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EDITORIAL



Drawing together international perspectives on material and embodied aspects of science education: Introduction to the special issue

Entering into dialogue

A special issue affords opportunities for authors to come together to collectively engage in critical dialogue around a central theme. In this sense, this special issue could be viewed as a group of colleagues that gather together to discuss, debate, explore, and challenge each other, to unpack both the familiar and the new, with a goal of understanding and furthering possibilities for exploring the nuances of interactions in science education. We are excited to host this gathering, with the purpose of sharing diverse views which together draw upon a rich history and differing trajectories and traditions for examining embodied and material aspects of science teaching and learning. We bring together herein voices from colleagues across the world, and we invite readers to join us in this conversation.

One year ago, an open-source version of the artificial intelligence (AI) chatbot ChatGPT was released to the general public. The floodgates opened. A tidal wave of awareness of how our lives are infused with AI-driven technology has filled our conversations, as we contemplate their relationship to our academic work and daily lives. How AI shifts the ways we relate to digital data and devices will continue to play out and remains to be seen, while at the same time calls us to be mindful of how we relate with our bodies and materials. Living amidst this paradigm shift, our research and the manuscripts drawn together here, offer first-hand views of how people interact with information, with materials, and with each other. We bring together research with the intentional aim of providing space to examine our bodies and materials in our contexts. With shifted technologies, come shifted bodies and changing relationships to material worlds. It is within this moment in history (in space and time) that we set the 10 manuscripts in this special issue into dialogue with each other, and with you the reader.

How this special issue came to be

The spark that initiated this special issue was ignited following on the European Science Education Research Association's (ESERA) 2021 Conference hosted online by the University of Minho, Braga, Portugal. The conference was a welcomed coming together after having been sequestered to our 'home offices' during the COVID-19 pandemic. The ESERA 2021 conference offered us an exciting place to gather and converse about our research, albeit virtually. Many of us who are contributing authors in this special issue presented together in a handful of symposia at ESERA 2021 on a range of topics investigating materiality and embodied views on science education. Following our presentations, we began discussing commonalities among our theoretical approaches to

material and embodiment. This prompted us to think wider, in terms of theoretical positions and approaches. We invited colleagues and scholars from across the globe to join our proposal for this special issue, which was accepted by the journal *Research in Science and Technological Education* (RSTE), under the editorship of Lindsay Hetherington and Peter Sorensen. We are excited and pleased that Lindsay Hetherington later accepted our invitation to write a response paper as a contribution to round off the issue.

Our goal for this special issue is to bring together varied, diverse frameworks and methodologies in ways that are productive, at times drawing from different epistemological and ontological positionings, in hopes of broadening and allowing for complementary complexification of perspectives. This keeps us walking on a path together as friends discussing how events and ideas evolve, rather than bound in respective methodological corners. In this way, we offer this special issue as a dialogue among researchers and research groups that have paused to ask, what is happening with the material and embodied here? What research methodologies can we use to explore this in ways that continue to shine a light on how we support students and teachers in contexts of science teaching and learning?

What sense of the body? What sense of material?

With a plurality of methodological groundings of what it means to be a body, to have a body, and to consider the body in interaction with materials, the manuscripts in this special issue have been contributed from researchers spanning various contexts across the globe. In a broad sense, this special issue explores the ways bodies and materials are interacting, and accordingly each group of researchers zooms into a context to explore entanglements of materials and bodies. As a collection, the research presented herein rises to the call of scholars who have long investigated the role of material and embodied aspects of science education (e.g., Scantlebury and Milne 2019). This is explored through a range of methodologies in the papers found here.

Many of the authors' groups are active as teacher educators, and committed to exploring the ways in which the body and materiality affords learning, doing, and being in order to draw implications for teacher education. Situated across places and spaces, the diverse manuscripts all have relevance for science education praxis and relatedly teacher education praxis, as they contribute to understanding the ways in which science meaning-making is afforded through sensory, embodied, materially grounded experiences.

The 10 manuscripts that follow have been loosely gathered into three groups, loose nets around the papers that build from similar views and theoretical perspectives, followed by a culminating response paper. Manuscripts are clustered to explore: semiotic perspectives across bodies and materials; material-discursive processes in early childhood settings; and storied approaches to highlighting emotions and entanglements, as we introduce next.

Semiotic perspectives on interactions of bodies and materials

The first loose grouping of manuscripts draws upon semiotic theoretical perspectives to examine movements, and transitions across semiotic entanglements. They invite us to

consider views on how these processes occur in science teaching and learning, urging us as teachers and educators to reflect upon how we can support diverse rich semiotic movement in science teaching and learning contexts.

Joseph Ferguson, Lihua Xu and Russell Tytler in "Student reasoning about the lever principle through multimodal representations: A socio-semiotic approach" (this issue) share with us their examination of 12-year-old students in Australia reasoning about the position of the earth, sun, and moon. As they reason about moon phases and Earth's seasons, the students transition between 3D models and 2D drawn representations. Ferguson, et al. examine how students' work and discussions with the earth models relative to their bodies are used to construct intricate and detailed schema depicting their understandings of the relative positions of the celestial bodies. Micro-level semiotic analysis of gestures, hand positioning, and interactions with models were analyzed to show how students' movement between the 3D and 2D depictions afforded students opportunities to coordinate earth-based and space-based perspectives.

Kok-Sing Tang (this issue) offers a consideration of two theoretical frameworks: multimodal interaction analysis (MIA) and social semiotics multimodal analysis (SSMA) in "Exploring the materiality of science learning: analytical frameworks for examining interactions with material objects in science meaning-making" (this issue). He sets the two approaches in conversation with one another as he presents analysis of video excerpts from two secondary science classroom in Singapore and the United States, and through this analysis explores the compatibility and complementarity of the theoretical frameworks in driving analysis. He shows how each provides micro-level consideration of the ways students and teachers interact with materials with the goal of zooming in on their function in the talking and doing of science. Analysis of the video-excerpts show how the MIA and SSMA frameworks, while both affording views on material interaction, place different emphasis on context, systematic application of rules across meaning-making potential, and human's interaction with the materials. Tang's paper contributes to a growing understanding that the holistic analysis of material aspects of interactions supports shifts in discourse analysis and interaction analysis from what is spoken, to the 'doing' of science to provide a much-needed focus on the role of materials in science teaching and learning.

In "Recurrent gestures in organic chemistry in tertiary education: creating emblems through material and embodied actions" (this issue) Eduardo Mortimer and Renata Pereira present analysis of teacher gestures in year-long study of embodied movement and gesture in a University-level chemistry course. Their analysis focuses on the embodied performance of a teacher and how over time she employs a series of gestures in similar ways while lecturing and discussing complex chemistry concepts with students. Their analysis shows how the use of recurrent gestures supports the concretization of abstract understandings as the teacher and students discuss aspects of chemical bonding. Their work zooms into embodied ways of relating complex topics in higher-education settings.

Material-discursive processes in early childhood settings

The next grouping of manuscripts brings us into early childhood contexts. Through the work of these three research groups, we peer into how the body and material are engaged by younger learners and teachers during science explorations.

Maria Impedovo and Anne-Marie Cederqvist explore the intersection of digital literacy and sustainable development education through the lens of materiality and embodiment in "Socio-(im)material-making activities in Minecraft: retracing digital literacy applied to ESD" (this issue). Their study focuses on the socio-materially embodied process of maker-centered learning, analyzing a case study of a seven-year-old child's engagement in Minecraft. The research highlights how digital environments can foster digital literacy skills and sustainable development understandings in early childhood education. By engaging in Minecraft, the child experiences a blend of virtual and physical materialities, enhancing their understanding of nature, technology, and science. The game's virtual setting allows for a unique exploration of materiality, where digital objects and interactions are intertwined with real-world experience and knowledge in the physical world. The paper underscores the importance of recognizing and integrating the socio-material aspects of digital tools in educational contexts.

Josephine Convertini, Francesco Arcidiacono, and Céline Miserez-Caperos in "Teachers' interventions in science education at primary school. The role of semiotic resources during argumentative interactions in class" (this issue) delve into how teachers facilitate argumentation in science classes through the use of various semiotic tools, including speech, gestures, and physical objects. A significant aspect of the study is the exploration of the materiality in practical-based classroom activities, emphasizing how objects and physical interactions shape the discursive process in science learning. The researchers observed and analyzed interactions between teachers and students (aged 6–7) during science tasks, revealing the crucial role teachers play in steering children's argumentation by integrating different semiotic resources. This study conducted in Switzerland, contributes to the understanding of how materiality coordinates with speech and embodied actions to shape argumentation in early years science education, where hands-on activities and argumentative discussions are key to fostering a deeper understanding of scientific concepts.

Sara Wilmes and Christina Siry zoom into how material and embodied interactions facilitate learning in a science classroom with plurilingual children in "Engaging with materials and the body: young plurilingual children's resource-rich interactions in science investigations" (this issue). Their study employs multimodal interaction analysis to examine in detail the engagement of a young student named Henry in an early childhood classroom in Luxembourg. The paper describes episodes where Henry interacts with various materials including a digital microscope, dirt, worms, and compost. These materials not only mediate his learning experience but also enhance his communication with peers and teachers. The incorporation of multimodal interaction analysis in this study offers a comprehensive understanding of the various ways through which children communicate and learn. Emphasizing the integration of tangible resources in diverse linguistic environments, the paper illuminates the multifaceted nature of learning and underscores the essential role of material and embodied interactions in science education in developing science understandings and engagement in science practices for all children.

Storied approaches to highlighting emotions, entanglements, dignity and justice

Three of the manuscripts featured in the special issue examine how narratives and stories can serve as approaches that shed light on complex ways in which learning, doing, and being unfold in science learning contexts, emphasizing the relational and embodied nature of learning and becoming in science.

Kathrin Otrell-Cass explores digitally mediated stories within science education in “Embodiment and asynchronous storytelling in science classrooms” (this issue) through presenting several examples of student-produced stories to investigate the role of storytelling within asynchronous activities in primary, secondary and tertiary science education. She argues that communicating about experiences through stories conveys embodied information, as she examines the role the body may play in such exchanges. Using a storytelling method, Otrell-Cass emphasizes how the materiality of the online asynchronous environment affords participants’ embodiment, and her work highlights that storytelling can be viewed as one discursive format that the body uses. Through examining digital stories created within science education activities, her research clearly emphasizes that students’ sensory experiences and embodiment ‘opened up the world’, shaping their understanding and interpretations.

“Embodied, Dramatizing Performances in Science Class: Multimodal Spaces and Places of Knowledge and Identity Construction”, authored by Maria Varelas, Amanda Diaz, Rebecca Kotler, Rebecca Woodard, Ronan Rock, Zachary Sabitt, Nathan Phillips, Rachelle Tsachor, Marcie Gutierrez, Hannah Natividad, Derek Threewitt, and Jaegen Ellison (this issue) illustrates ways in which elementary students’ knowledges as well as identities were shaped by dramatizing embodiments about science that they designed and performed themselves. The authors bring expansive perspectives on science as intertwined with the body to explore narratives of students dramatizing in three different classroom contexts in a large urban city. Their work provides a rich view on the generative nature of embodiments, as well as factors that shape generativity. Focusing on semiotic choices made by elementary children during dramatizing performances within science classes, findings highlight the ways in which the resources students had available, their own interests, and a multiplicity of modes all intertwined to afford the exploration and communication of ideas.

Jrène Rahm’s “The strawberry in the pot that became something’ – Entanglements of bodies, materials, and affect in science activities supported by a community organization” (this issue) focuses on community organizations to explore science as emergent from children’s interests with dignity. Arguing for the value of students’ sensual and affective engagement as being generative of acts of wonderment, her manuscript explores the work being done by affect during extra-learning opportunities offered to an elementary class, highlighting within that process the role of bodies and materials. Rahm considers lived and embodied emotions in order to attend to how the science activities from the community organization affect students’ bodies. Her work centers the body to explore the ways in which relational ways of approaching science education can support educational interactions that are generative, and she shares insights into entanglements and relationships, while highlighting dignity – and identity – affirming practices and opportunities in science.

Views on the embodied and material in science education overlap in multiple ways

Different perspectives on dialogue and interaction are brought together in this issue to illustrate the affordances of a diversity of frameworks related to embodiment and materiality. The overall aim of this special issue has been to hold up a range of nuanced ways in which material and embodied can be explored, and as guest editors, we are excited to see how the contributions have come together, in particular for gaining perspectives on embodied and material interactions for communicating, affording and affecting students' ideas, wonderings, meaning-making, and relations as connected to science learning and becoming. We find inspiration from looking across the manuscripts for working towards a science education practice that emerges from entanglements among the body and materials. New meanings emerged as we reflectively considered the contributions of the different manuscripts both individually and the issue as a whole, and also in our related conversations as guest editors and as authors and reviewers through the creation of this issue. 'A meaning only reveals its depths once it has encountered and come into contact with another, foreign meaning: they engage in a kind of dialogue, which surmounts the closeness and one sidedness of these particular meanings.' (Bakhtin and Holquist 1986 in Shields 2007). In this way, the perspectives that come together in this special issue can be put into dialogue to broaden understandings of the role of bodies and materials in science teaching and learning through acts of ideological becoming.

This issue culminates "Material-dialogic space as a framework for understanding material and embodied interaction in science education" a response paper contributed by Lindsay Hetherington (this issue) in which she layers her own perspectives onto the viewpoints put forward by the manuscripts herein to offer a related framework. She presents views on material-dialogic space in science education and takes the reader through thinking about views on doing, thinking, and being, in science education contexts through analytical lenses that bring the material and embodied to the fore. We have been inspired in looking across the perspectives, as she was, and we hope that you will be as well.

We echo the perspectives of Verda Delp (2004) who elaborates the notion of *ideological becoming* as related to reading across diverse manuscripts, interpreting such texts, and related interactions between author and reader, suggesting that such interactions are evocative opportunities to come together, thereby providing opportunities to reconfigure and reframe our ideological consciousness. In reflecting on the emergence and process of organizing this issue, coming together across difference has afforded a mutual becoming for us, the guest editors and also authors in this special issue, as we have sought to push methodologically and conceptually on boundaries on framing to ask: what does it mean to participate in science education? And how can we show that participation in meaningful ways? What implications can be drawn for teaching and teacher education?

It is both timely and necessary to keep these questions alive and in our discussions given new developments in technology and in our societies, in order to remain grounded in the embodied reality of the here and now. Methodological pluralism allows us views through a multiplicity of approaches and positionings, to support each through its own quality considerations. (Davis and Callihan 2013) Explorations of embodied and material interactions in science education is a focus

with long traditions, and with this special issue we seek to complexify this focus, while bringing different perspectives together. This body of work as a collection does not aim to flatten or condense views of material and embodied, yet to contribute to dialogue that seeks to complexify and amplify diverse voices that are in their own ways all speaking about material and embodied aspects of interaction. It is through our continued openness to come together across difference and to learn from one another that we are able to remain grounded in what we see, feel, experience and learn.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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