questions about the nature of place. 'Where' is no longer a simple question... Personal, mobile, digital devices are being used in ways that further soften the boundaries of place" (p. 1). The assemblage characterized in this paper moves the boundary beyond place to consider the way residue enables others to engage with learning objects across time. Residue becomes a form of distributed intelligence. White and Pea (2011) have described how distributed intelligence shifts the analytical attention to consider multiple participants and representations of learning (p. 495). By adding a sociomaterial framing, this paper extends distributed intelligence to show how representations of learning exist within co-evolving relationships of power and ownership. This paper also extends Tietjen et al.'s (2023) three analytical framings for emergent activity by introducing a fourth framing: residue-learner-network as an assemblage across space and time. This framing calls for an investigation of the residue in our designed environments while simultaneously looking at the relationship among residue, learners, and the network acting on the residue over time. We invite Learning Sciences researchers to use this paper as a starting point to consider the intended and unintended residue assemblages within their work which we believe will move the field forward.

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