Received: 20 June 2019 | Revised: 17 November 2019 | Accepted: 21 November 2019

DOI: 10.1002/tea.21615

RESEARCH ARTICLE

JRST | WILEY

Science notebooks as interactional spaces in a multilingual classroom: Not just ideas on paper

Sara E.D. Wilmes | **Christina Siry**

Institute for Teaching and Learning
University of Luxembourg

Correspondence
Sara E.D. Wilmes, Institute for Teaching and Learning, University of Luxembourg, Maison des Science Humaines, 11, Porte des Science, Esch-sur-Alzette, Luxembourg.
Email: sara.wilmes@uni.lu

Funding information
Luxembourg National Research Fund, Grant/Award Number: 4832121

Abstract

Past studies have explored the role of student science notebooks in supporting students' developing science understandings. Yet scant research has investigated science notebook use with students who are learning science in a language they are working to master. To explore how student science notebook use is co-constructed in interaction among students and teachers, this study examined plurilingual students' interactions with open-ended science notebooks during an inquiry science unit on condensation and evaporation. Grounded in theoretical views of the notebook as a semiotic social space, multimodal interaction analysis facilitated examination of the ways students drew upon the space afforded by the notebook as they constructed explanations of their understandings. Cross-group comparison of three focal groups led to multiple assertions regarding the use of science notebooks with plurilingual students. First, the notebook supported student-determined paths of resemiotization as students employed multiple communicative resources to express science understandings. Second, notebooks provided spaces for students to draw upon diverse language resources and as a bridge in time across multiple inquiry sessions. Third, representations in notebooks were leveraged by both students and teachers to access

[Correction added on January 8, 2020, after first online publication: The affiliation and correspondence sections were corrected to remove extraneous information.]

and deepen conceptual conversations. Lastly, students' interactions over time revealed multiple epistemological orientations in students' use of the notebook space. These findings point to the benefits of open-ended science notebooks use with plurilingual students, and a consideration of the ways they are used in interaction in science instruction.

KEYWORDS

student science notebooks, primary science, plurilingual, multilingual, semiotic social spaces

1 | INTRODUCTION

Student linguistic and cultural diversity is shifting in many national contexts (e.g., European Commission, 2017; Ministry of Public Administration and Security, 2011; Snyder, de Brey, Dillow, 2018). This has resulted in greater numbers of students being positioned to learn science through languages they are also working to master. Current science education policy and initiatives in various contexts globally advocate for science instruction that is participatory and that provides opportunities for all students to engage in the practices of science (Australian Curriculum and Reporting Authority [ACARA], 2015; Department of Basic Education [DBE], 2011; MINEDUC, 2012; Ministry of Education of the People's Republic of China [MOE], 2001; National Research Council [NRC], 2012; NGSS Lead States, 2013). Although the benefits of science instructional approaches grounded in inquiry methods for diverse learners has been supported by numerous studies (e.g., Lara-Alecio et al., 2012; Lee, 2005; Lee, Deaktor, Hart, Cuevas, & Enders, 2005; Llosa et al., 2016; Roseberry, Warren, Conant, & Hudicourt-Barnes, 1992; Stoddart, Pinal, Latzke, & Canaday, 2002), often these forms of science instruction are predicated on the ability to read, write, and interact in a given language. This can present a set of compounded challenges for language learners. First, the verbal and written forms of engagement assumed can serve as barriers to student interaction in ways that impede participation and thus learning (Lee, Quinn, & Valdés, 2013; Wilmes & Siry, 2018). Second, the varied modes of assessment used can obscure what students understand (Noble et al., 2012) by requiring levels of language mastery that mask the depth of students' science understandings (Shaw, Bunch, & Geaney, 2010; Solano-Flores & Trumbull, 2003). Given these challenges and given the documented persistent achievement gap of language learners on national tests of science achievement (Aud et al., 2012; Organization for Economic Co-operation and Development (OECD), 2016), it is imperative to find ways to provide students with science instruction that supports a range of multimodal participation emerging through classroom spaces and interactions.

Prior research has explored how science notebooks can support language learners' documentation and communication of science understandings (Huerta, Tong, Irby, & Lara-Alecio, 2016), and offer marginalized students a space to document science experiences en route to developing scientist identities (Varelas, Kane, & Wylie, 2012). While these and additional past studies have contributed to an understanding of the strengths of the use of student science notebooks (e.g., Butler & Nesbit, 2008; Campbell & Fulton, 2003; Shelton et al., 2016; Wiebe, Madden, Bedward, Minogue, & Carter, 2009), methodologically previous studies have positioned notebooks, and the multiple forms of representation students construct within them, as static texts. While positioning notebooks as static texts can provide a valuable lens on the final product constructed by students, it does not emphasize the *process* of co-construction of such documents in interaction with peers and teachers. In order to turn an analytic lens on this important component of students' participation in inquiry science learning, namely interaction with peers and teachers as students work with their science notebooks, this study investigated how plurilingual[1] students interacted *with* and *in* the space of their science notebooks across three inquiry science tasks at the end of an inquiry science unit.

2 | CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

Grounded in sociocultural views of interaction in science classrooms, this study examined students' interaction with science notebooks during inquiry science instruction and co-construction of their use in interaction by drawing upon two established areas of science education research; the use of student science notebooks as learning and assessment tools, and the conceptualization of science notebooks as a semiotic social space. In the literature review that follows, we first situate how we build upon prior studies of science notebook use, and then move to explain how this study explores science notebooks as semiotic social spaces of interaction in a multilingual classroom.

2.1 | Student science notebooks

Student science notebooks can serve a powerful tool for documenting students' thoughts, ideas, and investigations (Huerta et al., 2016; Klentschy, 2005; Ruiz-Primo, Li, Ayala, & Shavelson, 2004; Varelas et al., 2012). When implemented in ways that support students in going beyond the documentation of teacher-transmitted information, science notebooks provide a place for students to make their ideas and understandings visible to both teachers and their peers during the course of instruction (Butler & Nesbit, 2008; Campbell & Fulton, 2003; Wiebe et al., 2009), thus serving as an important formative assessment tool (Aschbacher & Alonzo, 2006; Shelton et al., 2016). In the context of inquiry science instruction that engages students in science practices (e.g., NGSS Lead States, 2013; NRC, 2012), the use of science notebooks can provide a place for students to construct entries that draw upon a range of genres and that create bridges between the multiple forms of texts students experience both within and outside of school (Shepardson & Britsch, 2001). When students are encouraged to revisit their entries and revise them over time, science notebooks can assist students in developing an understanding of the *nature of science* as a dynamic process, in ways that parallel how scientists use laboratory notebooks in their work (Butler & Nesbit, 2008). Thus, a wide body of research has established the many and varied benefits of the integration of student science notebooks in ways that encourage documentation and exploration of scientific concepts and understandings as students engage in science practices.

Specific to the use of science notebooks with plurilingual students, a handful of studies have examined their use with language learners (e.g., Lindquist & Loynachan, 2016; Wu et al., 2018). As a subset of a larger study investigating the integration of science and literacy instruction, Huerta et al. (2016) demonstrated that fifth-grade English language learners (ELLs) exhibited growth in academic language use and science conceptual development when constructing science notebook entries across three science units of differing content domains. Their quantitative study assessed notebook entries using the science notebook rubric (Huerta, Lara-Alecio, Tong, & Irby, 2014), and demonstrated that students' use of academic language in both drawn and written notebook entries developed in complexity over time. In fact, the amount of growth observed in language learners' use of academic language approached that of the English-speaking students, thus underscoring the value of student science notebook in supporting both linguistic and conceptual development.

A related study examined eighth-grade student science notebook use while participating in an intensive summer science and engineering camp (Wu et al., 2018). Analysis investigated students' use of hybrid language, defined as the employment of multiple linguistic modes, such as writing and drawing, within a single notebook entry. Analysis revealed that ELLs increased hybrid language use over time when constructing notebook entries to explain science concepts. These findings are fruitful, yet the analytical methods used as described by the authors, "were not able to analyze how the students were communicating verbally during the student group interactions" (Wu et al., 2018, p.18). Given the importance of interactions with communicative resources, science concepts, and science realia in mediating both linguistic and conceptual development (Jornet & Roth, 2015; Roth & Lawless, 2002; Ünsal, Jakobson, Wickman, & Molander, 2018), it is important to consider an important aspect of science notebook use, namely the notebook's role in interaction. In terms of science instruction in general, and instruction with plurilingual students in particular, there is a dearth of research on how students' and teachers' interactions contribute to the development of notebook entries, and in turn, how the notebook positions students to represent and communicate their science understandings, thus highlighting an area in need of further study. The inherent value of this study is in the examination of student science notebooks in interaction. The methodology we employed shines a light on students' and teachers' co-construction of notebook entries as well as their interactions with the notebook space in order to better understand how science notebooks can support student interaction and science learning, especially in multilingual classrooms.

2.2 | Science notebooks as semiotic social spaces

This manuscript presents a novel examination of student science notebook use in interaction, grounded upon theoretical conceptualization of *semiotic social spaces* as places where actors interact, as they draw upon the available semiotic resources to communicate and represent meaning. Semiotic social theories elaborate how the socially constructed, culturally situated nature of social spaces directly affects the processes of semiosis that unfold within them (Airey & Linder, 2017; Bezemer & Kress, 2016; Gee, 2005, 2012; Kress, 2010; Lemke, 1987). In classrooms, this means that the nature of the space and the semiotic resources made available in the space directly informs the semiosis and meaning making process that are enabled (Bezemer, Jewitt, Diamantopoulou, Kress, & Mavers, 2012; Bezemer & Kress, 2016; Lemke, 2001).

Past research of science teaching and learning employing semiotic views has demonstrated how meaning-making is emergent through interaction in contextually determined ways (e.g., Jornet & Roth, 2015; Rahm, 2004; Siry, Ziegler, & Max, 2012). A wide range of studies grounded in social semiotic views of meaning-making in science education have explored the processes teachers (Jaipal, 2010; Márquez, Izquierdo, & Espinet, 2006; Moro, Mortimer, & Tiberghien, 2019) and students (Gilbert & Treagust, 2009; Kress, Jewitt, Ogborn, & Tsatsarelis, 2001; Prain, Tytler, & Peterson, 2009; Tang, Delgado, & Moje, 2014; Waldrip, Prain, & Carolan, 2010; Zhang, 2016) employ as they decode teacher-constructed modal ensembles, engage in teacher-led lessons, and construct student-generated representations (Tang, 2013; Tytler, Prain, Hubber, & Haslam, 2013; Zhang, 2016) as they work toward building science understandings. These studies have shown how students and teachers draw upon locally available resources in ways that emerge from interaction, and that are distributed spatially and temporally (Rahm, 2004) to communicate about decisions, experiences, and meanings (Vanderhoof, 2018).

In a recent study of students' meaning-making discussions in a bilingual school, Williams, Tang, and Won (2019) showed how over multiple varying inquiry science experiences third-grade language learners were afforded differing dominant modes through which they could make sense of their science inquiry experiences. Their semiotic analysis of students' interactions while co-constructing diagrams and writing to explain their understandings of force and motion showed that "modes accessible to the English language learners had a direct affiliation to the multimodal discourse and as a result, the meanings that were made" (p. 26), supporting prior findings that demonstrate students in general, and ELL students in particular (Zhang, 2016), learn science concepts through the integration and assembly of multiple modes (Bezemer et al., 2012; Lemke, 2001).

Building from these prior studies, we position student science notebooks in this study not as products, nor as repositories of ideas and representations, but rather as semiotic social spaces that mediate interaction. Gee (2005) conceptualizes *semiotic social spaces* as organized according to both an internal and an external grammar. The *internal grammar* dictates how semiotic resources and meaning are designed, ordered, and used within the space. In examining the internal grammar of a space, it is possible to see what meaning is allowed to be represented, how it is represented, and how multiple representations are organized within the space. *External grammars* by contrast, detail the way participants, tools, and materials interact in a space and afford insight into who is able to interact with whom, in which ways, and to which ends (Gee, 2005). The relationship between the *external* and *internal* grammars of a semiotic social space, Gee (2003) explains, is direct and dialogical. Thus, interactions among participants involving the use of semiotic resources available in the space mediate which semiotic resources can be used in future interactions over time. Past studies have examined semiotic resource use in interaction in science classrooms (e.g., Givry & Roth, 2006; Jornet & Roth, 2015; Rahm, 2004; Zhang, 2016). Past analysis of student science notebooks, by contrast, has predominantly been limited to examinations of what is represented within the notebooks. Thus, we contend that an examination of student science notebooks as semiotic social spaces *in their own right* can provide a rich view of students' use of the semiotic social space in interaction over time.

2.3 | Meaning-making in semiotic social spaces

Central to semiotic social theorizations of teaching and learning are the concepts of *mode*, *modal ensemble*, and *sign*. Modes are the material resources (sound, color, gesture) that can be used by actors, including students and teachers, to make *signs*, which carry information and are made with intent (Kress et al., 2001). The modes available in science classrooms can be abundant and include language, gaze, body position, gesture, image, sound, spatial orientation, and movement (Danielsson, 2016; Jaipal, 2010). *Modal ensembles* are collections of modes, in which each mode collectively contributes to the signification of the ensemble (Lemke, 2001).

Central to social semiotic theorizations of learning, and thus to this study, is the process of *transformation*, which is the re-signing of meaning from one mode or modal ensemble to another as emergent through socially contextualized interaction (Givry & Roth, 2006; Jornet & Roth, 2015; Rahm, 2004). Transformation, referred to in some studies as transduction, chains of semiosis (Kress et al., 2001), or resemiotization (Klein & Kirkpatrick, 2010), is the ongoing situated agential process by which actors interacts with and transform a modal ensemble (Givry & Roth, 2006; Kress et al., 2001; Rahm, 2004). It is the socially, culturally, and historically contextualized process of engaging with available semiotic resources and resemiotization that lie at the foundation of semiotic social theories of learning (Airey & Linder, 2017; Bezemer & Kress, 2016; Klein & Kirkpatrick, 2010). While resemiotization has been examined in the context of science teacher professional development (Márquez et al., 2006) and in the context of science instruction (Tang et al., 2014; Zhang, 2016), the majority of past studies have provided detailed examination of teacher-guided science instruction with language learners. Few have investigated resemiotization within student-directed science inquiry forms with language learners. Thus, science education research lacks depth of understanding regarding the spaces that mediate the resemiotization processes students and teachers engage in while participating in inquiry science instruction, and how science notebooks mediate these processes, in particular with students working in languages they are also working to master.

2.4 | Research objectives

This study expands current understandings of the interactive ways plurilingual students engage with each other, with semiotic resources, and with their science notebooks when participating in inquiry science instruction. More specifically, we present multimodal analysis of the ways by which plurilingual students interacted with their science notebooks across multiple summative activities after participating in several student-directed inquiry science investigations. Drawing on semiotic social theoretical lenses this study explored two questions. First, when viewed as a semiotic social space, what do science notebooks enable in interaction in a multilingual classroom? Second, what does this reveal about how science notebooks position plurilingual students to draw upon meaning-making resources when learning science?

3 | METHODS

3.1 | Research approach

Our research is grounded in sociocultural theoretical lenses that position science instruction and learning as contextualized, co-constructed, and emerging through interaction (i.e., Tobin, 2012). This theoretical orientation provided a foundation for examining how students in this multilingual classroom were interacting with each other and with their notebooks, and through these interactions, co-constructing entries relative to their inquiry investigations. Based on this situated, contextualized use of the science notebooks, this study drew upon methodologies guided by a stance that honors the co-construction of social interaction in science classrooms (e.g., Kelly & Green, 2018). Building from these perspectives, this study examined the semiotic space open-ended student science notebooks afforded plurilingual students and teachers in interaction over the course of three assessment tasks at the culmination of an inquiry science unit on the process of condensation and evaporation.

3.2 | Participants and setting

This study was conducted with a fourth-grade class of 14 plurilingual students in a multilingual urban primary school in the European country of Luxembourg. Assent was obtained from all students and informed consent was provided by their legal guardians before confirming students' participation in the study. The 10–11-year-old student participants were ethnically, socioeconomically, and linguistically diverse. Nationwide approximately 46% of public school students hold a nationality from a country other than Luxembourg and 50% self-identify as speaking a primary language at home other than one of the three official school languages (Luxembourgish, German, and French) (Ministry of Education and Children [MENJE], 2019). The participating students reflected this diversity.

Primary school policy in our national context prescribes a trilingual curriculum, with kindergarten starting in Luxembourgish, and students learning to read and write in first grade in German. French is added as a third language in second grade, and it is expected that students have a proficiency in all three languages when they complete primary school at the end of sixth grade. This trilingual national curriculum also stipulates that science at the primary level be taught in German (Ministry of Education and Professional Formation, 2011). The high rate of linguistic and cultural diversity, when coupled with science instruction conducted in German, results in classrooms in which a majority of students are learning science in and through a language they do not speak at home. This was the case for the 14 plurilingual student working in this class, and the seven students at the focus of this study (Data S1).

Before introducing the data analysis, it is important to note that in many Luxembourgish primary classrooms, instruction is trilingual as per the national curriculum, yet the form of instruction is monoglossic in nature (Horner & Weber, 2008). As such, while the national curricula supports learning and communicating using three national languages (Luxembourgish, German, and French), it is done in ways that allocate separate instructional space for each language. French, for example, is typically accessed during French literacy lessons, and its use is often discouraged during science instruction. In this example, for students who speak French at home (13% of the student population describe French as their primary language at home; MENJE, 2019) monolingual science instruction in German can undercut students' access to important meaning-making resources. A growing body of research suggests instruction to support plurilingual students in accessing more communicative resources from their communicative repertoires can mediate students' engagement in science practices (Poza, 2018; Siry & Gorges, 2019; Suárez, 2017; Wilmes & Siry, 2018). Thus, a central focus of the larger study this manuscript arose from was to explore ways to support students in accessing more diverse communicative sources while engaging in inquiry science instruction.

Three plurilingual members of our research team (the two authors and a colleague) co-taught the inquiry science lessons with the classroom teacher. This allowed us to collectively support instruction as it unfolded and afforded us roles as participant observers, which provided a complementary layer of insight during analysis.

3.3 | Integrated inquiry science and language instructional approach

A subset of a larger research project investigating integrated language and science instruction (Wilmes, 2017a, 2017b), this study focused on the first of three integrated science and language instructional units grounded in instructional approaches shown to support language learners in learning science (e.g., Amaral, Garrison, & Klentschy, 2002; Stoddart et al., 2002; Varelas & Pappas, 2013). The analysis presented in this manuscript examined students' science notebook use for four 2-hr inquiry science sessions during a period of 2 weeks (Table 1). The unit of instruction explored the concepts of condensation and evaporation through a storyline that set the stage for several rounds of student-driven inquiry science investigations. The scenario in the story was a "science mystery" (Konicek-Moran, 2008), which described how two students were camping outside on a clear night when suddenly droplets of water fell on only one of the students inside the tent. This mystery was intended to challenge student groups to generate possible reasons for the condensation, and then to use these to conduct multiple rounds of self-designed investigations. On Day 4 of the water unit, three varied assessment tasks were conducted to provide opportunities for students to demonstrate their understandings. The three assessment tasks progressed from an individual writing task, to small-group discussion, culminating with individual student interviews (Table 1).

3.4 | Open-format science notebooks

Student notebook use was introduced on Day 1 (Table 1). The notebook format employed was open-ended, meaning that students' entries were guided by teacher-designed tasks, yet students were encouraged to construct entries that incorporated multiple modes and that drew upon their diverse language repertoires. This approach supported student participation in science instruction in ways that create participatory open-ended structures (Siry, 2013) and spaces that value students' diverse perspectives and contributions. Interviews with students and with the classroom teacher revealed that prior use of student science notebooks with this class was limited to the documentation of canonical science understandings. This was the first time this class had used open-format science notebooks and the first-time students were encouraged to represent and draw upon multiple modes and varied language resources to express science ideas.

TABLE 1 Condensation and Evaporation inquiry-based unit and associated notebook tasks

	Day 1	Day 2	Day 3	Day 4
Science lesson	Introduction to inquiry story Use of science notebooks introduced Small-groups plan first investigation	Small-groups conduct first investigation	Small-groups conduct second investigation	Students write in the notebooks, "My best understanding so far is…" Small-groups discuss what they understand about the droplets in the tent
Notebook task	Construct an investigation to test your questions	Record what happened during your investigation	Record what happened during your second investigation	Write, *My best understanding now is…*

3.5 | Data sources

A multilayered data corpus was collected to examine students' interactions while working with science notebooks in the water unit, consisting of whole class and small-group video recordings of all science lessons for the unit, student science notebook entries, classroom learning artifacts, and audio recordings of student interviews. Semi-formal student interviews conducted at the end of the unit explored students' perspectives of science instruction, science notebook use, and language use in the classroom. This expansive data set provided multiple entry points and perspectives on students' interactions in the space afforded by their notebooks and the instructional tasks.

3.6 | Data analysis

A multilayered analytical approach that drew upon video ethnography (Roth, 2005) and employed multimodal interaction analysis (Norris, 2004, 2012; Rowe, 2012) was used to examine students' science notebook interactions (Figure 1). First, *notebook trajectories* were constructed, to chronologically depict students' notebook entries for the science unit, by creating a composite of digital offprints of notebook entries over time. Students were encouraged to draw, write, and include photographs in their notebook entries, and these entries were then represented in the notebook trajectory created for each of the 14 students' notebooks. The notebook trajectories for all student were then analyzed for the progression of science content, form, and voice within each entry as well as across entries, to allow for an analysis of the modes (written, drawn, communicative resources) students incorporated. Second, *continuum sampling* (Patton, 2015) was used to select three focal student groups. Notebook trajectories for the 14 students were placed on a continuum based on the relative number of narrative entries versus representational entries students included over the course of the unit. Three groups were then selected, to include at least one student who did not speak the language of instruction (German) at home, from each end and in the middle of the continuum.

Third, multimodal interaction analysis (Norris, 2004, 2012; Rowe, 2012) of classroom video on Day 4 allowed for analysis of the moment-by-moment multimodal interactions among students, notebooks, and teachers within the three focal groups over the three tasks on Day 4 (Table 1, Figure 1). Video analysis identified how notebooks were accessed in interaction (for which purpose, at which points during the task, positioned how during the interaction), by whom they were used, which semiotic components were accessed and employed, and to which end regarding science engagement and understanding. From this, *notebook interaction maps* were constructed for each group depicting how group members interacted with the notebooks over time relative to students' engagement in science practices (Figure 1). These maps were used to identify shifts in whom interacted with which notebook entries, when, and for what purpose. This allowed for identification of focal interactions, for which multimodal transcripts (Erickson, 2017) were constructed. Multimodal transcripts of focal interactions detailed the characteristics of interactions, including the position of the notebook during discussions, the body position of all actors relative to the space including the science notebook, the modes accessed, proxemics, gestures, and content of conversations in the space (Data S2). Cross-group comparison (Patton, 2015) then allowed for comparison of aspects of interaction across the three focal groups, and afforded us the ability to make assertions about the nature of student and teacher interactions within the space of the science notebooks.

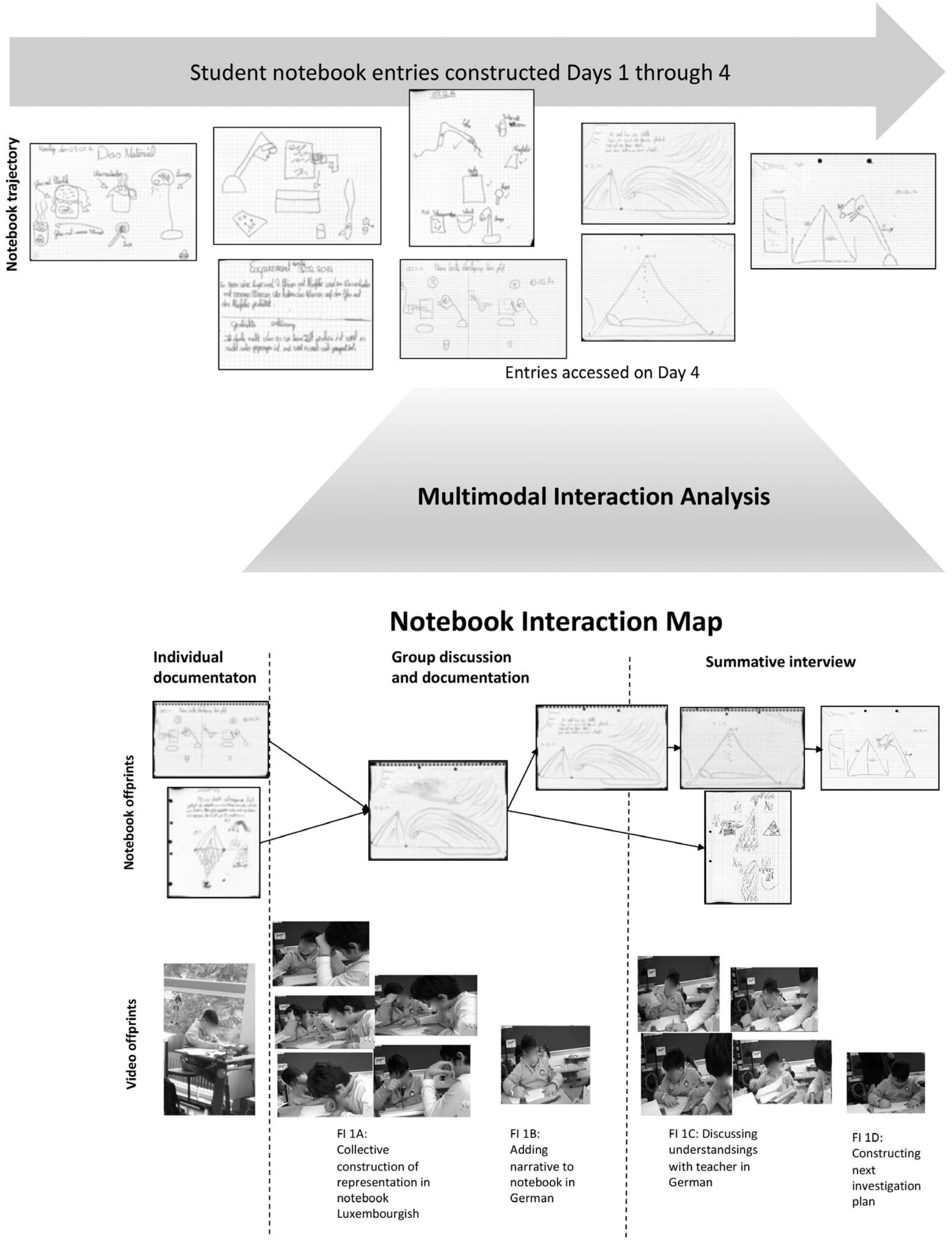

FIGURE 1 Multilayered analysis of student science notebook interactions

3.7 | A note about languages

This study was conducted in a multilingual classroom and with plurilingual students, teachers, and researchers, and as such the use of national languages and communicative resources is key and necessitates elaboration. Communication between the researchers/co-teachers and students during classroom activities and student interviews was conducted in German, which is the language of primary school science instruction in our national context. We also communicated with students in Luxembourgish, particularly outside of science instruction, but the majority of interactions between us and students occurred in German and combinations of German and Luxembourgish. Our plurilingual participants interacted with each other by drawing upon multiple language resources, as is customary in their out-of-school interactions, and these multilingual exchanges were primarily in Luxembourgish, French, and German. All data sources were analyzed in their original language. Researchers fluent in combinations of English, German, and Luxembourgish translated key data excerpts into English for research presentation and manuscript purposes.

4 | DATA AND FINDINGS

Analysis of aspects of interactions within and across focal groups allowed us to characterize the nature of the notebook interactional space. Five assertions regarding interactions with the science notebooks emerged. The notebooks: provided space for student-directed paths of resemiotization, provided space for students to draw upon diverse language resources, served as spatial and temporal bridges across inquiry investigations, served as leverage points that supported students and teachers in accessing and extending science understandings, and revealed students' conceptions of the nature of science. For each assertion, we will elaborate findings and present illustrative excerpts from analysis. As the excerpts that support each assertion are multiple, representative excerpts are presented to elaborate each assertion in the sections that follow.

Initial examination of notebook entries for all students for the entire science unit revealed students constructed complex and multiple storylines in their notebooks utilizing written and draw representations. Their entries over the course of the multiple investigations and different phases of inquiry depicted students' understandings of condensation and evaporation, and detailed analysis of the content of these notebook entries has been published previously (Wilmes, 2017a, 2017b). Based on the initial analytic phase, the multistep analytic process (Figure 1) was undertaken for the three focal students and their notebooks. The findings that emerged from this analysis are presented as five assertions, presented in detail next.

4.1 | Assertion 1: Science notebooks provide spaces for student-directed paths of resemiotization

Cross-group examination of notebook trajectories showed that each group demonstrated their understandings about the condensation inquiry along differing student-directed pathways across the time and space of the three assessment tasks on Day 4. Video analysis coupled with examination of the notebook entries accessed in interaction on Day 4 revealed that each of the three focal groups moved along differing paths of resemiotization as they worked through the individual, group, and summative assessment tasks.

For the initial individual writing task on Day 4, seven of the eight focal students constructed a narrative respond to the prompt written in German on the board, "Meine beste Überlegung bis jetzt... (*My best understanding now is*...)." One student in Group 3, by comparison, wrote the prompt at the top of a representation he created during a prior investigation on

Day 3, in which he examined the best way to generate condensation using a desk lamp. All seven students moved from this initial writing task to small groups for discussing their understandings.

When beginning the group discussion task, Group 1 began by reading their narratives to one another, including elaboration about the inside of the tent needing to be warm to generate the drops of water. Only after several minutes, and when prompted by the teacher, did the three members of the group draw a representation of their understanding that the tent was warm and thus the water dripped.

By comparison, Group 3 began the group task by discussing multiple ideas of what could have been driving the formation of condensation in the tent, and moved to together constructing one notebook entry. Following this, each of the two students carried on individually constructing a different series of entries. Within these two groups, students engaged in resemiotization, or translational processes (Prain & Waldrip, 2006), across the timespan of the three assessment tasks, meaning students represented their ideas in one mode (i.e., writing in the notebook) and subsequently transformed them into other modes (i.e., drawing in the notebook), or moved from representing an idea in drawing/representational form, and then to also representing their understandings in written form. Thus, it can be said that the notebook provided space for multiple representations of ideas and understandings and positioned students to determine which modes they selected (narrative and/or representational), and which pathways of resemiotization they employed. In all groups the pathways of resemiotization were simultaneously individual as well as collective. Classroom spaces often "do not have multiple routes to participation" (Gee, 2005, p. 231). Here however, the open notebook format enabled multiple routes of resemiotization as reflected in both individual and group selection of paths of transduction.

4.2 | Assertion 2: Science notebooks provide spaces for student to draw on diverse language resources

Building from the first assertion, video analysis showed that within all three groups the interactional space of the notebooks mediated students' communication utilizing diverse communicative resources. One example unfolded in interaction in Group 1 as the students discussed their understanding of the inquiry storyline during the group task. The three students had individually constructed notebook entries in German. When they moved to the group task, they began reading their notebook entries to each other. Calia began to read what she had written in German, word-by-word out loud (Figure 2a). Two-thirds of the way through she stopped, looked up at her groupmates, put her notebook down on the desk in front of her, and began using animated gestures to explain her reasoning in Luxembourgish (Figure 2b). This shift from reading in German to speaking in Luxembourgish was accompanied by shifts in posture and gaze, from focus on her notebook in German to focus on her group members in Luxembourgish. Accompanying this shift, her gestures became more elaborate as she explained in Luxembourgish how the evaporated water vapor moved upward within the tent, and its position as it condensed and dripped down inside the tent onto one of the characters, as if the science ideas related to the formation of condensation, and warmth in the tent, became enacted in the space between her and her groupmates when she spoke in Luxembourgish. In her verbal explanation she included information about the motion and position of the condensation relative to the tent, which was not clearly represented in her notebook narrative, and thus she expressed slightly different information from her written narrative in German than she expressed in her verbal embodied explanation in Luxembourgish.

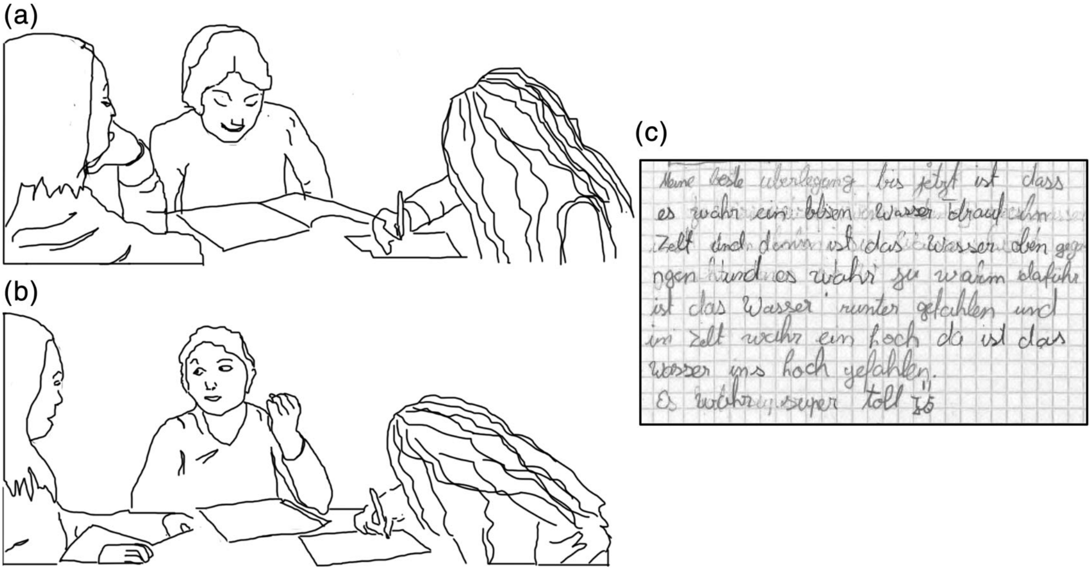

FIGURE 2 Calia responded by first reading from her notebook entry (a), then moved to explain verbally (b)

Following this, the three group members collectively constructed a diagram showing their understanding of the evaporation and condensation in the tent including elements from both their written and verbal explanations. In this way, they engaged in transduction of their understandings from one mode into another, which assisted the expression of additional facets of their understanding. Bezemer and Kress (2016) explain that when examining evidence of student learning, it is key to note that "any limitation on modes available to demonstrate learning leads to limitations on the learner's potential to demonstrate what she or he has learned" (p.54). This episode shows how Calia expressed a more limited view of understanding, lacking certain details, when writing in a language that she has less of a command of than when explaining the same understanding verbally in a language of which she possesses a greater command. Thus the notebook afforded the students' the opportunity to move from a task space that was more limited (the narrative written in German) to one that allowed them to convey a more nuanced expression of understanding (verbal explanation in Luxembourgish).

4.3 | Assertion 3: Science notebooks serve as spatial and temporal bridges

Over the course of the science unit students conducted multiple student-designed investigations and documented their findings. These multiple documentations, in turn, provided students access to the events and meanings from prior investigations which they were able to carry forward to their demonstrations of understanding on Day 4. One such interaction was seen in Group 1 as Nela explained her ideas to her group in Luxembourgish (Figure 3a). She looked up at her group mates and began speaking and gesturing further about her ideas, shifting her gaze to Calia (Figure 3b).

As Nela spoke, she flipped back several pages in her notebook to the photo of her investigation from Day 3. She asked, *Do you see these drops*? (pointing to the photo in her notebook of the condensation that formed on the plastic film) (Figure 2c), *They formed when we put the light over*

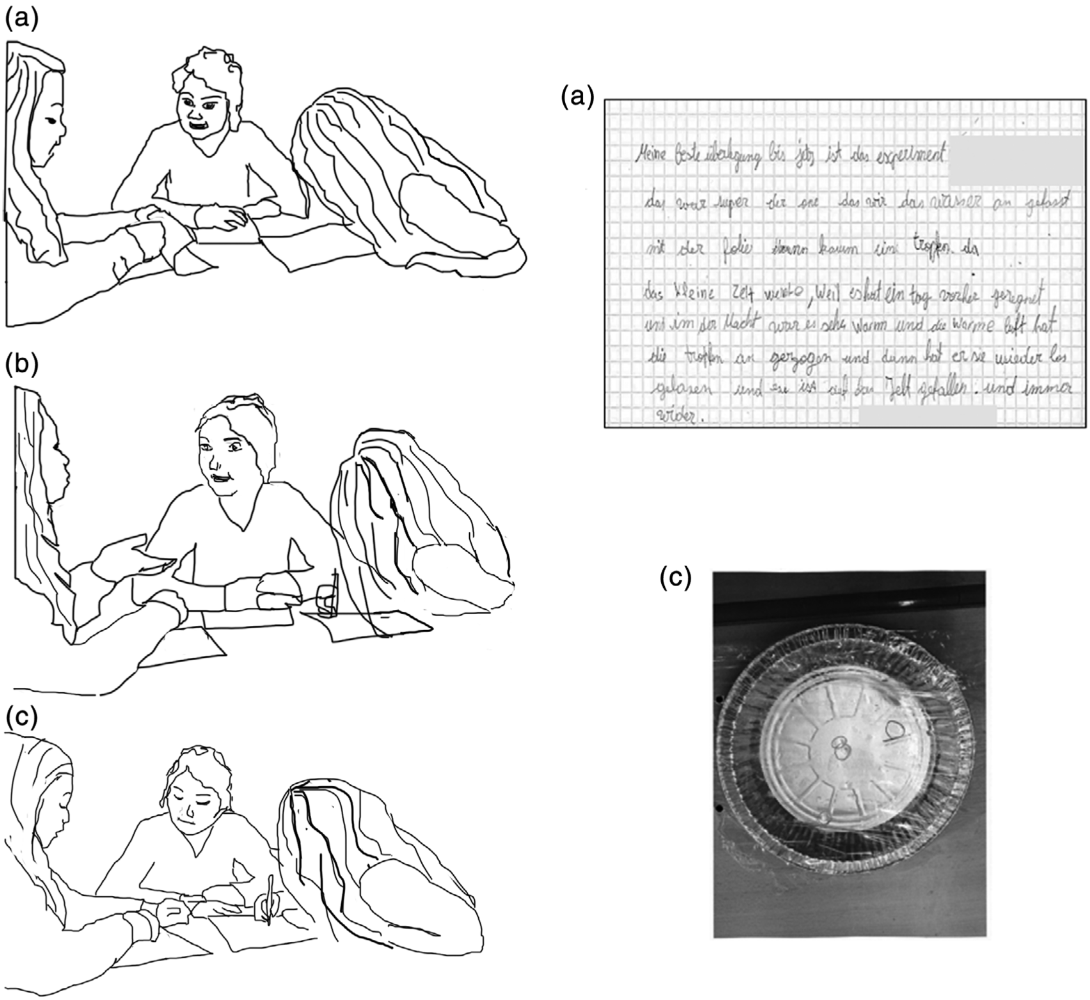

FIGURE 3 Nela read her entry in German (a) then transitioned to explain in Luxembourgish (b) while referencing entries from both Days 3 and 4 (c)

the setup, referring to their investigation on Day 3 in which they positioned a heat lamp over a container of water covered with plastic. In this interaction Nela incorporated evidence from the photo (Day 3) with her narrative writing (Day 4) into her discussion with her groupmates. Hence, the notebook created a bridge in time and space across their inquiry experiences.

4.4 | Assertion 4: Science notebooks serve as leverage points that support students and teachers in accessing and extending science understandings

Analysis revealed that in all three groups, the notebooks entries (photos, drawn images, written narratives) were leveraged in interaction to deepen and extend conversations about students' understandings of the inquiry story. An example of this occurred in Group 2 when a teacher approached the group and encouraged them, in German, to share their ideas saying, *Did you* *speak to each other about your ideas? Scientists speak to share their ideas and exchange about them*. One of the students, Roberto, turned to the other, Marc, and in Luxembourgish asked, *The experiment from before, did you understand it?* Marc replied, *No*, and as he said this starting flipping back through pages of his science notebook, pausing at the photo he took on Day 3 during their investigation. *There*, one of the teachers said as she pointed to photo and she asked, *What did you do there?* pointing to the photo (Figure 4a). Marc responded by pointing to the same spot on the photo in his notebook (Figure 4b) as he replied in German, *My thinking is that that…I thought that, I thought that the tent was wet*. The teacher extended this asking, *Where did the water (in the tent) come from?* Both students then continued sharing possible ideas, *From the head, from the eyes?* They suggested to the teacher quickly in German, while tracking her gaze. In this instance the teacher was able to access documentation from a past investigation, and to move Marc from thinking he did not understand, to generating a list of possible ideas with his groupmate.

A similar interaction occurred in a later episode as Group 1 discussed their ideas. One of the teachers (the first author, Sara) joined the group, bending down at their table to ask about what they had represented notebooks. Looking at the drawings for the three group members, Calia, Amy, and Nela,[2] the teacher saw that they all had represented the shape of the tent as pointed, and that Amy had written to the side of the tent representation, *Where did the water come from?* (Figure 5a). The teacher then asked,

Teacher[3]	Where did the water come from? ((pointing to the top of the tent and the question written on the notebook page)) (Figure 5a)
Calia	((Leaning over to Amy's notebook)) It was warm. The water went up ((tracing along figure up to peak of tent)) (Figure 5b)
	Then it came back down ((tracing finger down from peak along droplets)) (Figure 5c)

In this episode Calia and the teacher (Sara) interacted with the representation of the tent as drawn in Amy's notebook (Figure 5). Calia leaned over to Amy's notebook and explained that the warm water went up, and as she explained this, she traced the pathway of the water within the tent drawing in Amy's notebook with her finger (Figure 5b), which she then followed by

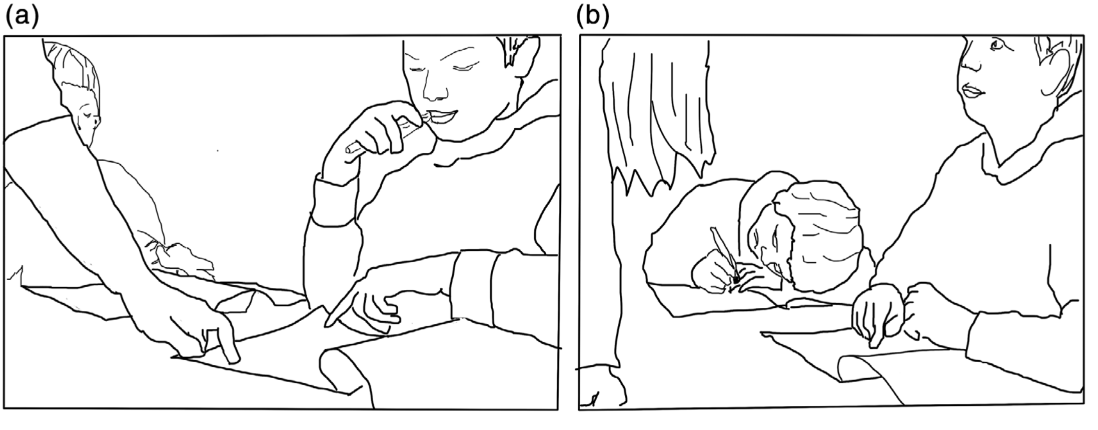

FIGURE 4 The teacher refers Marc to a photo of his investigation in his notebook from Day 3 (a), which he then incorporates into the ideas he shares verbally about the reasons for the condensation (b)

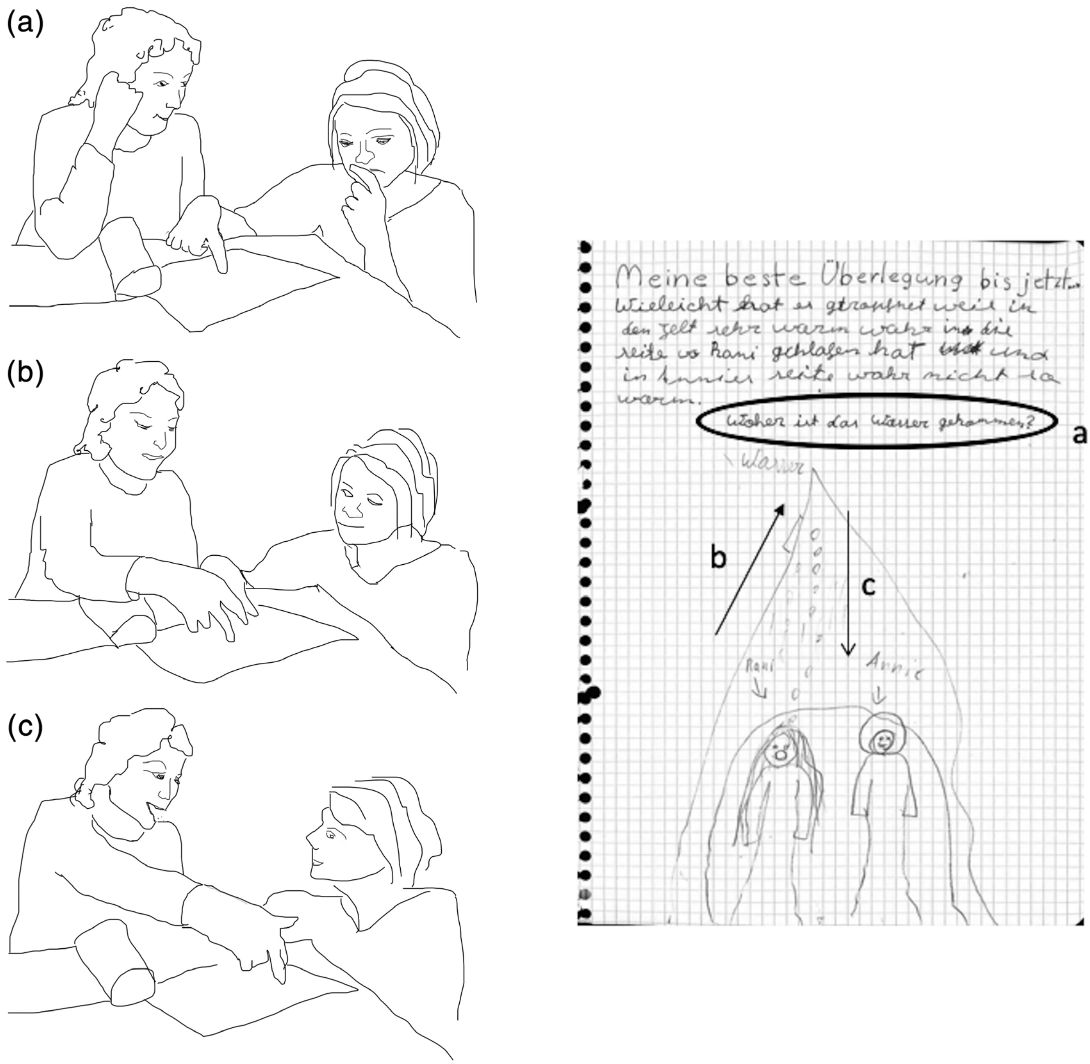

FIGURE 5 The teacher pointed to the question written in Amy's notebook (a). Calia leaned over to point to the representation in Amy's notebook in order to explain her ideas about the water vapor going up one side of the tent (b) and the condensation down the center of the tent (c)

describing, *it came back down*, and she traced down the middle of the tent, indicating the precipitation dripped on one of the people in the tent (Figure 5c).

In this way, the teacher was able to leverage the question and drawn representation in Amy's notebook in conversation to further discuss both Calia and Amy's, and the group's, understandings. The conversation was rooted in their interaction in the semiotic space afforded by the notebook, and it served as a site for mutual focus (Streeck, Goodwin, & LeBaron, 2011), with implications for accessing not only Amy's ideas, but also Calia's ideas and in doing so, provided access to both their thinking. The teacher (Sara) pointed to the representation in Amy's notebook moments later stating, *This is really interesting that it dripped here* (over the person on the left in the tent, Figure 5, left), *and not here* (pointing to the person on the right in the tent, Figure 5, right) which led to the conversation:

Teacher	Maybe the tent was not like this ((pointing to pointed shape of the top of tent drawing then making pointed shape with hands)) (Figure 6a, b)
	Maybe it was like this ((makes flat bridge with hands)) (Figure 6c)
Calia	((mirrors same flat shape with hands)) (Figure 6c)
	Or like this ((makes angled shape with hands)) (Figure 6d)
Amy	Or like this ((makes another angled shape with hands))
Nela	Or like this ((makes wavy shape with hands))

The representation in Amy's notebook served as a deictic resource in this episode that could be pointed to and made it possible to "jointly attend to particular features" (Jornet & Roth, 2015, p. 6) that could be accessed in collective discussion. The understandings and questions recorded in the notebook were revisited with different actors, at a different point in time and became a resource for further thinking and communication.

4.5 | Assertion 5: Science notebooks provide a space that reveal students' conceptions of the nature of science

Examination of each groups' use of the notebook, specifically how and when they made inscriptions in the notebooks over the course of the three summative tasks, revealed differing

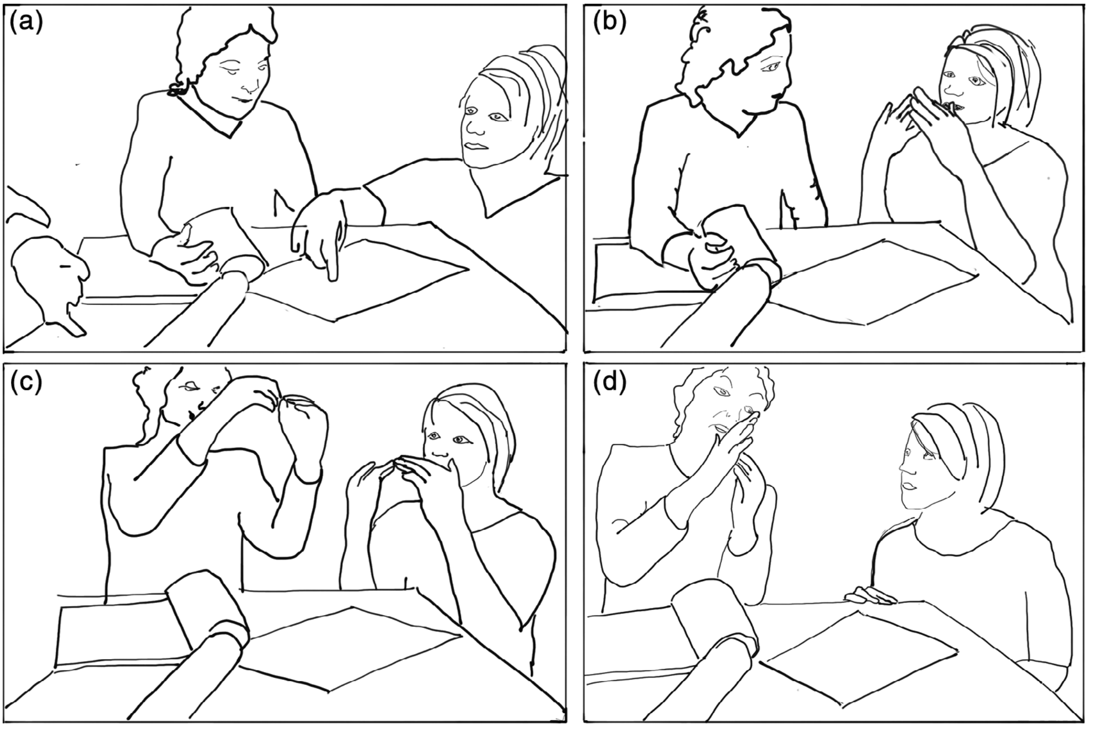

FIGURE 6 Calia and a teacher discussed possible tent as the teacher pointed to the tent shape represented in the notebook (a) and then that were subsequently visualized with hand motions (b–d)

orientations toward the use of the notebook. At one moment, one of the teachers approached Group 2 and explained that scientists share and discuss to clarify their experiments and their ideas. She then explained that the two students, Roberto and Marc, could now share their ideas with one another, to which Roberto exclaimed, *Ah, I know something! They (*the students in the condensation mystery) *showered*, and the teacher encouraged, *Okay write it out* she said and walked away from the group. The students continued putting forth ideas and drawing from their lived experiences as connected to their comprehension of the inquiry. *Water is produced by the body when you are sick and sweat*, Roberto explained. *Maybe they were sweating because it was so warm*, Marc conjectured while crossing his arms. The teacher passed by again and encouraged, *You can write this out*. However, although multiple ideas were exchanged in interaction with each other and with the teacher in the space surrounding the notebook, no trace of these multiple lines of thinking were recorded within the notebook.

This interaction was followed by the summative interview with the second teacher (author, Chris), who next visited the group to ask them their ideas about the condensation in the tent. The teacher joined Group 2 and began the interview asking, *Roberto, What did you find out*? Roberto replied:

Roberto	((Looking at teacher)) We didn't find anything out yet
Teacher	What did you write down?
Roberto	I had an idea, but it was a little bit too stupid
Marc	Mine was too
Teacher	What do you think you found out? ((Looking at Roberto and Marc))
Roberto	We have something ((looking at teacher)) but it was false.
Marc	((Flipping forward and backward in notebook, then his gaze returns to Roberto and the teacher))
Teacher	How so? Why?
Roberto	We invented a story.
Teacher	So, you wrote a new story?
Roberto	Noooooo. I wrote out the answer to the (inquiry) story, but it was false.
Teacher	What did you write down?
Roberto	We asked the other teacher, but it was wrong...and that it (the water) went up and then dripped down...but that is wrong.

Based on what was recorded in his notebook, and his explanation during the interview, the teacher concluded that he and his group mate had one idea, recorded it in their notebooks, came to the conclusion it was false, and crossed it out. However, video analysis of their interactions with their notebooks revealed Roberto and Marc had generated numerous ideas in discussion. The fact that they discussed multiple ideas yet recorded only one in their notebooks, coupled with their claim during the summative interview that their idea was "wrong" indicates that they positioned the science notebook as a receptacle for transmission-based forms of science knowledge. Even though they were working within an inquiry-oriented unit and were positioned by task structure and the notebook to consider multiple ideas, they situated the use of the notebook as the receptacle for *the* one correct answer.

This sat in contrast to the way Group 3 utilized the space of the notebook. Hank (Group 3) drew three possible ideas for how there might be condensation in the tent. At the end of the

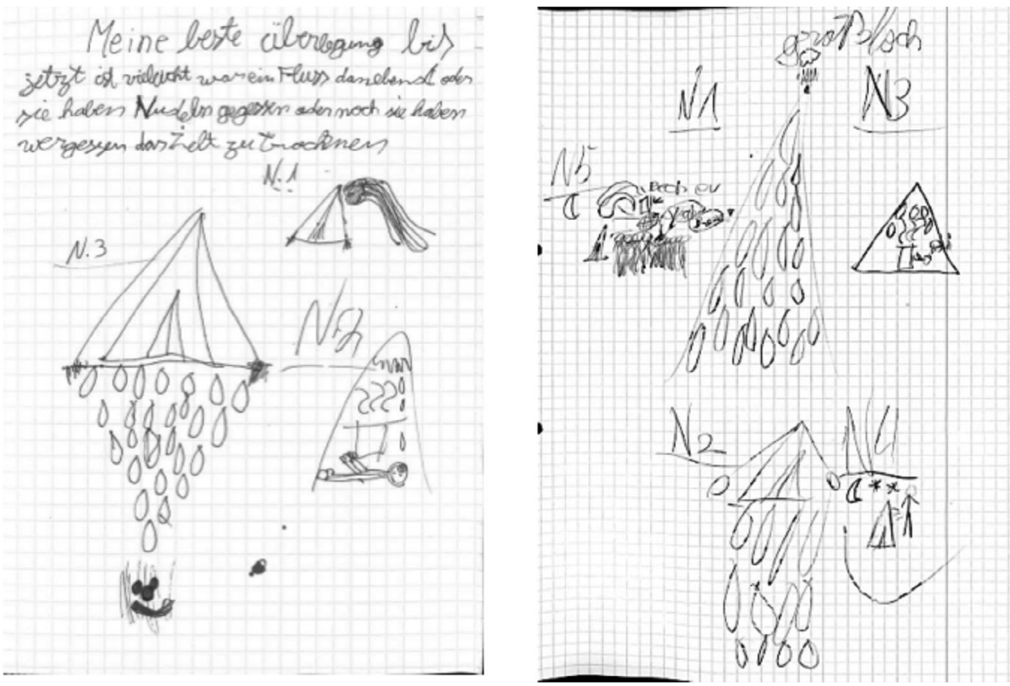

FIGURE 7 Hank considered multiple causes for the condensation in the tent. His notebook entries showed he had three ideas (N.1, N.2, N.3) at the start of the lesson (left) which grew to five at the culmination of the lesson (right) on Day 4 (N.1 - N.5)

lesson during the summative interview, he says to the teacher, *I am trying to make five ideas*, as he draws five representations in his notebook (Figure 7). The teacher responded, *Five ideas, okay, and how are the ideas different?*, to which he replied, *I don't know yet*, with his gaze set on his drawings in his notebook. His conversation with the teacher conveyed that he had multiple ideas and that the notebook afforded him the space to document these. In both this and the prior episode, it is clear that the space of the notebook afforded students the ability to entertain multiple explanations, yet how students oriented their work within the notebook space varied.

5 | DISCUSSION: SYNTHESIZING THE ASSERTIONS

Multimodal interaction analysis of plurilingual students' interactions with science notebooks revealed how the semiotic social space of the notebooks, coupled with the science inquiry instruction, supported students in representing their understandings in diverse ways. Co-construction of explanations in the space of the science notebooks enabled plurilingual students to communicate and extend their science ideas in interaction with their classmates and their teachers through fluid processes of resemiotization as they represented, discussed and explained their ideas and understandings through time, while drawing upon diverse communicative resources.

In response to the first question guiding this study, analysis showed how the notebook space coupled with the inquiry tasks enabled students to formulate connections across the time and space of their own experiences, and multiple science investigations. These findings support prior findings that show how students move from one representation to another in the process of constructing meaning in science class, and when doing so, incorporate multiple layers of understanding through shifting modal ensembles of understanding (Tang et al., 2014; Williams et al., 2019). What is newly revealed in this study is how the notebook enabled each group to do so through student-directed pathways of resemiotization that revealed diversity and multiplicity in students' understanding of the inquiry storyline. More specifically, across the three groups there was less variation in the forms of entries constructed for the first assessment task, yet in moving into the subsequent discussion task and interviews, there were varied student-directed paths of resemiotization that revealed multiple students were entertaining multiple ideas about the inquiry storyline.

The study shows how the notebooks, through interaction, provided space for students to fluidly draw upon multiple and diverse semiotic resources (Williams et al., 2019) in ways that showed the documentation of investigations, and communication of ideas as a "process, a drama in several acts that unfolds in time" and space (Pozzer & Roth, 2019, p. 1). Multimodal interaction analysis showed that students were afforded multiple opportunities to perform processes of resemiotization as they moved from one assessment task to the next, at times drawing or writing what they understood, and in the next moment discussing their understandings, and then representing again yet drawing upon different modal ensembles. This fluidity is significant, in particular for this class of plurilingual students, in that it revealed that students were afforded the space to draw upon semiotic resources across multiple forms, as they were able to write in German about their findings, and then to discuss their findings in Luxembourgish. The notebook provided a space for students to do so in self-determined ways that are not always supported by classroom practices in our national context. This supports prior findings of open-ended science notebook use as a support for fluid translanguaging in our national context (Wilmes, 2017a, 2017b). This form of science instruction supports science teaching practices which create spaces that allow students to draw upon diverse communicative resources during process of semiosis, even when aspects of classroom instruction, and assessment are regulated to be conducted in one language (Flores & Schissel, 2014; Kiramba, 2019).

Moreover, in mediating resemiotization practices, the notebooks provided bridges across the time and space of students' multiple inquiry experiences. In this way, the notebooks served as a bridge among diverse forms of multimodal meaning making (Jornet & Roth, 2015; Williams et al., 2019) across time and space (Rahm, 2004; Tang et al., 2014) and they mediated the synthesis of multiple phases of students' inquiry experiences. Prior studies of student science notebook use have examined notebook entries as products, and thus have not examined the interactions coupled to their production and further use in interaction. If the notebook entries students constructed in the analyzed classroom had been analyzed simply as two-dimensional texts, students' multiple representations and the interactions they were associated with would have not been visible. This speaks to calls from researchers such as Adami (2016) who elaborate that, an "analysis of texts alone do not do justice to understanding the complex inter layering of meanings" (p. 18).

Relative to the second question guiding this study, notebook use positioned students to flexibility draw upon diverse semiotic and communicative resources to represent and communicating their experiences and understandings. The analysis we present in this study illuminated moment-to-moment interactional details of how each student within the three groups developed a storyline across the multiple days of inquiry tasks. In this way, this study reflects what Varelas et al. (2012) described in their exploration of science journal use by elementary students, as spaces within which students are able to construct stories of themselves as scientists, by intertwining their science experiences and ideas across multiple spaces and places.

Analysis further showed how the notebooks positioned students to expand their ideas in interaction, and when doing so, to draw upon diverse communicative and semiotic resources, practices shown to support language learners and marginalized students (e.g., Karlsson, Larsson, & Jakobsson, 2019; Poza, 2018). We see how students' preferred common language (Luxembourgish) was used to interact during the verbal discussion with each other, although their notebook entries were written in German. This is key relative to language policy, in that German is the sanctioned language of instruction for primary school science in our national context. Our assertions highlight the role of the notebook for positioning students to draw on a wide range of semiotic and linguistic resources, and is aligned with prior studies that detail the importance of opportunities for students to draw upon multiple and diverse linguistic resources, even within more restrictive educational practices (Flores & Schissel, 2014). It is even more relevant in science units during which students can be required to construct meaning over several periods of participation and investigations and supports prior findings that show students representations can serve as a bridge across time and space (Varelas et al., 2012) and across multiple representations (Tang et al., 2014).

Analysis also revealed how the space of the notebook coupled with the task structure positioned the teachers to enter into dialogue with students regarding their representations. At times this revealed complex understandings that were reflective of the multiplicity of students' understandings. By contrast, Group 2's interactions with the teachers in the space of the notebooks failed to result in representing their ideas in their notebooks, even though these were included in discussion. Video analysis revealed that even when students were thinking through multiple ideas, they were oriented toward representing one correct answer in their notebooks. This most likely occurred as students were positioning themselves to document in more rigid ways, in keeping with their prior use of notebooks for documentation and representation in science classes, as compared to the open format used in this study.

Conceptualizing student science notebooks as an interactional space and analyzing their use with multimodal interaction analysis revealed that that the use of the notebook positioned students to be able to draw upon diverse linguistic resources in interaction around the notebook entries, in ways that were student directed and specific to each of the three groups. Entries in their notebooks were used in interaction as points of leverage with teachers, thus helping students to express their ideas. This is important given their expressive language capabilities in the language of instruction, which might have presented truncated views of their understandings. Interactions with the notebooks provided an increased layer of insight into students understandings.

While this study illuminates the ways in which plurilingual students in this multilingual classroom interacted within the space afforded by the notebook and associated tasks, this points to the need for further research to explore this and similar instructional tools commonly used in science instruction as spaces of interaction. Next steps could include the investigation of the use of open-ended science notebooks in diverse plurilingual contexts, and additionally in interaction in monolingual classes working with one national language. As the use of the notebook is closely coupled to the structuring of the activities by the teacher, further research in this area would provide insight into the ways in which teachers' epistemological positionings result in the use of the semiotic social space of the notebook by students. This study has scratched the surface in its examination of how plurilingual teachers and students in interaction co-constructed the use of the notebook space as they conducted science investigations, pointing to the need for further exploration.

In sum, the novelty of this study is the fine-grained view of resemiotization which was revealed to unfold in interaction along student-directed pathways, and the ways the notebook semiotic space positioned students to draw upon multiple meaning-making and communicative resources. Through the examination of science notebooks use in interaction, this study moves beyond the limitations of prior studies of notebook use by language learners as critiqued by scholars (Wu et al., 2018) and reveals how the notebooks through interaction provided a space for dynamic resemiotization.

6 | IMPLICATIONS

The findings from this study point to implications for science teaching and science education research. Methodologically, this study contributes to a growing body of research that theorizes science instruction as contingent upon and unfolding in interaction (e.g., Jornet & Roth, 2015; Wilmes & Siry, 2018). To the best of our knowledge, student science notebooks have yet to be examined through this theoretical positioning and with video analytical approaches over the course of an inquiry unit of study. Thus, this theoretical position of science notebooks coupled with methodologies that investigate use-through-interaction reveal richer views of students' semiotic resource use as they engage in science. In this way, we work towards an understanding of students' resemiotizations that can be positioned as "less a discovery of the new, and more as recovery and recuperation of alternative dispositions toward meaning making" (Horner, Selfe, & Lockridge, 2015, p.16). This study allows the field to build upon prior studies that examined individual notebook constructions by highlighting the multimodal nature of science notebook use in interaction, and in doing so, emphasizing views of the interactions that took place in the space afforded by the notebook. This study additionally underscores the value of research grounded in video-based methodologies to examine plurilingual students' engagement in science as an embodied interactional process that is co-constructed through interaction, while working in languages they are also working to mastering (Karlsson et al., 2019; Wilmes, Gómez Fernández, Gorges, & Siry, 2018).

The findings generated from this study point to multiple interrelated implications for science teaching. First, the results show how student science notebooks, when used in the course of inquiry instruction, support the processes of representation and communication, which are essential to science learning. Second, the findings illustrate how open-ended science notebooks created spaces for students to voice multiple and varied pathways of resemiotization and thus provide valuable learning spaces for students who are learning science in language(s) they are also working to master. This aligns with the work of researchers who underscore the value of such semiotic spaces for students often marginalized through normative processes of student documentation (e.g., Varelas et al., 2012).

Moreover, the semiotic interactions and processes of resemiotization observed in all of the groups mirror translanguaging practices (Infante & Licona, 2018; Poza, 2018) supported by language-inclusive instructional approaches (Lemmi, Brown, Wild, Zummo, & Sedlacek, 2019). These science instructional approaches can support language learners in meaning making and participation in science practices as they are positioned to draw on diverse communicative resources in their linguistic repertoires. Translanguaging pedagogies promote and support students' access to and use of varied communicative resources to co-construct meaning making processes in general (García & Lin, 2017), and in science in particular (Poza, 2018). These lie in contrast to monolingual, bilingual, or multilingual instructional approaches which either limit students' access to specific national language resources or create distinct boundaries between when and how students are able to access and employ diverse national language resources over the course of learning. What we have shown regarding open-ended science notebooks in this study supports prior findings in our national context that revealed how science notebooks support spaces of translanguaging in ways not always supported through instruction (Wilmes & Siry, 2018).

When students engage in science practices in classrooms, they are positioned to synthesize experiences, ideas, and understandings over a series of lessons and experiences. Most often, they are required to do so through talk, writing, and drawn representation of their ideas, and through the co-construction of these ideas with group members and teachers. This high level of embodied and linguistic engagement can be supported through the use of open-ended science notebooks. For plurilingual students, opportunities to represent classroom learning experiences in science journals, and to interact with their journal as a site for representing, communicating, and interacting around their ideas, can provide additional avenues for further thinking, interacting, and meaning-making. This contributes to the growing body of research that supports the use of translanguaging pedagogies in science instruction (e.g., Kiramba, 2019; Poza, 2018; Wu et al., 2018), and that calls for science instruction that supports plurilingual students in accessing, discussing, and co-constructing meaning by drawing on diverse communicative resources (e.g., resources from multiple national languages). Language hierarchies and classroom structures that often marginalize students working to learn science in languages they are also working to master can be shifted and broken down. More specifically, this study shows that when coupled with inquiry science instruction, science notebooks can support plurilingual students in expressing science ideas in multiple ways. Furthermore, science notebooks provide opportunities for students to discuss their understandings of science topics using everyday language and translanguaging, key elements of science instruction for language learners.

Even though open-format notebooks may present open pedagogical opportunities (Siry, 2013), it is important to consider that students may orient themselves within the notebook interaction space in a range of ways. For example, students may self-limit their representations based on prior school practices. Use of the notebooks then, requires a degree of explicit support to reinforce their use in ways that encourage students to consider and document a multiplicity of ideas. If teachers are aware of this, they can seek to dialogue with students around their entries to explore students' decisions about what they construct in their notebook representations.

In conclusion, student science notebooks, when implemented in ways that allow for student-driven selection of semiotic representation over time, can serve as a rich interactional space. This contributes to an understanding of *sites*, in this case the science notebooks, which provide students with rich opportunities for linguistic and social interaction embedded in situated learning spaces (Puvirajah, Verma, & Webb, 2012). This study revealed that the science notebooks supported students in drawing upon diverse communicative resources as they constructed and communicated intricate and multiple representations of science understandings, thus establishing powerful instructional spaces for students learning science through languages they are also learning to master.

ACKNOWLEDGMENTS

We declare that we do not have any conflicts of interest relative to the research presented in this study. This research was supported by an Aide à la Formation Recherche (AFR) grant (No. 4832121) from the Luxembourg National Research Fund (FNR).

ORCID

Sara E.D. Wilmes https://orcid.org/0000-0003-1039-4376
Christina Siry https://orcid.org/0000-0002-6376-7060

ENDNOTES

[1] In this study, and in our research in general, we employ the terms "plurilingual" and "multilingual" in accordance with the Council of Europe (2001) definition, which attributes plurilingualism as an attribute of individuals and multilingualism as an attribute of spaces. For a more detailed discussion refer to (Wilmes, Siry, Gómez Fernández, & Gorges, 2018). This is a methodological choice that valorizes the multiple and diverse linguistic resources students bring with them to the classroom and who are referred to using many different terms in terms of normative classroom practices such as "language-learners," Emergent-bilinguals, which assume deficit views of students with diverse linguistic repertoires.

[2] Student names are pseudonyms.

[3] Transcripts were constructed in their original language for research purposes and subsequently translated into English and verified by our multilingual research team for publication purposes. Transcription conventions used throughout this manuscript are as follows:

- … pause in speech, one equals one tenth of a second.
- (( )) action.
- xxx unintelligible vocalizations.

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Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Wilmes S.E.D., Siry C. Science notebooks as interactional spaces in a multilingual classroom: Not just ideas on paper. *J Res Sci Teach*. 2020;1–29. https://doi.org/10.1002/tea.21615