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# Engaging with materials and the body: young plurilingual children's resource-rich interactions in science investigations

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## ABSTRACT

**Background:** Children's interactions are inherently multimodal. Accordingly, when children engage in science in classroom communities, their interactions are grounded in material and embodied aspects of interactions with teachers and their peers.

**Purpose:** This study explores the nature of children's science interactions in a classroom community where students are working in a language they are also learning through examination of the ways in which open-ended pedagogical approaches mediated embodied and material science participation and sense-making.

**Study and method:** We employed multimodal interaction analysis layered with a critical ethnographic perspective to explore the embodied and materially-grounded experiences of a student working in an early-childhood classroom with peers and teachers in science through a language he is also working to learn.

**Results:** Multimodal interaction analysis allowed us to build views of how the classroom interactional spaces afforded embodied and material participation and learning in science, and uncovered the multimodal ways in which this mediated his engagement in science and communication of science meanings and wonderings.

**Conclusions:** Open-ended pedagogical approaches afforded spaces in which this student was able to engage with phenomena, materials, and embodied interactions, regardless of his verbal participation. This embodied participation and materially grounded interactions entangle and unfold to become learning. Pedagogical implications for the teaching and learning of science with all children, and in particular with plurilingual children, through the use of open-approaches that afford resource-rich embodied engagement and learning are discussed.

## KEYWORDS

Material; embodied; multilingual; science education; early childhood

## Introduction

5-year-old Henry walks up to a small table in his kindergarten classroom, and peers into a plastic container set out by the teacher. Inside the container is a sample of worms and dirt from the class vermicomposter. Henry takes a spoon, reaches it into the container, and carefully begins to shift the soil from side to side. Around him at the table, his classmates

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dig into other containers. Exclamations of excitement can be heard as students spot an insect or when a worm comes to the surface. Children are heard exclaiming 'Teacher! Teacher! Look what I found!' Amid these productive sounds of discovery, Henry is looking down, silently concentrating on his sample, occasionally looking up and over at a classmate, and then returning his gaze down at his spoon and the soil.

Young children's explorations are inherently embodied, and often their investigations and wonderings are not bounded in verbal expressions (Siry and Gorges 2020; Günther-Hanssen 2020; Wilmes and Siry 2018, 2021). In the above excerpt, Henry is intensely focused on moving the soil back-and-forth silently, clearly observing the sample as well as the interactions of his classmate. Herein we share analysis of Henry and his classmates' investigations of samples from the vermicompost to examine the embodied and material nature of their interactions. Focusing on Henry's storyline enables highlighting how the classroom pedagogical structures allowed for his embodied participation in building science understandings, and communicating these, while working in a language he is still learning. The analysis details Henry's experiences and is intended to contribute to a growing body of science education research which explores how access to a range of modes in addition to languages can mediate children's participation in classroom science in ways that build from their resources, leads to science learning, and opens access to diverse ways of coming to know.

### **Sociocultural views on science teaching and learning**

We situate our research within sociocultural lenses of science education (e.g. Tobin 2015), which provides us with views of the classroom cultures, participants, and interactions that unfold within them through time and space. These are theoretically positioned as contingent, situated, emergent, and grounded in embodied and material aspects (Hwang and Roth 2011). The perspectives we bring situate culture as enactment – with culture consisting of practices and systems of meaning making that mediate interaction (Sewell 2004). We theorize both systems and practices as dialectically related, in that each constitutes the other. In other words, as inseparable. In this view of social systems, both contribute to interaction that plays out among actors, and their contexts and environments over time. Nested within this sociocultural positioning, our view of science education is one which views interaction in spaces such as classrooms, and among students and teachers, as relational, and contextual, and taking place through material and embodied motions and actions. Through these perspectives we situate children's engagement in science as a material and embodied lived experience through the lens of culture as dialogue (Bell and Gardiner 1998) that manifests in material and embodied ways (Leigh and Brown 2021). As such our work explores and encourages open-ended approaches to instruction, and herein we consider how a Kindergarten teacher set up and enacted an open-ended pedagogical approach and how this supported students' science experiences, affording us views on how the students were able to interact within these contexts over time.

### **Multimodal theorizations of embodied and material**

We work through analytical lenses rooted in Bakhtinian notions of dialogue, grounded in the notion that all communication is multiperspectival, and multi-voiced, with dialogue unfolding through relational processes. Bakhtin's literary work provides a grounding perspective for social analysis, one which allows for highlighting the multi-voiced nature of everyday life, and for recognizing that each word has multiple meanings (van Eijck and Roth 2011). In a dialogic encounter, the listener is equally as important as the speaker (Bakhtin 1981). This means each dialogic interaction is oriented towards back and forth exchange between speaker and listener, not to either/or, but to both. Grounded in this perspective, in our research we position human understanding as embodied (Leigh and Brown 2021) and thus take a broad view on dialogue as entangled and emergent in embodied and material aspects of communication and interaction (Wilmes and Siry 2020).

The body in this dialogic sense is the medium through which the world is received, processed, interacted with and through, and expressed (Hwang and Roth 2011). We see the body as a form of *knowing*, it is both simultaneously the medium and the locus of experience (Impedovo et al. 2017), the body is in continuous dialogue with others and with the surrounding environment. The body is at once the recipient of the messages of others, processing messages, and continually becoming through expression to others. How the body senses, processes, communicates, moves, performs, processes, and expresses are included in the totality of what we consider as embodied, and as such, engagement in science practices is *embodied learning*. We situate learning as a contingent and relational process that emerges in context through interaction (with materials, with environment, with oneself and others). Learning emerges from the coming together of resources – including the body, languages, materials – in interaction, into a continual process of becoming (Freedman and Ball 2004). To shine a light on the ways in which such embodied learning unfolds with young children, we employ multimodal methodologies to interrogate what we are able to see and to hear in order to provide insights on the multilayered embodied aspects of teaching and learning in and through inherent multiplicities (Williams and Tang 2019). This allows us views on the diverse resources at play in classroom contexts.

Material theorizations in this dialogic view involve considerations of all physical aspects that could be or are involved in interactions. For example, in the case of a student exploring with a digital microscope, the digital microscope, the table and digital device, the floor of the classroom, the building itself, the student's hand moving the microscope, and the entirety of the student's body are considered as material aspects of this interaction. Actively or passively involved, these materials are potential resources that at once set the stage for what is possible, and what unfolds in this setting through dialogic interaction and meaning-making.

We have written elsewhere on this theoretical grounding as it allows us to foreground the material and embodied aspects of interaction while honoring the semiotic (e.g. Wilmes and Siry 2021). To highlight these aspects of interaction, we employ a method of multimodal interaction analysis (MIA) that enables us to see and to hear a wider range of semiotic aggregates drawn upon interaction. Important for understanding the arguments that follow in this manuscript are issues of equity that relate to language use in

communication in our national context. We live in a society that tracks and marginalizes students based on how well they communicate in the languages of instruction, a factor which is not unique to our context, and which might resonate with many readers' own experiences. In our research we consciously work to *background* language as we explore how interactions unfold in classroom contexts (e.g. Wilmes and Siry 2018), allowing for focusing in early analysis on what is being *done* rather than what is being *said*, with the goal of illuminating the rich and beautifully complex engagement of children in these environments (Wilmes et al. 2018, 2020; Wilmes 2021). This helps us to quiet the human tendency, and tendency in much of science education research, to frame our analysis in what is uttered. To employ this method, we grow quiet, and we look at data resources with the sound off, to see what comes to the fore, and then in a recursive process we move between what we see and what we hear, layering together our experiences and theoretical perspectives.

We have found that beginning video analysis from silence allows us to better see how bodies and materials interact (e.g. Wilmes and Siry 2021). This approach affords us views on our work with the teachers and students in ways that purposefully background our human/teacher disposition toward speech and what is spoken in classroom contexts and learning interactions with children. We take inspiration from scholars that have emphasized the ways in which embodied doing, languaging, and materials and tools come together to mediate children's conceptual development and science engagement (e.g. Hetherington et al. 2018; Smith 2023), and through our research we seek to work towards views on young children's participation in science that build from the resources available in interaction. In the study we present here, we use a process of multimodal interaction analysis (MIA) in order to approach the questions: **In what ways do open-ended instructional approaches mediate students' material and embodied participation in science practices?** This question is intentionally framed broadly, to enable us to examine how these spaces support participation and communication in science. We explore this question by zooming into the experiences of a plurilingual student working within a classroom community, to examine the ways in which the resources available in interaction played a role in his embodied meaning-making.

## Study context

Our research focuses on primary and early childhood education contexts in Luxembourg, a tiny European country nestled between Belgium, France, and Germany. Luxembourg is a trilingual country, with the official languages of German, French, and Luxembourgish, languages that are used in different contexts in myriad ways. Of all the countries in the European Union, Luxembourg has the highest sustained inflow of immigrants with respect to our total population and one of the highest percentages of foreign population. The population is just over 625,000 people, and as of last year, 47% of those living in Luxembourg have a nationality that is not Luxembourgish (STATEC 2023). Statistics emphasize that Luxembourg has by far the highest recent percentage increase in population in Europe. When considering how these aspects intersect to create the fabric of our national landscape, Luxembourg is a multilingual country, woven together from over 170 nationalities, creating a context which is rapidly changing, resulting in a diverse and highly complex cultural and linguistic landscape.

### ***Luxembourg's multilingual primary schools and plurilingual students***

Luxembourg's national public school system is trilingual, and requires students to be fluent in Luxembourgish, German and French by the end of primary school at the age of twelve. In early childhood classrooms the language of instruction is Luxembourgish. This means that the first optional year of schooling, at age 3, and the first two years of mandatory schooling, at the ages of 4 and 5, are conducted in Luxembourgish. The goal being to immerse our plurilingual children in speaking and interacting with their teachers and peers in Luxembourgish. We intentionally use a plurilingual lens to honor the diverse ways students and teachers draw upon a range of communicative resources (Council of Europe 2018). In addition, more than half of our students speak languages other than Luxembourgish at home (MENJE 2022). German is formally introduced in first grade as a written language, the language in which children first learn basic literacy skills. Important to consider for the research presented herein is that it is common for most of the children in a kindergarten classroom to not yet be fluent in Luxembourgish, often drawing upon a wide range of communicative resources used at home, that often are not any of the school system's languages of instruction.

The data we will explore comes from an ongoing research and teacher professional development project called The SciTeach Center, at the University of Luxembourg. The overarching aim of the Center is to support the teaching of science in Luxembourg's primary schools through inquiry-oriented approaches, with a goal of working with teachers towards inclusion and equity (Siry 2020). We strive for this aim through the multi-faceted development of pedagogical resources and teacher professional development opportunities, all co-developed with teachers, work which provides the backdrop for the classroom data we share next. A key component of the SciTeach Center is our Teacher Leader Network, consisting of teachers that are supported by the Ministry of Education to collaborate with the Center researchers. Teacher Leaders co-plan, co-develop and co-teach teacher professional development (TPD) for other teachers, a process which supports them in developing their praxis as teachers of science (Siry 2011) and which leads to contextually-responsive TPD (Siry et al. 2022; Wilmes et al. 2018, 2018).

### ***Classroom context and participants***

The analysis we detail next arose from our work in the early childhood classroom of one of our collaborating Teacher Leaders, Therese.<sup>1</sup> Therese is an experienced kindergarten teacher, which in Luxembourg extends for two years and is called Cycle one. Cycle one classrooms are multi-aged, composed of 4- to 6-year-old students in their first two years of mandatory schooling. We co-developed and co-taught a unit of investigation with Therese and her class of fifteen students. As introduced earlier, the process of co-teaching is key to our research and work in the Center, with co-teaching providing the opportunity to share responsibility for the success of lessons, and for those who co-teach to learn 'at the elbow' of each other (Roth and Tobin 2002). In this study, co-teaching allowed us to collaborate with Therese in the development of the unit of instruction, providing a valuable lens on the pedagogical reflections and considerations in developing and teaching the lessons. All of the students in Therese's class were plurilingual, meaning that their families identified that they spoke national languages other than Luxembourgish, or in addition to Luxembourgish, at home, including Portuguese, French, English, Creole, Arabic,

Chinese, Italian, and German. As the language of instruction was Luxembourgish, close to one-hundred percent of the children in this classroom were working and learning in a language that they were also learning. While this may seem extraordinary, this linguistic diversity is common within our schools (MENJE 2022), a diversity which creates a high level of communicative complexity for teachers and children to navigate.

This research was approved by our University Ethics Review Board and conformed to the guidelines for seeking informed consent from participant's guardians through both verbal and written explanations of the research. While co-teaching in the classroom, we explained to the class our research and ways we would videotape and record our experiences together, in order to additionally obtain assent from children for their participation in this study.

While co-teaching with Therese, we video recorded classroom interactions for a six-month period, conducted interviews with her, and recorded reflective field notes, all of which we accessed for later analysis. The unit at the focus of analysis presented here was *Living Things: Worms and Vermicomposting*, which consisted of 8 2-hour videotaped classroom sessions; 16 hours of video in total. The unit objective was to engage students in science practices as emergent from investigating worms from the class vermicomposter. The analysis presented here highlights the story of Henry, a story which emerged and shifted into the forefront through our analytical journey in that we saw over time, both in working with him in the classroom and through video analysis, that he was very engaged in the science investigations. This could be seen through his gaze, body position and engagement with the materials and worms, his peers and his teachers during discussions and interactions. At home Henry speaks a dialect of Chinese with his family, and at the time of this study, he was five-years old, and in his first year with this classroom. We observed and additionally learned from Therese that Henry was not yet speaking Luxembourgish, the language of instruction, with his peers, nor with his teachers. For this reason, we became curious about his ways of engaging with his peers and teachers in general, and in particular with how materials and embodied resources played a role in his communication and meaning-making across the interactional spaces of this classroom.

### **Analytical approach: multimodal interaction analysis**

The qualitative analytical process involved a multimodal interaction analysis (MIA) approach grounded in sociocultural views of interaction, which we have detailed in prior work (Wilmes and Siry 2021). This MIA analytical approach affords opportunities to examine essential components of semiotic resource use and mobilization. Guided by Roth's (2005) notion of *zooming in* we conducted analysis that allowed us to zoom into focal interactions embedded within the overall classroom context over several sessions. Recursive rounds of viewing classroom videos, layered with analysis of conversations with the teachers and children, and classroom artifacts afforded us views of interactions of this class engaged in science investigations. This iterative process provided views of interaction through which we could explore material and embodied components of interactions. Key to this process is that we engaged in ongoing reflection, dialogue and co-design, and we were active participants in the classroom, as we co-planned and co-taught the lessons with the teacher, which facilitated a high level of reflexivity (Leigh and Brown 2021). The analyzed dataset was composed of videos from eight lessons recorded with multiple video cameras, digital photos, and interviews with students and the classroom teacher.

Our analytical process helped us to construct the case of Henry guided by Patton's (2014) notion of a critical case. Critical cases 'are those that can make a point quite dramatically or are, for some reason, particularly important in the scheme of things' (p. 54). Thus, multimodal interaction analysis of Henry's interactions in his classroom community allowed us to consider the ways the class was afforded opportunities for interaction within open-ended pedagogical spaces set up by Therese. The analysis focused on classroom activities in which Henry was present (whole class, small group, and individual activities) and noting Henry's body position, motion, and interaction with classroom materials (those provided for the lessons and tables and chairs, for example) and those of his teachers and classmates, across various classroom spaces. This enabled drawing attention to how bodies and materials came together and interacted to support meaning-making and communication on Henry's worm discoveries and wonderings.

For the duration of the unit we co-taught with Therese, the class was set-up to engage students in investigating in individual and collective ways and that allowed for open science exploration around the theme of Living Things: Worms and Vermicomposting, and we engaged in a recursive and iterative process of ongoing analysis of field notes and impressions from co-teaching, then listing all teaching activities, in order to view the range of instructional approaches Therese employed. All videos in which Henry was present were viewed using the MIA approach (Wilmes and Siry 2021), the first step of which is to view videos in real-time with the sound off. This process involved the construction of analytical notes for video segments and noting with whom Henry interacted, the interactants' body positions, and resources mobilized in interaction including communicative resources, and body movements. Layered on this were analytic interpretive discussions about what we were seeing in interactions. From this we built the case of Henry within this classroom community and were able to describe which resources were mobilized and how bodies and resources moved and entangled within instructional spaces.

## Findings

The analysis we present emerges from exploration of our focal question, in what ways do open-ended pedagogical approaches mediate students' material and embodied participation in science practices? We explored how classroom spaces mediated Henry's engagement, and communication, and meaning-making in science. We next unfold the story of Henry's engagement in this classroom community, and examine the material and embodied enactments afforded to illustrate the central findings from this research, which are that: i) his participation and meaning-making are mediated and facilitated through material and embodied ensembles in the classroom with classmates and teachers, and ii) in these spaces he is able to develop and demonstrate his understandings, without always producing verbalizations. To illustrate these findings we next share three episodes whereby open classroom spaces mediated embodied material engagement and science learning.

The class investigated worms and vermicomposting over seven extended (one hour-plus) sessions during a three-week period. Throughout the unit, Therese structured activities during which students could investigate alone and with their peers, and she repeatedly engaged students in whole-class group discussion around their investigations, building upon established classroom routines. For example, the class began each morning sitting together on benches in a circle and discussing the topics and activities ahead.





**Figure 1.** An embodied whole-class discussion. Therese engaged the class in discussing the size of the worms in the vermicompost (black bin in front). Students responded by gesturing with their bodies.



**Figure 2.** Students work with digital microscopes. Students could work individually or in small-groups at ateliers which supported science investigations with worms and opportunities to work with digital tools such as microscopes and laptops.

These types of interactions were conducted in Luxembourgish and were used throughout the day to support whole-class dialogue. A second structure used was ‘ateliers’, which are stations set up for group work of three or more children at small tables in different areas of the room. These structures were used frequently throughout the three-week unit, and students were accustomed to engaging in these forms of interactions with prior topics, as they had been used from the beginning of the school year. As we detail in the sections that follow, analysis showed that these structures afforded students opportunities to engage using their body and ensembles of modes grounded in the material and bodily engagement, as was seen in whole-class discussions (Figure 1).

Over several class periods Therese engaged the students in open exploration of the worms and the compost, by first discussing with the class their ideas and wonderings, and then inviting them to share what they think will happen, or what they will see. This was followed by students’ exploration with provided tools and materials, either individually or with peers (Figures 2 and 3). Cycles of whole-class discussion, small-group and individual investigations were used throughout the unit over multiple weeks. Therese put out materials for students to explore, including flashlights, digital microscopes and materials that would enable them to investigate the worms’ reaction to light, to damp surfaces, as well as other investigations that



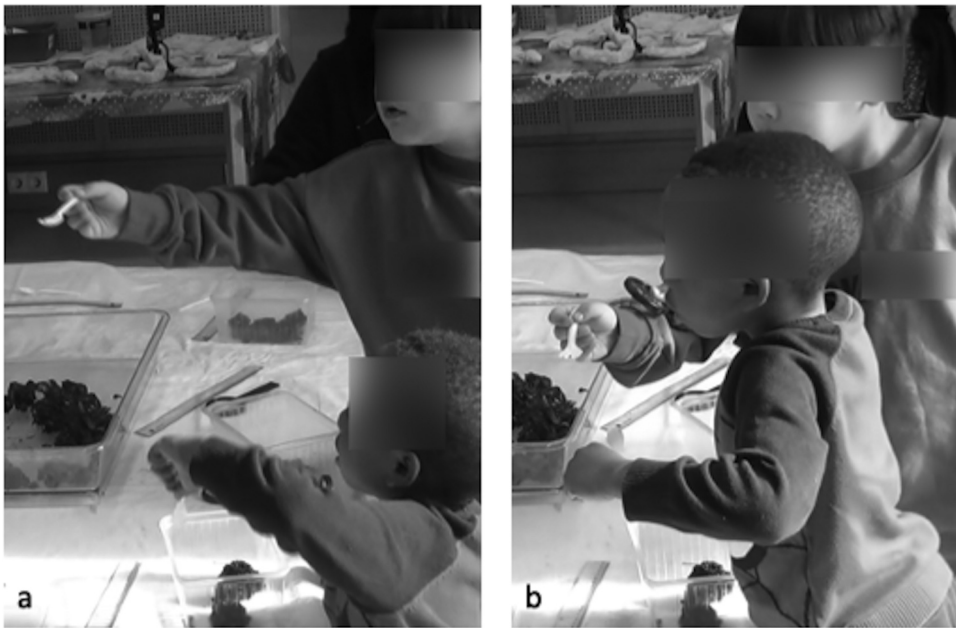
**Figure 3.** Students work with children's literature and drawings.

arose from the students' wonderings and observations. The first episode that became salient during analysis occurred on the second day of the unit as students observed the worms with handheld digital microscopes.

### **Episode 1. Observing worms: Henry finds a baby worm**

After being introduced to the worms and the compost bin (Figure 1) students were invited to work in a small-group at a student-sized table. On the table there were magnifying glasses and basic tools to observe the worms and to look through the dirt from the compost bin. Therese set up a digital microscope attached to a laptop on one end of the small table (Figure 2). Students approached the table to observe the worms. Henry, our focal student, joined the table and his attention focused on a small plastic container of worms on the table in front of him. Henry spent several minutes, looking through the dirt, moving the contents of the container carefully around with a spoon, and peering into the contents of the dirt.

After looking in the dirt, Henry quickly stands up with an outstretched spoon and exclaims in Luxembourgish, *Teacher, look!*<sup>2</sup> (Figure 4a). The teacher responds, *What did you find?* as she leans in toward his spoon, and his classmate pulls down his arm as they all look together at what Henry has on the spoon (Figure 4b). *Shall we look with the microscope?* Therese asks. Henry walks around the table with the spoon, and holds it out to his classmate and says, *look*, keeping his gaze on the spoon, *a baby!*, and they both look at the spoon. Henry comes to stand by the teacher and waits while she sets up the laptop and digital microscope. *Come let's look at what you've found*, Therese says. She explains, *lay what you've found here* (in a petri dish laying on the table) *and we can look at what you have*. Henry stands up and brings what he finds to the teacher (Figure 5). Therese next places the petri-dish on the table and begins to position the digital microscope directly on the petri dish (Figure 5a). She brings the contents of the dish into focus, as they both look at the laptop screen. *Wow!* She gasps, *WOW!* Henry exclaims. Therese says *You found something really nice*,



**Figure 4.** Henry shares what he found in the vermicompost with his teacher (a) and classmate (b).



**Figure 5.** Henry brings his teacher a petri dish and they used a digital microscope to observe what he has presented (a). Together they look at the computer screen (b) and she tells him he found a cocoon (c).

as she continues to focus. A second student comes around to her other side, leans into the laptop and asks, *what is that?* Henry exclaims again, *WOW!* And says *a baby*, pointing to the laptop screen. *Yes, a baby*, Therese repeats, holding the microscope on the petri dish so they can all look. As she moves the microscope around she begins to focus on another object, as it comes into focus, *WOW* they all gasp. *A baby*, Henry says and points directly to the screen, to the newly focused image. This allows them both to see the contents of the dish on the laptop screen (Figure 5b). Therese turns from the computer to look at Henry, and says, *Yes, you are right, you found a cocoon and there are baby worms inside.* (Figure 5c). Therese leaves the cocoon in focus as Henry moves around the table, and comes back again and looks at the screen, again exclaiming and saying *WOAHHHH* with enthusiasm while pointing to the laptop screen. Other students come to look at what Henry found.

Henry is visibly enthusiastic about his discovery. He jumps up with an outstretched arm, points enthusiastically to the laptop screen. Henry communicates with the teacher through gesturing and his body position. This is key, as Henry had not been verbalizing in class with her nor with other adults in Luxembourgish, yet during this exchange he verbalized in Luxembourgish in interaction with Therese. Therese had set-up the open-ended tasks which afforded Henry opportunities to interact with materials in self-directed ways to explore the dirt and worms, and then to initiate communication about his discovery in the interactional space afforded through the open-ended, material-rich structures. The space at the table, the materials, and the compost were key materials in interaction as Henry explored, observed, in essence, engaged in the doing of science, and then in presenting his findings to the teacher, findings which they then together examined with the digital microscope. This interaction happens between the student and the materials (spoon, dirt, cocoon, table) and the student – the teacher – materials (digital microscope, cocoon) and through this interaction grounded in this space a multilayered science investigation occurs.

### **Episode 2. Observing a worm with a digital microscope: Henry answers a question**

The next day, the microscope station is again set out on a table for small-group work. At one point, Therese shows three of the students a petri dish containing worms and encourages the students to use the digital microscope to observe closely. Henry had been at the microscope station already with a classmate, looking at their shirts and their belly buttons. He turns towards Sara, one of the authors, and then moves with the two students to the table with the petri dish and worms. He and his classmate pass the microscope back and forth. Therese asks Henry to pass the microscope to his classmate, who exclaims excitedly about what they are seeing on the laptop screen. Therese says, *I think that is a cocoon*. At which point Henry turns from viewing the laptop, to look up at her (Figure 6 top, right). He nods up and down, indicating yes in response. Therese moves to the table to join them, accepts the microscope and says, *focus really slowly* as she turns the knob as the three gaze collectively at the laptop screen. Henry points to the screen and makes a noise. They continue looking together at the screen (Figure 6).

The microscope and laptop mediate Henry's interaction (are entangled in this space) with his classmates and teachers, and through these interactions Henry answers Therese's wondering in an embodied manner. The open-ended space allows Henry and his classmates to interact with each other and their teacher regarding their observations and discoveries, and to learn through embodied, material ways of becoming.

Later the same day during a whole-class discussion, Therese asked the class, *Did you find something new?* She records the children's responses on a class poster titled, 'What we know about worms'. In response to her question, one student calls out *Cocoon!*, and Therese builds on this exclamation saying enthusiastically to the group sitting together in a discussion circle, *A lot of small babies came out of the cocoons*. Therese points to the photo of the cocoon hanging just to the side of the poster on the board, then she writes, *a lot of babies come out of the cocoons, Henry found a cocoon*. In this way, Henry's findings added to the classes' collective findings and his discovery is valorized. Material and embodied interactions in the spaces afforded to Henry, his classmates, and us and his



**Figure 6.** Henry and his classmate observe worms with the digital microscope (top) and together with their teacher discuss what they see on the screen (bottom).

teachers continued to unfold over the course of the Living Things unit. Two weeks into the three-week unit Henry engaged in a conversation with his classmates and his teacher, as we next detail.

### ***Episode 3. Discussing the vermicompost: Henry uses photos in discussion with his classmates and teacher***

Therese gathered a small group around a table to discuss how the classes' compost bin was built, and what the worms eat, in order to prepare food (vegetable pieces) to put into the vermicompost. For this discussion, she brought the compost bin next to the student-sized table, prepared a plate of vegetables and vegetable peelers, and placed card-sized images on the table in front of the students which included scientific illustrations of the compost bin's layers, and photos of organisms that live in the soil in the bin. First, Therese holds up the image depicting the layers of the compost, and asks the students, *what is in our bin? Where are the worms?* They discuss that the worms, the dirt, and the food they provide for the worms are in the different layers, shown on the image she holds up, and in



**Figure 7.** Henry points to the photo of an insect on the table.

the bin itself, next to the table. Henry sits with the group at the table next to a classmate and looks at the images in front of him. To one side of the table, Therese opens up the bin, to show the students inside, and they join her around the compost bin at one end of the table. Still seated at the table, Henry moves the image cards, and points to one gaining the attention of the student sitting next to him and says, *I look at that* (pointing to the insect depicted in the photo and speaking in Luxembourgish). Henry next says to his classmate, *Look at that*, and points to the image showing an insect that can be found in certain compost ecosystems (Figure 7). The cards mediate him being able to turn to his classmate and initiate interaction relative to the card that depicts what he observed during his prior investigation. He is able to talk in Luxembourgish with a peer, referring to the card, and in a non-formal relaxed space.

Therese next asks the small group of four children seated at the table if they have seen any of the things depicted in the images shown on the cards. Henry repeats quietly, *Teacher, Teacher*. He stands up and walks around the table holding the photo of the insect as he stands next to her and repeats *Teacher, Teacher*. Therese turns to look at Henry and he says, *I saw that*, holding up a card which shows a centipede. Henry passes the card to her, and then walks away back to take his seat at the table. Therese accepts the card from him and says in Luxembourgish, *what is this called in French? Tausendfüßler* (German), *Mills-pattes* (French). *That is what this xxx is called in different languages* she explains to the small-group.

In this episode the cards and the table are materials that mediate Henry's embodied interaction and verbalization with the group, in a way that he is able to contribute what he saw in the compost from prior investigations including those highlighted in the first two episodes by drawing upon his experiences together in dialogue with Therese and the other children (Figure 8). The openness of the pedagogical approach afforded spaces that enabled a high level of material and interaction in diverse ways. In fact, during our time with Henry, we saw Henry begin to verbalize more often in Luxembourgish with peers, and Therese affirmed that he began expression more verbally with her and classmates in Luxembourgish.



**Figure 8.** Henry tells the group about what he saw in the vermicomposter with the digital microscope during prior investigations.

## Discussion

The analysis we present herein brings to the forefront the ways that open-pedagogical approaches afforded students and teachers' material and embodied interactions, that were in turn foundational to students' engagement and learning in science in this classroom community. We show through the illumination of episodes how one plurilingual student in particular (Henry) engaged across several classroom science spaces in material and embodied ways that were afforded all students through the open pedagogical approaches used. By foregrounding three episodes, we showcased specific aspects of Henry's embodied and material interactions with his peers and classmates. When considered together, the analysis we present reveals the complex ways he engaged and learned science in this multilingual classroom community. We see his full dynamic and embodied, materially-grounded participation and learning in and through these spaces. Through the development of Henry's case, we present key findings arising from this work which are: i) his participation, meaning-making, and learning in this classroom community are mediated and facilitated through material and embodied interactions (entanglements) in the classroom, and ii) in these spaces he interacted in ways that allow him to demonstrate and develop his understandings, without always producing verbalizations. The central claim arising from these findings is that the embodied and material engagement and interactions ARE the learning (Roth 2021). The (science) learning is not the result per se, but rather learning is the *entangled becoming* that is developed through material, embodied growing together of Henry, his peers, and us, his teachers.

In each of the episodes presented, Henry's engagement and enthusiasm are evident as he observes, wonders, and builds understandings about worms and vermicomposting. The multimodal analytical approach provided a lens that allowed us to see Henry's participation in ways that go beyond his verbal interaction. That is to say, foregrounding embodied and material aspects of interaction afforded us views on Henry's *interaction-in-situation* whereby the body and the material play a central role in experience (Roth 2009).

This contributes to a growing body of research employing MIA and analytical video viewing with the sound off layered with methodological approaches that allow views on collective entanglements of embodied, material grounded student science learning (Gómez Fernández and Siry 2018). With this approach, we see that Henry's embodied and material interactions are more than just a way of participating in science; the embodied and material engagement is his learning science (Roth 2021). Science is a practice in which Henry participates, a process grounded in the material and embodied, through which learning emerges and evolves as, regardless of how much he verbalizes. Given our time working with Henry he verbalized very little if at all and over time we noticed him verbalizing more in Luxembourgish. Methodological approaches that are grounded in science learning based on verbalizations could have led to a tendency to overlook his participation, his contributions to the class's investigations, and his learning, as happens for many children who are not considered proficient in the classroom language. Through views on his multimodal participation, we illuminated aspects of his engagement, and the open-ended instruction. This work contributes to a growing body of science education research that challenges notions of science learning and participation as grounded in verbal expression (e.g. Cho 2021; Varelas et al. 2022). This work helps us come to understand how we can build educational spaces that support embodied and material learning.

This work calls attention to the role of Luxembourgish in our national context relative to learning in early childhood classrooms. In an operational sense, Luxembourgish is the language of instruction which is supported through our national curriculum in Cycle 1 classrooms throughout Luxembourg (MENFP 2011), and it is the goal of the national school system that children are supported in learning to communicate in Luxembourgish. Relative to what we observed in this classroom and in prior work, Therese engages her students in open science investigations regardless of their ability to verbalize in Luxembourgish. She models the use of Luxembourgish in interaction, and simultaneously supports the students in full engagement with and through entanglements of materials and bodies, which allow them space to draw upon diverse communicative resources to document, to communicate, and to learn. These instructional strategies support children as they develop their use of Luxembourgish communicative resources. We see in the episodes we present herein, and in analysis that we present elsewhere (Siry et al. 2022), that Henry and his classmates learn in science regardless of their own verbalizations in Luxembourgish. This shows that deep meaningful science learning is taking place, and that the language of schooling, while one of many learning goals, is not the only goal, and certainly does not need to precede children's participation in science.

### **Implications and concluding thoughts**

This research has important implications for the teaching and learning of science and for research. Relative to teaching and learning, consideration of how children can use material and embodied resources as they participate in science is key for supporting their participation, engagement, and sense-making (Impedovo et al. 2017). Specifically, an implication of this work highlights how open pedagogical spaces afford interactions that support embodied and materially-grounded meaning-making and resource-rich engagement. Instruction in this classroom took place in Luxembourgish, one of three national languages, yet all students had highly



diverse communicative repertoires and spoke at least one additional language at home, with most not speaking Luxembourgish at home. The insights we share herein show how open pedagogical spaces to engage in material and embodied ways afforded Henry's opportunities for learning. These educational opportunities are important not only for plurilingual students, but for all students. Early childhood science education should build from children's curiosities in ways that include children's embodied and multiple ways of knowing (Siry and Gorges 2020; Caiman and Lundegård 2018; Larimore 2020). Prioritizing verbal participation over embodied and materially-grounded interactions can marginalize the ways children participate in their everyday interactions. This tension, between the embodied and materially-engaged ways children interact as situated within the language-dominant views of classrooms, places children learning the languages of instruction at a deficit and denies them opportunities and spaces to engage their diverse communicative resources.

A second related implication for teacher education is the crucial need for supporting teachers in designing learning environments and experiences that make space for children to employ and build from the multitude of diverse resources that they have available (Areljung, Ottander and Due, 2017). This supports calls for teacher education that engages teachers in reflective use on dialogic instructional approaches and in the consideration of the role of the material in science instruction (Hetherington and Wegerif 2018). Teacher education that focuses on the value of resource-rich science engagement for children provides opportunities for students often marginalized in dominant-language environments by offering spaces to engage and employ diverse resources (Te Heesen, Siry, and Wilmes 2022). This leads to reconsidering notions of learning in classrooms grounded in living ontologies that honor becoming together, with learning not preceded or dependent upon the use of a specific communicative resource, as learning is a mutual growth and becoming together.

In conclusion, this work underscores that material and embodied aspects of interaction are key components of learning. This exploration has illustrated the ways in which learning emerged from the interaction of a multiplicity of resources; including bodies, languages, materials; through a continual process of becoming. Perspectives on learning as becoming push us to embrace multiplicity and subjectivity, and to understand the process as relational and emergent (Rahm 2023). Through the insights gained from this work we emphasize the value of providing spaces for students to engage diverse material and embodied resources in interaction and to reimagine notions of science learning together with teachers to work towards equitable learning opportunities (Grapin et al. 2023). Key to this is to provide opportunities that allow for and valorize diverse ways to engage with the body and with materials, and with and through mobilization and valorization of multiple resources.

## Notes

1. Pseudonyms have been assigned.
2. Verbalizations were analyzed in their original version (Luxembourgish), and translated into English for publication purposes.

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## References

- Areljung, S., C. Ottander, and K. Due. 2017. "Drawing the leaves anyway': Teachers embracing children's different ways of knowing in preschool science practice." *Research in Science Education* 47 (6): 1173–1192. <https://doi.org/10.1007/s11165-016-9557-3>.
- Bakhtin, M. M. 1981. *The dialogic imagination: Four essays*. Edited by M. Holquist. Translated by C. Emerson & M. Holquist. Austin: University of Texas Press. <https://doi.org/10.2307/40136453>:
- Bell, M. M., and M. Gardiner. 1998. *Bakhtin and the Human Sciences: No Last Words*, 1–256.
- Caiman, C., and I. Lundegård. 2018. "Young Children's Imagination in Science Education and Education for Sustainability." *Cultural Studies of Science Education* 13 (3): 687–705. <https://doi.org/10.1007/s11422-017-9811-7>.
- Cho, Kyungjin. 2021. *How Do Young Children Learn Science through Narrative, Embodiment, and Play?* Dissertation. The Pennsylvania State University.
- Council of Europe. 2018. Common European Framework of Reference for Languages: Learning, Teaching, Assessment. Companion Volume with New Descriptors. Strasbourg: Council of Europe. Available at <https://www.coe.int/en/web/common-european-framework-reference-languages>.
- Freedman, S. W., and A. F. Ball. 2004. "Ideological Becoming: Bakhtinian Concepts to Guide the Study of Language, Literacy, and Learning." In *Bakhtinian Perspectives on Language, Literacy, and Learning*, edited by A. F. Ball and S. W. Freedman, 3–33. Cambridge, UK: Cambridge University Press.
- Gómez Fernández, R., and C. Siry. 2018. "Opening Up'a Science Task: An Exploration of Shifting Embodied Participation of a Multilingual Primary Student." *International Journal of Science Education* 40 (7): 771–795. <https://doi.org/10.1080/09500693.2018.1447709>.
- Grabin, S. E., A. Pierson, M. González-Howard, M. Ryu, C. Fine, and S. Vogel. 2023. "Science Education with Multilingual Learners: Equity as Access and Equity as Transformation." *Science Education* 107 (4): 999–1032. <https://doi.org/10.1002/sce.21791>.
- Günther-Hanssen, A. 2020. "A Swing and a Child: How Scientific Phenomena Can Come to Matter for Preschool Children's Emergent Science Identities." *Cultural Studies of Science Education* 15 (4): 885–910.

- Hetherington, L., M. Hardman, J. Noakes, and R. Wegerif. 2018. "Making the Case for a Material-Dialogic Approach to Science Education." *Studies in Science Education* 54 (2): 141–176. <https://doi.org/10.1080/03057267.2019.1598036>.
- Hetherington, L., and R. Wegerif. 2018. "Developing a Material-Dialogic Approach to Pedagogy to Guide Science Teacher Education." *Journal of Education for Teaching* 44 (1): 27–43. <https://doi.org/10.1080/02607476.2018.1422611>.
- Hwang, S., and W. M. Roth. 2011. *Scientific & Mathematical Bodies: The Interface of Culture and Mind*. Vol 22. Springer Science & Business Media. <https://doi.org/10.1007/978-94-6091-567-3>.
- Impedovo, M. A., A. Delserieys-Pedregosa, C. Jégou, and K. Ravanis. 2017. "Shadow Formation at Preschool from a Socio-Materiality Perspective." *Research in Science Education* 47 (3): 579–601. <https://doi.org/10.1007/s11165-016-9518-x>.
- Larimore, Rachel A. 2020. "Preschool Science Education: A Vision for the Future." *Early Childhood Education Journal* 48 (6): 703–714.
- Leigh, J., and N. Brown. 2021. *Embodied Inquiry: Research Methods*. Bloomsbury Publishing. <https://doi.org/10.5040/9781350118805>.
- MENFP (Ministère de l'Éducation nationale et de la Formation professionnelle). 2011. *École fondamentale. Plan d'études*. Luxembourg. <https://men.public.lu/fr/publications/courriers-education-nationale/numeros-speciaux/plan-etudes-ecoles-fondamentale.html>.
- MENJE (Ministère de l'Éducation national, de l'Enfance et de la jeunesse). 2022. Key Numbers of National Education: Statistics and Indicators 2020/2021. Luxembourg. <https://men.public.lu/fr/publications/statistiques-etudes/themes-transversaux/21-22-enseignement-chiffres.html>.
- Patton, M. Q. 2014. *Qualitative Research & Evaluation Methods: Integrating Theory and Practice*. 4th ed. Thousand Oaks, CA: Sage Publications.
- Rahm, J. 2023. "Learning and Becoming in Movement: A Conceptual Lens to Research in Science Education, Committed to Fostering Scientific Citizenship in an Uncertain World." In *Fostering Scientific Citizenship in an Uncertain World. Contributions from Science Education Research*, edited by G.S. Carvalho, A.S. Afonso, and Z. Anastácio. Vol 13. Cham: Springer. [https://doi.org/10.1007/978-3-031-32225-9\\_2](https://doi.org/10.1007/978-3-031-32225-9_2).
- Roth, W. M. 2005. *Doing Qualitative Research: Praxis of Method*. Vol 3. Rotterdam, NL: Sense Publishers.
- Roth, W.-M. 2009. *Dialogism: A Bakhtinian Perspective on Science and Learning*. Leiden: Brill Sense. <https://doi.org/10.1163/9789087908645>.
- Roth, W.-M. 2021. "Gardener-Becoming-Tree, Tree-Becoming-Gardener: Growing-Together as a Metaphor for Thinking About Learning and Development." *Cultural Studies of Science Education* 16:915–930. <https://doi.org/10.1007/s11422-021-10032-0>.
- Roth, W.-M., and K. Tobin. 2002. *At the Elbow of Another: Learning to Teach by Coteaching*. Vol 204. Peter Lang. <https://doi.org/10.5860/choice.40-1685>.
- Sewell, W. H. 2004. "The Concept (S) of Culture." In *Practicing History*, 90–110. Routledge. <https://doi.org/10.4324/9780203335697-11>.
- Siry, C. 2020. "Dialogic Pedagogies and Multimodal Methodologies: Working Towards Inclusive Science Education and Research." *Asia-Pacific Science Education* 6 (2): 346–363. <https://doi.org/10.1163/23641177-bja10017>.
- Siry, C. A. 2011. "Emphasizing Collaborative Practices in Learning to Teach: Coteaching and Cogenerative Dialogue in a Field-Based Methods Course." *Teaching Education* 22 (1): 91–101. <https://doi.org/10.1080/10476210.2010.520699>.
- Siry, C., and A. Gorges. 2020. "Young students' Diverse Resources for Meaning Making in Science: Learning from Multilingual Contexts." *International Journal of Science Education* 42 (14): 2364–2386. <https://doi.org/10.1080/09500693.2019.1625495>.
- Siry, C., S. Wilmes, K. Te Heesen, D. Sportelli, and S. Heinericy. 2022. "Young Children's Transmodal Participation in Science Investigations: Drawing on a Diversity of Resources for Meaning-Making." In *Translanguaging in Science Education*, 61–85. Cham: Springer International Publishing. [https://doi.org/10.1007/978-3-030-82973-5\\_4](https://doi.org/10.1007/978-3-030-82973-5_4).

- Smith, T. S. 2023. *Occupying Spaces of Liminality and Hybridity: Exploring a Caribbean Dutch Girl's Positioning and Identity in a Community-Based Science Programme*. Dissertation University of Groningen.
- STATEC. 2023. La Démographie Luxembourgeoise en Chiffres. <https://statistiques.public.lu/en/publications/series/en-chiffres/2023/demographie-lux-en-chiffres-2023.html>.
- Te Heesen, K., C. Siry, and S. E. D. Wilmes. 2022. "Inquiry-Based Pedagogies as an Inclusive Practice: Approaches for In-Service Teacher Education." *Educação, Cultura e Inclusão: Contextos internacionais e locais* 101–111.
- Tobin, K. 2015. "The Sociocultural Turn: Beyond Theoretical Imperialism and the Imperative of Learning from Difference." In *Sociocultural Studies and Implications for Science Education*, edited by, C. Milne, K. Tobin, and D. DeGenarro. Springer. [https://doi.org/10.1007/978-94-007-4240-6\\_1](https://doi.org/10.1007/978-94-007-4240-6_1).
- van Eijck, M., and W.-M. Roth. 2011. "Cultural Diversity in Science Education Through Novelization: Against the Epicization of Science and Cultural Centralization." *Journal of Research of Science Teaching* 48 (7): 824–847. <https://doi.org/10.1002/tea.20422>.
- Varelas, M., R. T. Kotler, H. D. Natividad, N. C. Phillips, R. P. Tsachor, R. Woodard, M. Gutierrez, M. A. Melchor, and M. Rosario. 2022. "'Science Theatre Makes You Good at science': Affordances of Embodied Performances in Urban Elementary Science Classrooms." *Journal of Research in Science Teaching* 59 (4): 493–528. <https://doi.org/10.1002/tea.21735>.
- Williams, M., K.-S. Tang, and M. Won. 2019. "ELL's science meaning making in multimodal inquiry: a case-study in a Hong Kong bilingual school." *Asia-Pacific Science Education* 5 (1). <https://doi.org/10.1186/s41029-019-0031-1>.
- Wilmes, S. E. D. 2021. "Interaction Rituals, Emotions, and Early Childhood Science: Digital Microscopes and Collective Joy in a Multilingual Classroom." *Cultural Studies of Science Education* 16 (2): 373–385.
- Wilmes, S. E. D., R. G. Fernández, A. Gorges, and C. Siry. 2018. "Underscoring the Value of Video Analysis in Multilingual and Multicultural Classroom Contexts." *Video Journal of Education and Pedagogy* 3 (1): 1–14. <https://doi.org/10.1186/s40990-018-0016-0>.
- Wilmes, S. E. D., and C. Siry. 2018. "Interaction Rituals and Inquiry-Based Science Instruction: Analysis of Student Participation in Small-Group Investigations in a Multilingual Classroom." *Science Education* 102 (5): 1107–1128. doi:10.1002/sce.21462
- Wilmes, S. E. D., and C. Siry. 2020. "Science Notebooks as Interactional Spaces in a Multilingual Classroom: Not Just Ideas on Paper." *Journal of Research in Science Teaching* 57 (7): 999–1027. <https://doi.org/10.1002/tea.21615>.
- Wilmes, S. E. D., and C. Siry. 2021. "Multimodal Interaction Analysis: A Powerful Tool for Examining Plurilingual Students' Engagement in Science Practices." *Research in Science Education* 51 (1): 71–91. <https://doi.org/10.1007/s11165-020-09977-z>.
- Wilmes, S. E. D., K. Te Heesen, C. Siry, N. Kneip, and S. Heinericy. 2018. "The Role of Critical Reflexivity in the Professional Development of Professional Developers: A Co-Autoethnographic Exploration." *Interfaces Científicas-Educação* 7 (1): 13–24. <https://doi.org/10.17564/2316-3828.2018v7n1p13-24>.