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"*Is there another word for 'water'?*"
Designing for student progression in academic literacies and epistemic agency

by

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Abstract

This longitudinal study conducted over one school year reports on a design-based research intervention which investigates conditions for fostering academic literacies in a small-group setting of English language learners aged 9-10. The aim is for the learners to achieve increased proficiency enabling them to fully participate in the mainstream class subjects. The study analyses issues of teaching practices in a middle school that support subject literacies development of students from diverse language backgrounds in the multilingual classroom.

Drawing on language learning as subject literacies practices, knowledge building for deeper learning and transferable skills, this intervention enacted a set of DPs across four iterations fostering progression in students' knowledge along the Everyday Language and Academic Language continuum. The design is informed by sociocultural theory and situative perspectives on meaning-making in the social context of the classroom. It draws on the knowledge construction metaphor of learning as joint collaboration for constructing shared, improvable objects, which are conceptualized not only as material artifacts but as the practices of epistemic work embedded in their construction.

In a science topic, anchor texts and representation construction are used as entry points for discursive moves to discuss academic terms and diagrams for knowledge construction. There are three moves: meta-talk around repeated read-alouds of the anchor texts, focussing on academic word choices for concept-building; text editing through languaging to over-write academic terms; and epistemic work with representation construction or using appropriate disciplinary registers to re-write the anchor texts. A focus on reasoning practices enabled students to experience epistemic agency and authority, and progress from transcribing words and representations to reconstructing artifacts through edits. Such processes then led to constructing original artifacts where learners showed mastery in using academic literacies as sign forms and cultural tools. DPs with specific descriptors were developed, providing new design knowledge to support learning of academic literacies as appropriation of sign-making tools for epistemic work. The study therefore contributes new insights by articulating the underlying mechanisms for ELL progression and building a local theory of practice.

LAY SUMMARY

This study, carried out over one school year, reports on a design-based research project which investigated creation of a culture of academic language, including reading and writing, with English language learners aged 9-10 and their teacher.

The aim is for the students to improve in proficiency in Academic English, so that they can fully participate in the mainstream class subjects. The study is set in a middle school that support academic English development of students from diverse language backgrounds in the multilingual classroom.

Through a view of language learning as taking place through reading and writing practices in the school subjects, a set of DPs were prepared and applied in four different topics, so as to help the students improve their knowledge of the differences in everyday English and Academic English.

In school science topics, small chapter books are read and diagrams are prepared, as a context for group discussion about academic terms and diagrams for representing and communicating information. Findings show the emergence of three kinds of talk in the group discussions. There is meta-talk taking place around repeated read-alouds of the books, focussing on academic word choices and concepts. Through languaging work, the text is edited for grammar and academic terms. Through epistemic work, diagram work and writing activities are carried out to re-write these using academic terms. Through these processes, students were able to experience a sense of agency and developing identity as participants in activities in school subjects.

This study contributes to the field of design instruction to support learning of academic language in school topics and provides new insights into English language learner progression in Academic English.

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1 Introduction

This study reports on a design-based research intervention with the dual purpose of developing a new design for a learning environment fostering academic literacies, and generating evidence-based claims for formulating and refining design principles (DPs) to confirm the Design Features (DFs) of the intervention, through studying iterative implementations of this design.

The intervention aimed to investigate the conditions for fostering language learning for 9-10 year old ELLs (English language learners) in a small-group setting. Language learning is conceptualized as subject literacies practices, knowledge building for deeper learning and transferable skills. Hence, the overarching research question for this investigation is *How can a learning environment be constructed in order to support ELL students appropriating academic literacies and disciplinary practices?* To operationalize this question in the format suggested by design based research practice, I have reformulated this question as a High-level Conjecture (Bakker, 2018; Sandoval, 2014; Van den Akker, et al., 2006), namely, *Students' knowledge and use of the Everyday Language (EL) and Academic Language (AL) continuum requires their appropriation of disciplinary discourse practices, including representing and reasoning about phenomena and processes in school science topics*.

Findings for this study indicate that guidance in the practices of academic literacies leads to student progression in academic literacies as disciplinary practices. This progression takes place through students enacting mediating processes connecting knowledge construction with discourse moves around text and representations, and thereby learning to move from everyday language to academic language in a self-directed, purposeful way. I present arguments for the new design knowledge emerging from this design-based research intervention: DPs developed in this study are applied successfully so as to support students'

- learning as changes in participation in literacies practices over time
- learning as appropriation, sophistication and mastery of cultural sign-making and semiotic resources for knowledge construction

- learning as increasing proficiency of participation in a maturing culture of academic literacies for knowledge construction

fostering a progression in *Students' knowledge and use of the Everyday Language (EL) and Academic Language (AL) continuum for representing and reasoning about phenomena and processes in school science topics*, as suggested in the Revised High-level Conjecture for the DBR intervention presented in this study.

1.1 Background to the Research

This study grew out of pilot projects that I carried out over several years in the context of my small-group work with ELLs in a middle school. In this section, I review this preparatory work with the dual aim of presenting the evolving focus of the problem definition and design of activities, in preparation for designing the intervention, in chapter 3 (Bakker, 2018; Gravemeijer and Cobb, 2013), and situating the study in an emerging theory of practice, in chapter 5 (Coyle, 2020).

I first briefly describe the social context and general background of the students in this school, as well as certain school policies relating to ELLs, which are not a focus of this study. The context is a bilingual English/French-medium instruction private school environment located in a French-speaking region in Europe. Students are admitted to the school regardless of English or French language proficiency, and may be of any nationality and linguistic background. However, according to school policy, new students' language proficiency levels in English are evaluated so as to determine their ability to participate in the core subjects enacted in that language, according to an array of criteria. These criteria include social and emotional elements in the profile of each student determined through family interviews, as well as language proficiency levels determined through formal testing and informal interviews. Students whose profile indicates a relative inexperience in English medium instruction, or whose testing showed achievement below a certain required level, are assigned to a pull-out language group during part of each school day. In this group, a specialist teacher provides daily direct instruction of language and literacy skills during certain core subject lessons (variously English language arts, science and social studies). These language learners still participate in mainstream class lessons with their classmates for

the balance of the day. The duration of the attendance in the pull-out group is flexible and contingent on factors not limited to increased language proficiency; students may also join the group during the course of the term, again due to factors beyond the scope of this study.

My role is that of the specialist teacher for ELLs aged 9-11 in this school, with other specialists attending to other age levels. I conduct my teaching with my student groups in my own classroom, separate from the mainstream classes, due to the pull-out teaching program. The content of the program involves English language instruction using language teaching materials that I select and adapt, including resources from the Oxford Discover series (Oxford University Press, 2022) of topic based, non-fiction graded readers used in this study. For instruction in my small-group setting, I select readers such as reflect the topics of the year level curriculum enacted by the teachers in the mainstream class, so as to provide my ELL students with a sense of the activities being undertaken by their classmates, but also to prepare these ELLs for participation in some aspect of these mainstream class activities. I expand the material in the graded readers by drawing on and adapting educational materials (Coyle, Hood and Marsh, 2010) published on web sites designed for teachers, such as Enchanted Learning (Col, 2025). I enact instruction using these materials through activities which concurrently investigate language structures, vocabulary, visuals and text through which the content is represented. These activities form the basis of the intervention reported in this study (see section 3.5).

My ideas for these activities, and my approach to working with the topic based non-fiction readers and curricular materials, developed over several years prior to the present study. This development formed a sequence in my continuing professional reflection (Tracy, 2013): in this specialist role, my practices originated in grammar teaching through language coursebooks, transitioning to pre-teaching and re-teaching content area lessons (science and mathematics) that ELLs were attending, and on to teaching the genres of science texts and reports used in these science lessons. These changes were motivated by my perception that ELLs were still struggling to participate in content area lessons, as expressed in their comments about these lessons, and noted in the feedback from the teacher on their written work. I sought to address the gaps in student attainment and make ELLs' school experience more enjoyable, which I felt required certain changes in my teaching methods.

The transition from working mainly with coursebooks emerged through my discussions with these students. To promote student reflection on learning, I would regularly have short group discussions about their activities in other lessons; in discussing these, ELLs would describe their science lesson in uncertain terms, with each person recalling a different point which they stated vaguely, forgetting the key vocabulary. As this situation persisted, I eventually resolved on a new phase of pre-teaching the science lessons to focus more on preparing for the lesson objectives and relevant academic terms. I began preparing key vocabulary and previewing diagrams or short video clips similar but not identical to the material in the upcoming science lesson. Activities would consist of tasks ranging from word recognition in listening and reading, to constructing sentences through talking and writing, to rehearsing key terms reflecting the key points in the video clips or diagrams. Following the science lesson in the mainstream class, I would assess the effectiveness of this preparation by again inviting discussion on this lesson, including asking students to attempt to present some point of their choosing by drawing or writing on the board, as a talking point. Here, individual differences became apparent, as some students showed a disposition to notice patterns in the words and sentences, or make connections and guesses which appeared to help with retention and retelling, while others were concerned with completing the task correctly and were emotional about the outcome. Still others appeared disengaged by not volunteering, or claiming to be unsure. I continued by attempting to individualize instruction, although I did not think more time spent preparing and reviewing would improve these results overall, as there appeared to be many learner variables involved.

However, in 2012, the school offered a major professional training opportunity to teaching staff in the form of a practical course addressing the above concerns, namely the theory and processes for engaging students in using language for learning, or content and language integrated learning (CLIL) (Coyle, Hood and Marsh, 2010), more recently developed as the Pluriliteracies Teaching for Deeper Learning (PTDL) (Coyle, 2020). Through this course, I began to explore selecting and modifying materials and tasks, as well as constructing new materials and activities, with the aim of learning more about designing for engaging and comprehensible language and content to provide learning opportunities in the disciplines for all my students. This work culminated in a project using the iPad: my ELL students each used a personal device as a tool for note-taking in their science class, constructing assignments

and reports in my class, and communicating these in a way that promoted learner agency in individual trajectories of language and content learning (Eerikäinen, 2015). With this study, I began work in the processes of knowledge construction and knowledge sharing, through a focus on the language and genres of disciplinary literacies for deeper learning, to foster learner progression along a continuum of expertise in communication, as suggested by Meyer and Coyle (2017):

> In other words, progress becomes evident as novices increase their meaning-making potential by moving outwards along the continuum alongside an ability to verbalize their increasingly complex conceptual understanding adequately in the appropriate language (pp. 205-206).

In my iPad study, I designed activities through which the students were able to use the iPad to construct their own lesson materials, by taking photos of the stages in their activities, such as planting seeds, and articulating about the actions, observations and processes through typing these into the digital notebook. With time, during the course of the school year, each student was able to engage in and author work in the cognitive discourse functions of science, including doing, organizing, explaining and arguing about science phenomena and processes (Meyer and Coyle, 2017, p. 205).

However, I then began to consider documenting and characterizing the conditions fostering movement along this continuum (e.g. Gibbons, 2003). In my iPad study, the ELLs practiced and developed mastery of the genres of their science inquiry activities, since my design focused on the content of these activities and the appropriate text structure for the discourse function being mediated by the notebooking processes. Due to that specific focus, the ELLs and I did not accord equal time to discussion on how vocabulary and language structures were being used. The required academic terms were pre-determined by the science teacher's unit plan, as were all the inquiry tasks, which followed the pace and sequence set by the mainstream class, with no conditions for collaborative design (e.g. Cochran-Smith and Lytle, 1999; Bakker, 2018).

To fully investigate the conditions fostering these literacies practices in science content, and the emerging language, I felt it was necessary to have a direct view of all aspects and features of enactment, as well as agency in their design. Reflecting also on this stage in my teaching practice working in this role, I considered it productive to pursue these points; in

chapter 6, I return to these points, and teachers and researchers collaborating for change in the classroom for a learning ecology fostering student agency in academic literacies (e.g. Wells, 1999; van Lier, 2008).

In this section, I have delineated my evolving professional practice in the role of specialist working with ELLs in this school context, and through this, the developing area of the questions that I aim to investigate through the intervention reported in this study (Tracy, 2013). I now turn to an overview of general conceptualizations of academic literacies, science and ELLs, to briefly present research and reports on studies and programs addressing this area of teaching and learning, so as to situate my area of investigation within established relevant research directions, and also determine gaps in this literature within this area of interest (Cohen, Manion and Morrison, 2017).

1.2 General area of the study and context

This study is concerned with English Language Learners (ELLs) and designing instruction fostering their participation in academic literacies in a middle school setting. In this brief overview of the research context of this study, I begin with issues reflecting my initial concerns in my teaching practice, as noted in section 1.1, which motivated me to engage in the work reported in this study, namely ELLs ' learning the genres and registers that are essential for school success (e.g. Colombi and Schleppegrell, 2002; Gibbons, 2007; Goldman, 2018). In working with ELLs, I focused on vocabulary learning and reading comprehension strategy instruction using coursebooks, in order to increase their language proficiency and so facilitate the transition of the students to their mainstream classes. However, transitioning the ELLs to work in content area lessons in the mainstream class has been a particular concern for me and the other specialist teachers in our school, in terms of equity and participation (Bravo and Cervetti, 2014). Achievement disparities persist in science class for many ELLs compared with more language proficient peers, as noted in my review in section 1.1. Bravo and Cervetti (2014) state the need for focused language work with ELLs:

> Without instructional attention to language within content areas, like science, ELs will not develop the type of academic register they need to fully engage in the discipline and be career and/or college ready. Hence, understanding more effective approaches to assist ELs in developing science knowledge and academic English is a social justice imperative—ensuring access to the curriculum for all students. (p. 231).

In preparing for this study, I chose to focus on the disciplinary literacies of science in the middle school context as my area of investigation, as described in the outline of my preparatory work, in section 1.1.

The use of language in science has been studied from vocabulary level through reading and writing tasks and on to work attempting to characterize literacy in science. Studies that focused on the vocabulary of science find that it poses challenges to learners because it is quite different from everyday English. In their discussion of academic language, Nagy and Townsend (2012) outline six characteristics, such as nominalization, Latin and Greek vocabulary, morphological complexity as well as abstractness, which enable greater density of information than normally found in conversational English (p. 93). Schleppegrell goes further to characterize the "language of schooling", drawing on Snow's features of "decontextualized language", including precise lexical references, a distant author stance,

and complex syntactic structures that are also very cohesive and coherent (Schleppegrell, 2004, p. 9). The author goes on to make use of Cummins's notions of context dependence and cognitive demand to explain that the difficulty of this language for the school age learner is in the high cognitive demands placed on students. Both the task, and the language used to describe the task, are unfamiliar and require simultaneous processing (Schleppegrell, 2004, p. 15). Schleppegrell advocates instructional interventions that give students "control of academic language". Teachers therefore require the means to incorporate language analysis in the classroom, for better disciplinary learning. Wellington and Osborne (2001) are even more explicit in urging the teaching of the language of science, rejecting the advice given to teachers in the 1980s and 1990s which encouraged them to use everyday English words as much as possible, even if this meant using ten ordinary words in place of one, as the ideas of science are difficult enough for students (p. 6). They point to the connection of language and science so as to explain the need for teachers to know the modes, or meaning making using words as well as other representations, and use them appropriately in teaching science:

> …learning to use the language of science is fundamental to learning science. As Vygotsky pointed out, when a child uses words, he or she is helped to develop concepts. Language development and conceptual development are inextricably linked. Thought requires language, language requires thought. (p. 6)

Whereas the preceding authors refer to descriptions of science or academic language and science learning in terms of genres of writing, authors such as Lemke (1990) and Gee (2008) go further in establishing a necessary link. Lemke (1990) states,

> Learning science means learning *to talk* science. It also means learning to use this specialized conceptual language in reading and writing … It means learning to communicate in the language of science and act as a member of the community of people who do so. (original emphasis) (p. 1).

Gee (2008) explains in detail the factors hindering or assisting a child in developing conceptual learning, due to the language that he or she is using. He cites the example of the term "rusty", used by two children in a reported classroom dialogue, and the confusion that ensued as one child was trying to describe an object being rusty, and the other was more interested in its getting rusty (p. 58). For Gee, this clearly indicates the role of the teacher in science education in teaching precise language for clear ideas:

> Academic styles of language differ from conversational …in the ways they organize meaning in the sciences. It is important for teachers to understand the distinction between these language styles and how their teaching can support children's acquisition of academic styles of language (p. 58).

The centrality of language in human activity, and language development being constitutive of conceptual development, as noted by Vygotsky, Lemke and Gee above, is therefore clearly established as socially organized and interactionally developed in a specific context, or community of practice. This view of knowing and learning as taking place in a community of discourse, practice and thinking drawing on Vygotsky's work, is termed a sociocultural perspective (Greeno, Collins and Resnick, 1996). Science education may therefore be viewed as collective activity involving epistemic and social practices shaping how knowledge is constructed and communicated, as argued by Duschl (2008). I turn to sociocultural considerations for designing science and language integrated lessons below, to discuss views of conceptual learning and language learning in designing for such lessons. First, I briefly consider research on science literacy, content area literacy and programs that have attempted to define and implement instruction addressing these aims for students, to determine relevant design suggestions and gaps for further investigation.

An early reference to content area literacy refers to "skills needed to obtain knowledge of content" (McKenna and Robinson, 1990, p. 184), and more recently, "study skills that can be used to help students learn from subject matter specific texts" (Shanahan and Shanahan, 2012, p. 8). Heller and Greenleaf (2007) state that these definitions led to recommendations that teachers teach "reading and writing across the curriculum", due to the interpretation that there were certain core or "all-purpose" reading and writing processes for which a core set of strategies could be taught (p. 8). However, both Shanahan and Shanahan and Heller and Greenleaf point to the danger of "across the curriculum" core strategies teaching imparting the notion that all academic texts are the same. Instead, Heller and Greenleaf argue that "…each discipline emphasizes particular kinds of language and particular approaches to reading and writing" (p. 11); Shanahan and Shanahan (2012), on the other hand, go further to clarify:

> …content literacy emphasizes techniques that a novice might use to make sense of a disciplinary text (such as how to study a history book for an examination), whereas disciplinary literacy emphasizes the unique tools that the experts in a discipline use to engage in the work of that discipline. (p. 8)

Both sets of authors agree in the need to teach disciplinary literacy explicitly for largely the same reasons: students will need to be taught advanced literacy skills because the reading materials and tasks become progressively more difficult in the school subjects throughout secondary school; students would make greater progress with explicit guidance; and students in fact learn skills better in the context of difficult reading and tasks because these may be perceived as authentic and therefore more motivating.

These definitions clearly point to the challenges students face in carrying out academic work in the school subjects, and give an indication of the sorts of interventions that they might need; nevertheless, there are critics who argue that a polarization has ensued, to the detriment of real discussion about practices. Brozo et al. (2013) question the usefulness of the dictum "every teacher is a teacher of reading" issuing from the work on disciplinary literacy, in fact calling it "outmoded and largely ineffective". The authors argue that there is a literacy-content dualism which impedes productive discussion on the possible features of effective literacy teaching (p. 353). They urge content area teachers to collaborate with literacy specialists to keep delving into the nature of those processes that a disciplinary expert engages in, while building on what the literacy specialist can advance on strategy instruction, so as to create classroom activities to better teach those processes. Hynd-Shanahan (2013) recommends that the disciplinary purpose leads the choice of strategies, and the reading specialist helps the subject teacher "unpack the perhaps implicit understandings and practices" that are required for a particular task (p. 95). Moje (2008) agrees that it is insufficient to suggest to content teachers that they implement literacy teaching practices. Furthermore, she refers to disciplinary learning as more than building knowledge in the discipline; it is understanding how knowledge is produced (p. 97). Hence, subject teachers build knowledge and engage students with texts of the discipline; that is to say, they provide students with the opportunities to construct knowledge according to the representations of the disciplines, so that they can examine and practice "how the norms of knowing, doing and communicating are constructed" (p 102).

Therefore, explicit teaching of disciplinary literacy seems to be necessary for science teaching, and has in fact been termed "crossing borders", referring to the connections between science and literacy (Saul, 2004, p. 2). For Gee (2004), there is no border: he states

that literacy should be "embedded in and integrated with" content area reading, writing and discussion, in particular in science (p. 13). I therefore turn to a brief overview of programs and instructional approaches that attempt to define and implement integrated instruction in middle school settings, to present common characteristics and results.

Instructional programs have been devised to connect aspects of science teaching and literacy teaching, with different emphases, methodologies and goals. Some of the earliest such programs began by identifying certain practical problems in contemporary education, such as the very limited instructional time allocated to actual science teaching (Romance and Vitale, 1992; Cervetti, et al., 2006), in conjunction with a prevalence of students who lack skills in writing and reading informational text (Raphael, Kirschner, and Englert, 1988), or who are not very proficient in critical reading comprehension skills for evaluating scientific information (Casteel and Isom, 1994; Palincsar and Magnusson, 2001). Romance and Vitale (1992) point to the lack of proper, in-depth science teaching as resulting in negative attitudes to science on the part of students; Casteel and Isom (1994) are more specific and point to the need for relevant and motivating instruction to mitigate the complexity of science processes and content. These authors state that those students who struggle in science activities also have limited proficiency in literacy skills, and so go on to justify and call for a teaching that combines these: "Literacy-based instruction can support students' interest in science content and extend their scientific knowledge through integrating science process skills with literature and literacy process skills" (p. 538). The authors emphasize drawing on the similarity of the process skills, which should be used during instruction, and the goal is to teach science content through activities that the students find meaningful. Romance and Vitale (1992), in their early study, emphasize the need for skills in reading content based material to promote thinking skills and knowledge building and thereby conceptual understanding (p 546), which they continued to investigate with studies providing details on tasks and sequencing in suggested units (Romance and Vitale, 2006).

The above authors focused on reading, without referring to the language of science as such. Palincsar and Magnusson (2001) closely tie hands-on science activities with reading of text that has been designed to foster children's thinking as they engage in scientific inquiry. The authors report interviewing science teachers who felt that science texts would supplant

children's inquiry and discourse, and so went on to define a "second-hand investigation", or working with a text that was specially designed to complement student discussion on phenomena, claims and arguments, in conjunction with their "first-hand inquiry". The authors refer to the benefits of this approach as enhancing metacognition in the children's discourse, and that the interplay of this first and second hand investigation provided a common ground resulting in greater conceptual understanding. The emphasis here is on students investigating models of reasoning from a purpose-built text, so as to learn ways of scientific practice such as interpreting data tables, to be in turn carried over into personal practice in science inquiry lessons. This approach addresses the problem that children in effect need to be apprenticed into science practices, which is effectuated by texts pre-adjusted for the unit of inquiry and reflecting the activities to be enacted. However, the oral and written discourse that the authors promote are analysed in terms of students' knowledge-building practices to inform the first hand inquiry for individual conceptual growth. The authors are not delineating the processes of *talking science* as constitutive of science practices, as Lemke urges, or the discourse processes involved in metacognitive strategy teaching for critical language awareness as advised by Schleppegrell (2004, 2013).

Later studies by the same authors explicitly seek to establish and draw on similarities in the processes of learning from text and learning from scientific inquiry, as they pursue the model of using specially designed texts which help model thinking in scientific practices so that students may achieve scientific reasoning goals (Magnusson and Palincsar, 2004). I consider that this approach with pre-designed texts pre-empts an essential meaning-making practice in teaching reading comprehension with a focus on science language, namely the reciprocity of the reading-writing connection (Proctor, et al., 2020), and current practices in "interactive" reading (Lapp, Fisher and Grant, 2008; Lennox, 2013; Li, et al., 2021; Marchessault and Larwin, 2014) and particularly in science (McKeown, 2019; Irby, et al., 2018). As noted, Romance and Vitale develop their early work into a model that includes explicit guided reading and both oral and written reading comprehension activities around texts selected for relevance to the science core ideas being investigated, but which are not specially modified or constructed (Romance and Vitale, 2006). I note that the authors state the aim of students learning scientific practices and of improving their ability to read informational text, so as to promote both science and reading achievement:

> Connecting hands-on learning experiences with multiple reading sources for science, combined with opportunities for writing in science, provides a cumulative context for in-depth science learning and development of reading comprehension (and writing) proficiency (Romance and Vitale, 2006, p. 394)

These authors refer to reading and writing in a more balanced way than Magnusson and Palincsar, for whom the purpose of the reading activity is to support the oral discourse around the inquiry, for the purpose content goals, guided by the teacher. Romance and Vitale delineate sequences of activities explaining the reading and writing tasks in support of their inquiry unit, which I discuss in chapter 2. However, I note here that enacting discourse practices around these activities to access and practice the "science talk" remains implicit, as does the connection of the science practices in the hands-on activities with the emerging disciplinary literacies. The emphasis is on students' individual learning as a cognitive process for reaching content and reading comprehension goals, rather than a view of science-as-practices and a learning trajectory of "novice to expert", as I will discuss below.

Other programs point more clearly to the importance of writing in science as knowledge construction, and begin to lead to the language of science. Klentschy (2006), in his review of student achievement in science in the U.S., refers to programs of instruction also involving hands-on science activities but followed by reading, writing and discussion about the activities, which led to achievement gains for the students. Klentschy argues that the science and literacy connection occurs best in two ways: in linking science and reading comprehension, and in exposing students to writing in science (Klentschy, 2006, p. 379). He goes on to refer to his programs involving student science notebook use (published in 2010) and the centrality of student writing: the notebook is a record of student progression in understandings, procedural as well as conceptual; it is an assessment tool; it is a tool to develop student identity and voice; it is essential for science, finally, in that writing is a process that enhances thinking. Klentschy's arguments therefore seem connected to the "writing-to-learn" approaches to science lessons (Yore, 2000), discussed below. Klentschy meanwhile states that the benefits to science learning for the students lie in the way writing makes students carry out scientific practices, i.e. "organize knowledge, link evidence to claims, and draw conclusions", much as noted above in the discussion on science education, and in section 1.1, concerning my work with the iPad as notebooking tool in the science class. The author's teacher guide to using science notebooks provides aids to teachers ranging from a list of "Essential features of classroom inquiry" with an array of activities, to

actual instructional moves involving language such as sentence stems (Klentschy, 2010). Again, the features and developmental sequence of the discourse moves enacting science language, to foster reasoning and conceptual growth, remain implicit: it is the sequence of designed activities in Klentschy's program that are carefully delineated and foregrounded.

Yore and associates (Yore, et al., 2004) have conducted extensive work on the role of the language of science and the role of writing in science, drawing on Yore's work developing the approach known as "writing to learn in science" (Yore, 2000). This approach has also led to a program called the Science Writing Heuristic (Wallace, Hand and Yang, 2004) as well as the "Pacific Crystal Project", which expands considerations of written literacy to include oral discourse (Anthony, Tippett, and Yore, 2010). Yore (2000) presents a framework of science reading and science writing activities that he terms "embedded", instead of integrated, arguing that science education consisting of hands-on activities alone is insufficient for "meaningful learning" (Yore, 2000). His model of science instruction exhorts teachers to sequence hands-on activities first, followed by reading and writing. The author presents a set of suggestions which include explicit metacognition and strategy instruction, as well as reading and writing as interactive, meaning-making processes (Yore, 2000, p. 108). Yore also draws on Kucan and Beck's list of reading strategies used by the expert reader, and links these to science reading, so as to devise a list of effective science reader characteristics (Yore, 2000, p. 109). These involve strategies, as he states that explicit strategy instruction that is "embedded in inquiry oriented science teaching" and makes use of "metacognitive awareness" leads to gains in science learning. Discussing science writing strategies, Yore refers to the "dual nature of science language" as including visual elements as well as vocabulary, although he emphasizes that it should not be understood as a "grammar across the curriculum...it is about the value of writing to enable the discovery of knowledge", citing Connolly (Connolly, 1989, p. 5, cited in Yore, 2000, p.112). This view of writing appears related to that of epistemic practices: I turn to consider the visual elements and metacognition in these meaning-making processes, followed by a connection with social and epistemic practices, as suggested by Duschl (2008) and Kelly and Licona (2018).

Prain and Hand (2016) draw on a socio-semiotic perspective to expand science language to multimodal representations, by explicitly widening the scope of science literacy to include

linguistic, visual and mathematical modes. The authors state that writing is a key epistemological tool for learning, through the work of attending to concepts and their representations in the drafting and conjecture revising processes (p. 2). They contrast what they term the "genrist" approach, or learning text structures according to disciplinary norms, with the "writing-to-learn" approach emphasizing individual meaning-making. The authors suggest that the latter approach promotes students' experience of the reasoning processes by which scientists produce new knowledge. These views relate more closely to the view of learning as apprenticeship activity, and thus point to a learning trajectory of "transition from novice to expert performance" (Duschl, 2008, p.8). However, Prain and Hand are concerned with individual progress in meaning-making as semiotic processes for appropriating the sign systems of science in sense-making on scientific explanations and activities over time (p. 6). The authors point to a need to study the micro level conditions to optimize student learning, and the communicative tasks and representational challenges to enact: it is agreed that

> ...for language to serve learning, students must reflect explicitly on the adequacy of the links they are making between intended meanings, conceptions and different or diverse expressions...this use of language as a knowledge constituting activity is a developmental recursive process. (p. 5).

However, there remain questions on the features of the appropriate classroom practice such as determining effective task challenges, sequences and appropriate representations. This view of language and representations appears to point to a need for discourse practices incorporating a metacognitive component, and a learning trajectory ensuing from the recursive process, which should be characterized more clearly to enable instructional design.

Tytler et al. (2020) draw on the views of Lehrer and Schauble (2015) in foregrounding modelling and representation construction as constitutive of science-as-practices. In their report, Tytler et al. (2020) present semiotic sign-making as "epistemic mediators": student generation of representations are shown as enacting scientific disciplinary literacy in the manner of the conventions guiding scientific discovery. The authors emphasize that "reasoning is necessarily a multimodal process of meaning making – we can reason by *doing* as much as by *thinking*" (p. 212). Tippett (2016) and Tytler and Hubber (2016) discuss the shift in instruction of science concepts from a focus on canonical interpretation of science diagrams to learner construction of diagrams, which is shown as a form of language. Furthermore, this shift promotes student agency, through of science representational

challenges, where students build their competence while assessing the adequacy of their representation construction and making claims about phenomena (Tytler and Hubber, 2016, p. 163). Tytler et al. (2020) present a detailed methodology for studying this representation construction approach, which I will turn to below and in chapter 3. However, although the above studies emphasize the active involvement of students in the generative reasoning process of constructing and assessing representational challenges, the language and metacognitive processes mediating these activities remain implicit.

The social practices that mediate the representation activities and the reasoning processes enacted with and through the construction of texts and diagrams are learned through participation, as noted by Kelly and Licona (2018). These authors refer to learning of scientific literacy as "a mastery of a range of epistemic practices that require knowing how to draw from the texts signs and symbols of relevant communities and employ concepts in the processes of knowledge construction" (p. 141). Hence, the authors consider that a focus on epistemic practices is relevant, and therefore suggest a need to examine the social processes by which activities and construction of texts and diagrams develop into patterns and routines, that is, epistemic practices in a community.

However, many studies on discourse processes in the classroom are concerned with spoken argumentation and claims, through dialogic processes known as productive and accountable classroom talk (Resnick, Michaels and O'Connor, 2010; Michaels and O'Connor, 2015; Resnick et al., 2018) and exploratory talk (Hennessy et al., 2021; Mercer, Hennessy and Warwick, 2019) where the emphasis is to show results in conceptual development through specific forms of teacher student dialogue fostering argumentation, also referred to as talk moves. Resnick, Michaels and O'Connor (2010) characterize these talk moves as not only norms for social contexts but "reasoning-in-conversation skills" (p. 171). Mercer, Hennessy and Warwick (2019) define Exploratory Talk as involving ground rules for joint activity in classrooms in a dialogic pedagogy mediated by artifacts, which include digital artifacts. These authors state that foregrounding artifacts is based on Säljö's (1998) notion of "thinking with and through artifacts". which in turn draws on Wertsch's (1985) work with semiotic mechanisms in Vygotsky's sociocultural theory of forms of semiotic mediation. I

discuss works by Säljö (1998) and Wertsch (1985; 1997) in section 2.2.4, regarding mediation through artifacts, as this is essential for my design.

Mercer, Hennessy and Warwick (2019) take a sociocultural perspective on learning, affirming that knowledge is shared, created and shaped in communities through cultural and historical factors, therefore through situated learning processes. These authors discuss argumentation centered on digital artifacts, which are constructed and evolve in the dialogic space encompassing the digital mediation of the Interactive Whiteboard (IWB). The emphasis throughout is characterizing and establishing dialogic classrooms for the active extended involvement of students and teachers in which knowledge and understanding are constructed together. However, the above research does not explicitly address academic language as science language, or talking the language of science; it is about characterizing quality interactions to make reasoning visible, so as to enable teachers to guide student thinking in productive ways. Although the artifacts are relevant, the epistemic work in constructing them is not the focus of the above research, nor the academic terms to be used in the activities. I therefore discuss other views of object-oriented collaboration below.

Wright and Gotwals (2017) discuss "disciplinary talk" as engaging in science-specific talk and present instructional strategies to support this talk as students made use of science vocabulary in their activities. In this research, the authors refer to young learners' use of science terms as they were guided to express science ideas. Of particular interest for my work is the detailed outline of talk moves suggested for performances of read-alouds, drawing and writing. However, when the learners are guided to focus on new words in an informational text, the aim is to relate the words to driving questions, and not to the academic word choices for the epistemic practice being undertaken. The teacher is asked to select relevant words to teach, thus retaining authority in the epistemic work. The explicit connection of language for epistemic practices is therefore not made, although the learners were discussing inquiry activities: the focus remains on the ideas, and strategies of facilitating oral language production to articulate these ideas. Furthermore, the authors state that their suggested instructional strategies are suitable for teachers' enactment of disciplinary talk across the content areas in primary years of schooling: hence, with the focus on the teacher's role, it seems more directed at teacher professional development rather

than promoting students' epistemic practices in a disciplinary subject through semiotic mediation.

Investigating metatalk about writing, Myhill and Newman (2016; 2019), and Myhill and Newman and Watson (2020) argue for dialogic talk in the classroom consisting of metatalk around writing with a focus on language use. Myhill and Newman (2019) note that the term 'metatalk' originates in Swain and associates' work on focus on form, as negotiation of meaning in communicative task performance (e.g. Swain and Lapkin, 2001). Swan and Lapkin (2001) present research where the task provides opportunities for students to notice language forms, and communicate hypotheses about the meaning of these forms, such that the students' internalized understandings are made public through metatalk, which therefore constitutes evidence of ongoing language learning. The importance of these instances of meaning negotiation on form is stated by Swain and Lapkin: their research shows that students' use of the negotiated forms in later learning events is linked to the prior metatalk on these forms. It seems therefore that this constitutes evidence of internalization and transfer of learning, which points to a visible learning trajectory that can be analysed. Myhill and Newman (2019), however, define their form of metatalk as the students' "articulation of thinking about linguistic choices" as writers, which for the authors includes students voicing shared understandings developed in the classroom during the course of many writing activities. The authors note that the metatalk helps foster noticing differences in oral and written language choices but also as meta-level learning: "in the context of metalinguistic understanding, dialogic teaching needs to be adaptive to the need for this meta-level change" (p. 367). The role of the teacher according to the authors, is to shape the purposefulness of the discussion by means of the metatalk, through which students develop a view of writing as "an induction into a fluid community of practice, rather than a compliant adherence to a set of conventions" (p. 371). Myhill, Newman and Watson (2020) develop this meta-talk as hinging on the teacher's orchestration of purposeful grammar teaching for metalinguistic understanding of the rhetorical effects of language choices: effectiveness is defined as teacher questions prompting for student elaboration and explanation, structured to link grammar and meaning. Explicitness of the language patterns is essential, according to the authors, to ensure that all students have access to understanding of how texts work. I find this view of grammar teaching and rhetorical

choices through metatalk particularly relevant for a situative meaning-making and participation approach to language use for knowledge construction and for promoting equity for all learners. Schleppegrell (2004, 2013) also advocates situated and contextual language learning, supported by metalanguage use for critical language awareness in ELLs, as noted above: hence, the above authors' suggestions for interaction around language choices will be relevant for my design, to be taken up in chapter 2.

Also building on the view of writing as a social practice rather than a set of cognitive processes seen as independent of context, Bloome, Carvalho and Ryu (2018) define the concepts of literacy practice and academic literacies. The authors explain that the term 'academic literacy' refers to writing as involving cognitive processes of the reader acquiring strategies of the expert in the genre and academic domain. Research in those processes therefore focuses on a process and product design identifying different variables that assist or hinder individual students acquiring domain specific strategies for making sense of academic texts in the domain. The term "academic literacies", according to the authors, refers to writing as those social practices engaged in by participants in a specific academic community, and "literacy practice", as "a way of using written language in a specific type of social situation that is shared by others and learned" (p. 890). The authors go on to define research in this area as involving a language socialization framework, focusing on how participating in activities and social practices socializes people into the community. Hence, the individual and the text are not separable from the social context in which literacy practices are being undertaken, and research in this perspective therefore considers the situated literacy practices as unit of analysis, according to the authors (p. 892).

Returning to the language of science, and the socio-semiotic perspective taken by researchers such as Prain and Hand (2016) as discussed above, talking science may be viewed as situated practices of socialization where students in school interact with scientific ways of knowing introduced in the classroom and socially negotiated (Driver, et al., 1994). Driver et al. (1994) state that individual, empirical discovery learning is insufficient for learners to access the knowledge systems of science, since learning involves being introduced to a symbolic world which cannot be mastered without the aid of others according to Vygotsky (p. 7). The teacher's intervention is necessary, in order to guide

students' canonical conceptual learning: the teacher's role is "...both to provide experiential experience and to make the cultural tools and conventions of the science community available to students" (p. 7). In this perspective, teacher and student negotiation of these cultural tools and conventions as a socialization view of academic literacies, may be viewed as developing a repertoire of discursive practices, including representation and modelling practices (Tytler and Hubber, 2016; Lehrer and Schauble, 2019).

Tytler and Hubber (2016) argue for a representation construction approach to science learning, as noted above: the models and representations may be considered as knowledge objects or artifacts, and the activity around their construction and revision as object-oriented collaboration, as discussed by Damşa and Muukkonen (2020). These authors discuss their view of learning as a process of knowledge creation taking place through interactive practices such that ideas are made material as shared knowledge objects. Research should therefore aim to reveal the mechanisms of collaboration and epistemic work that are mediating this process, according to the authors. Of particular interest for my design process is the view of knowledge objects as developing entities, having both a material and ideational nature, i.e. an object-of-thought (p. 86). Wells (1999) explicates the centrality of written text in the construction of knowledge, also affirming that communities of inquiry are active and object-oriented. Wells states that in his view, "...in classroom activities the object that provides the focus should be the artifacts that are made and improved through the students' and teacher's participation in the activity" (p. 123). This is due to the "evanescent" nature of speech according to Wells, whereas text is a mediating tool for knowledge construction and also a record of it: "...text can function as the 'improvable object' that provides the focus for progressive discourse and simultaneously embodies the progress made" (p. 115). Wells defines progressive discourse, citing Bereiter 1994, as a form of apprenticeship, in that "understandings are being generated that are new to the local participants and that the participants recognize as superior to their previous understandings." (p. 113). Hence, although artifacts are referred to by Mercer, Hennessy and Warwick (2019) as important as noted above, the view of artifacts as material objects, ideas and practices explicates the epistemic goal of the interaction. Wells explains that Vygotsky considered text as including written words as well as diagrams, maps and point

form notes, for instance, as semiotic artifacts, which support the recursive reflection and revision necessary for knowledge construction.

The definition of academic literacies, and language practices around text such as metatalk, and the suggestions for designing instruction through disciplinary literacies as representation construction and drawing on a view of science-as-practice, lead me to adopt representation construction practices as part of my DFs.

I have therefore identified the following areas of research:

1. How can language learning practices foster the learning of disciplinary literacies for language learners in middle school settings?
2. What are the characteristics of the learning environment conducive to language learning practices about disciplinary literacies?

The goal of the present study is to explore ways that certain discursive practices around disciplinary text and practices can promote student awareness and use of academic language and disciplinary discourse, so as to arrive at DPs for how such a learning environment may be implemented in similar settings or wider contexts. In the next section, I present the structure of the thesis, according to the DBR approach.

1.3 Structure of the thesis

In this section, I outline the structure of the thesis. It follows the outline and reporting methods specific to DBR methods, due to the different levels of analysis applied at different phases of the research process (Cobb, et al., 2003; Bakker, 2018).

In this chapter, I defined the area of the study: I identified the practical teaching problem through a discussion of my prior empirical work and presentation of the context of the research problem, namely ELLs and academic literacies learning in middle school settings. I briefly reviewed research addressing this issue, and noted certain gaps in the literature. I defined research questions to focus the area of the study.

In chapter 2, I conduct a literature review of the area identified by my research questions, to inform my theoretical framework and link theory with pragmatic design aspects of my intervention (Bakker, 2018, p. 224). The results are summarised as the Conceptual Framework for the study in table 2-1, and applied to formulate DPs for the design of the intervention, in chapter 3, table 3-2.

Chapter 3 presents the methodology and analytic approach of the study. The selection of design-based research methods is delineated: the initial design is presented through a discussion of pilot projects which were used to inform pragmatic aspects of the design-based intervention. I present the DPs for the intervention, which are derived both from theory and empirical knowledge from pilot projects. I delineate the features of the intervention by means of conjecture mapping (Sandoval, 2014), containing the components of the intervention and conjectures about their effects for a learning trajectory (figure 3-9). According to Cobb et al. (2003), DBR interventions are conjecture-driven tests, where the initial design constitutes a conjecture about the means of supporting a particular form of learning. The chapter presents the features of the design, and conjectures about each aspect, which are to be investigated and tested through the DBR process of cycles of iterations and revisions, so as to determine their ecological validity and contribution to design knowledge about achieving the suggested learning outcomes (Van den Akker et al., 2006, p. 44). These conjectures are examined in the different levels of analysis (Green, et al., 2020), shown next.

Chapter 3 thus sets out the data collection methods, analysis and presentation:

- **the first level of analysis**:
  recursive and abductive viewing of video and artifact material, through which Rich Points are identified and episodes containing these are selected for each iteration;
- **the second level of analysis**:
  recursive and inductive analysis of the selected episodes according to the three discourse moves defined as interactional units of analysis; Intermediate Analysis and Outcomes testing the validity of the design conjectures according to the iteration findings;
- **the third level of analysis**:
  retrospective analysis through inductive contrast and overview of the iterations to generate a coherent framework accounting for the effects of the intervention: a situated account of learning and the design for supporting that learning.

The discussion of these levels of analysis then leads me to affirm the trustworthiness and significant contribution of the study through a review of the rich rigor, credibility and meaningful coherence in reporting the research process, findings, and the development of a design with practical as well as theoretically significant contributions (Tracy, 2013).

In chapter 4, I present the intervention, consisting of four iterations of the initial design, and the second level of analysis. The chapter is introduced by an overview of the iterations and DBR methods, with the iterations divided into Parts A and B. These are introduced by an overview, seen in figure 4-2, which summarizes the findings in the overall learning trajectory of the intervention as a temporal sequence. This figure indicates a demarcation which emerged through the process of retrospective analysis, explicated in chapter 5, where I note a clear signpost at the start of Iteration III, thus separating the first two and the second two iterations. This major signpost in the learning progression is already noted in the Intermediate Outcomes section of Iteration III (section 4.4.1). However, as the second level iteration analysis will delineate a progression in learner participation through discourse moves around text-based activity, the data is presented as a sequence through a succession of key events termed Rich Points (see section 3.8) although divided into the two main parts, containing the first two iterations and the last two iterations, respectively.

Each iteration is in turn presented in two sections: the Analysis and Outcomes, and the Design Narrative. To facilitate reporting of the detailed episodes of data, each iteration is

introduced by a map of the DPs and the Enactment Processes applied to the summarized findings, points which are then discussed in the Analysis and Outcomes section. This is in turn followed by the Design Narrative of the iteration, which, through an ethnographic story (Emerson, Fretz and Shaw, 2011, p. 202) presents the emic perspective of the participants and social processes being enacted in selected episodes linked as a narrative in the form of a thick description (Tracy, 2013) of the interaction around the Rich Points in each episode (Green, et al., 2020).

Chapter 5 presents the discussion of the third level of analysis, namely the retrospective analysis, through applying recursive and analytic induction on the Intermediate Outcomes (Erickson, 2012). By this means, a coherent framework is presented, characterizing and accounting for the learning trajectory emerging across the iterations of the design. A situated account of the learning is developed, and refined DPs and a Revised Conjecture Map are presented in figure 5-5, as a result of the retrospective analysis (Cobb, et al., 2003).

In Chapter 6, I overview the results and findings, situating the study as an innovative design for fostering a progression in ELLs' academic literacies in a middle school setting, contributing both practical and theoretically significant research on a relevant and timely topic (Tracy, 2013).

2 Literature review

2.1 Introduction

In this chapter, I present the review of the research through which I construct the Conceptual Framework and DPs for the intervention reported in this study, and which I set out later in the chapter. I set out the research relevant to the focus of this study as discussed in chapter 1, namely fostering academic literacies in my teaching practice in a plurilingual learning context. My teaching practice involves working with ELLs in a small group setting with 9-10 year old students, with the aim of fostering a progression in academic literacies so that these students may join the mainstream class and fully access instruction in the academic subjects.

The sequence of this literature review is in itself inductive, as I present the path of my research investigation as a process of professional development and reflexivity in my role as teacher-researcher (Tracy, 2013). Hence, this research of the literature is conceptual, and in narrative form: I present the pathway that I engaged in to gain insights (Kennedy, 2007) into the issues in my practice and develop my research question, DPs and conceptual framework for this study. These insights are explicitly stated in each context of the review, as I build the points for constructing my DPs.

I begin with issues in teaching vocabulary and reading comprehension. This reflects my initial concerns in my practice, which motivated me to engage in the work reported in this study. These points are linked to the question of academic language, and discussed and treated within research on content and language. These three topics are reviewed sequentially, so as to indicate an initial genre and disciplinary literacies based approach to teaching academic literacies that informed my views at the start of my work in this study, as noted in chapter 1. These sections are followed by research on "New Literacies" and metaphors of learning located within the discussion of sociocultural and situative perspectives adopted for this study. I now turn to the discussion of my research on these concepts through following this sequence of points.

2.2 Theoretical background: review of main concepts in the study

This section reviews the main concepts informing the Conceptual Framework and DPs of the study, arising out of the discussion in chapter 1, to investigate areas of research of relevance to my research questions. It is followed by section 2.3, in which the Conceptual Framework this study is presented (table 2-1), drawing on sources from this review.

2.2.1 Vocabulary learning: overview of principles

For over twenty years, my teaching practice has centred on working with English Language learners (ELLs) in middle school settings with the aim of fostering their language proficiency to a level sufficient for them to carry out academic work in the regular (or mainstream) classroom setting. During that time, my work has primarily involved vocabulary development enacted around various reading, writing and discussion activities similar to many in the regular class in terms of topic and purpose, but shorter and more carefully structured into separate steps. I thus initially viewed language acquisition primarily through vocabulary development, which I now turn to as part of a discussion of genre-based literacies practices (Colombi and Schleppegrell, 2002).

It is acknowledged that vocabulary is critical in language development, both in second language (L2) and native speaker (L1) education, as stated by Nation (2020). Nation states that "Knowing a word involves knowledge of a variety of different aspects of knowledge, and these aspects of knowledge can be known to different levels of strength and detail, and to different levels of fluency" (p. 15). He goes on to explain the importance of these aspects for teachers so that the latter may be better informed as to how to foster and monitor the development of this knowledge. He groups word knowledge into three aspects, namely form, meaning and use, and thus, "Essentially, vocabulary learning depends on how often words are met and the quality or depth of the mental processing at each meeting" (Nakata, 2011, cited in Nation, 2020, p. 23). He notes that this learning is a cumulative process, emphasizing that instruction should provide multiple opportunities and contexts for effectiveness. However, Nation acknowledges that this model does not address vocabulary in use nor how it develops over time, pointing out the lack of longitudinal studies on this,

especially as different aspects of word knowledge come more into focus as learning progresses (p. 25). Hence, I take note of Nation's main points on time, opportunities and contexts, as part of my DPs. I now turn to the contexts of L2 instruction and effective practices for vocabulary learning, while still comparing research in L1 vocabulary learning.

Laufer (2016) reviews and compares L1 and L2 vocabulary learning by first discussing the issue of vocabulary learning through extensive reading, pointing out that "only a small number of L2 words can be 'picked up' from exposure to texts without any subsequent vocabulary practice" (p. 344), as opposed to L1 learners. Regarding the point of multiple encounters with words, she cites research stating that this cannot be achieved through reading alone, even with graded readers. Laufer identifies and discusses effective task types for vocabulary learning. These involve reading together with word focused exercises; furthermore, what the learner *does* with the words seems more helpful for retention than the number of encounters. This is extremely important for my DPs, as it confirms my enactment processes described below in section 3.3 and 3.5.

Hence, Laufer (2016; 2017) proposes a framework of vocabulary teaching and learning involving *input*, *instruction* and *involvement*. I take this point as I consider my work with graded readers in my small group setting: my DPs should include activities involving reading and discussing the graded reader through tasks that involve processing the key terms in the text in a variety of ways, and more deeply.

Laufer (2017) also points to the need for longitudinal studies, both in order to test the retention through recall tasks, but also due to the established need for multiple encounters in varieties of contexts, which requires time. Hence, I consider that it is important to process the graded reader deeply, carrying out different tasks requiring processing over several weeks, rather than aiming for completing quantities of readers. Webb, Yanagisawa and Uchihara (2020) discuss vocabulary learning activities in a meta-analysis, noting that the most common involve constructing flashcards and word lists and doing writing or fill-in-the-blank tasks. These tasks are typically found in the graded readers intended for ELLs which I have been using for many years. As with Laufer (2016; 2017), Webb and associates (2020) therefore point to involvement and going more deeply in productive tasks. However, the

characteristics of this involvement and tasks remain to be defined, which is of interest for my DPs.

However, Webb and associates (2020) point out that form-meaning knowledge is only part of Nation's word knowledge framework, stating that few studies go beyond form meaning. I therefore turn to research on *types* of words for instruction as informing effective vocabulary instruction. McKeown (2019) also reviews the main characteristics of word knowledge. Her findings resonate with the points noted above involving aspects of word knowledge, including meanings, situations of use and gradual development over multiple encounters. She divides types of words into tiers to inform decisions in vocabulary instruction. Tier 1 includes "everyday words" and Tier 2, "the language of text". Tier 2 words therefore occur more in written language and less in spoken language, and McKeown refers to these as "words of high utility for literate language users" (p. 468). Her recommendations for effective instruction include focusing on Tier 2 words, in addition to the other suggestions. Crosson et al. (2019) refer to these Tier 2 words as high-utility academic words, which are abstract in meaning and occur in subject content texts. The authors state that teaching should "focus on high-utility academic words, and ... morphological problem solving skills for generative word learning", as well as draw on learners' home languages as resources for the problem solving skill development (p. 493). These studies feature a word-level focus on determining meanings, which leaves out considerations of other aspects of reading skills, as well as purposes of reading in school settings. I consider research on these aspects below.

Researchers working in the context of reading comprehension discuss academic language (AL) as "a precise set of high-utility academic language skills that support informational text comprehension during middle childhood (ages 9-14)" (Galloway, McClain and Uccelli, 2020, p. S331). Furthermore, these skills develop over time during formal schooling, and are essential for reading comprehension: the authors refer to a set of AL *forms* (my emphasis), which students experience as sociocultural practices. The authors therefore point to the importance of language uses in their social context, which I will explore below. Fang, Schleppegrell, and Cox (2006) also refer to AL use, focusing on its forms used "in constructing knowledge in different subject areas and the challenges they present for

comprehension of academic texts" (p. 247). Their study explores how focussing on linguistic register informs the development of pedagogical methods to teach the characteristics of AL effectively, highlighting the "language of schooling" for specialized language use in educational settings, often involving complex grammar and structure. I return to these authors in the next section on disciplinary literacies.

This approach to developing AL is also taken up by Nagy and Townsend (2012), as they present a pedagogy of language acquisition for work in disciplinary content. They state that developing word knowledge occurs in conjunction with learning about the register of the discipline. This confirms the emphasis on AL as language-in-use, characterized as register in knowledge construction settings, different from social settings. Moreover, Nagy and Townsend (2012) state specifically how AL relates to knowledge construction:

> ...because academic language conveys the abstract, technical and nuanced ideas and phenomena of the disciplines, *it can help one think* in the requisite abstract, technical and nuanced ways. Academic language therefore is a tool that promotes a kind of thinking different from that employed in social settings. (my emphasis) (p. 93)

In this extract, I have emphasized my interest in words as tools for thinking, which I will explore in more detail as I review sociocultural perspectives of language mediated learning further below. In conjunction with my interest in situative perspectives on learning, the positions of Fang, Schleppegrell, and Cox (2006), and Nagy and Townsend (2012) in focusing less on characterizing AL independently from uses in context, resonates with my own understanding of learning as knowledge construction, which I present further below. Here, it becomes clear that discussion on vocabulary and AL is best explored in contexts of their uses and with purposes or type of knowledge construction more clearly defined. I now turn to a specific review of questions involving reading comprehension, so as to consider effective practices in reading pedagogy.

Recently, Cervetti et al. (2023) also report on vocabulary instruction, finding that "interventions that targeted word meaning instruction do not show overall positive effects on measures of breadth of vocabulary knowledge" (p. 672). They cite the short duration of most interventions as a problem, noting that these may not provide the kinds of opportunities required for practice of strategies as already discussed. Cervetti and associates suggest that "a broader view of language" is needed, with vocabulary knowledge

as an inextricable component of language skills and knowledge. They advocate a view of vocabulary instruction as part of reading instruction, using texts on the same topic, in particular, content-specific and academic words. This advice confirms my earlier decisions in designing my content-based work to investigate the development of language skills and literacies over time. Furthermore, their call for a broader view of language confirms considerations of "New Literacies" and semiotic resources, discussed below through literacies as social practices and semiotic systems.

2.2.2 *Content and language: views of disciplinary literacies*

In order to design language instruction for vocabulary and reading comprehension that will promote my students' ability to work in the academic school subjects, my DPs should take into consideration the advice presented in the preceding sections. Word knowledge as discussed in preceding sections is critical for language development and therefore the development of reading comprehension and writing skills, which work in reciprocity. Notable points are differences in everyday language (EL), and academic words, or academic language skills (AL), as well as vocabulary differences in narrative and informational text. These points necessitate teaching for academic registers, in disciplinary contexts, so that students may have opportunities for integration and meaningful use of new language structures through guidance in decoding the structures and integrating these with their prior knowledge.

Hence, Shanahan (2013) advises genre modelling instruction, through use of templates, with a gradual release of responsibility as familiarity increases (p. 337). However, Fang and Schleppegrell (2010) caution against overreliance on cognitivist skills and strategies for comprehension instruction, such as those mentioned by Shanahan, including summarizing, predicting, determining main ideas and facts versus opinions: they view these as tasks through which students merely show acquisition (p. 588). The problem, according to the authors, is a lack of connection with the contexts and practices that the abovementioned strategies are required to support, calling for a program of disciplinary literacy instruction with a focus on accessing knowledge in the disciplines, citing Moje (2008). Cervetti, Jaynes and Hiebert, (2008) also call for what they term "integrated instruction that foregrounds knowledge," specifically, a synergistic approach:

> Our way of describing the phenomenon is "opportunity to learn" – something we believe is best achieved through the integration of content area learning and literacy learning. The instruction we envision integrates content area learning with an emphasis on reading and writing in the context of knowledge development and on the cultivation of shared and reciprocal processes across domains. (p. 93)

However, Cervetti and associates envision thematic instruction through which to merge language, literacy and content area, whereas Fang and Schleppegrell (2010) call for the development of a "metalanguage" of functional language analysis termed systemic functional linguistics (SFL), to enable students to understand how language works in the

content area texts. Fang and Schleppegrell go on to describe the need to analyse and discuss challenging aspects of secondary science texts, giving examples of these, where "technical, dense language" and language forms such as nominalizations serve different purposes according to the content area. Furthermore, they point to texts being multisemiotic, that is, drawing on visual representations with meaning which students must learn to recognize. Hence, they advocate a "functional analysis of language patterns to explore meaning in text" so that students might "learn through language and about language" concurrently, as they *deconstruct* and discuss challenging texts with guidance from a teacher knowledgeable in these matters" (my emphasis) (p. 596).

Schleppegrell (2013) states that this kind of language learning is situated and contextual, and examines how metalanguage supports disciplinary goals: she explains that it is not only about acquiring knowledge about language, but also about "how language and other semiotic systems are put to use in the service of socialization to a new culture and participation in a new community" (p. 154). Students thereby learn to form abstractions of form and function constructing meaning, through encountering many examples in instances being discussed (p. 164). Furthermore, students learn about register as choices that speakers and writers make to construct meaning, and so are supported in their learning of curriculum. Moore and Schleppegrell (2014) report on a DBR project implementing SFL metalanguage to help students as they encounter academic language patterns in literary texts, taking place through extended discourse to recognize and understand an author's craft, relating language forms to meanings. They draw on Wells' (1999) work on the role of language in knowledge construction, which therefore takes place through dialogic interaction rather than transmission from teacher to student. In addition to the dialogic interaction, this construction work is also mediated by artifacts, or "non-human participants", which Moore and Schleppegrell define to include texts, charts, diagrams and worksheets.

I return to these points below, in discussing representation construction and modelling (e.g. Lehrer and Schauble, 2019; Tytler and Hubber, 2016) through object-oriented collaboration (Damşa and Muukkonen, 2020) on artifacts as *improvable* knowledge objects (Wells, 1999), in contrast to deconstructing difficult texts. These design characteristics for the use of

mediating tools and artifacts are of particular interest to my preparation of my DPs, as I work to design an intervention for academic language learning through purposeful activity around texts and content. I am interested in the development of practices analysing language patterns, including multisemiotic features, as noted above; however, I feel that the focus on genre through the study of its grammatical features implies a focus on the *expert* performance of the genre as *advanced* literacy (Colombi and Schleppegrell, 2002, p. 14). Drawing on my pragmatic knowledge from working in the diverse multilingual classroom, I feel that these practices should take place in the context of *constructing* text and other semiotic features through engaging in knowledge construction, at various stages of proficiency, through an emphasis on student agency. I therefore return to a discussion of Wells' (1999) work on mediating tools and artifacts, and on views of knowledge construction in later sections.

Returning to the area of literacy and inquiry synergy, I consider studies on the "writing-to-learn" approach to writing in science inquiry, with an early review by Keys (1999). The author reviews the rationale for explicitly teaching scientific genres as enabling students to access "the discursive power of scientific texts" (p. 118) in terms of equity of access to both the information and the chance to master genre conventions that are needed for success in continued higher education. Keys also points to a distinction between writing to communicate, as "the transmission of learned knowledge for the teacher's approval" and the teaching of scientific genres with the aim of writing to produce new knowledge: *Writing in scientific genres promotes the production of new knowledge by creating a unique reflective environment for learners engaged in scientific investigation*. (original emphasis) (p. 119).

This point resonates with my interest in fostering an active learning environment for knowledge construction as meaningful language learning, as noted. Bravo et al. (2006) report on such a program, with direct instruction of vocabulary integrated in science inquiry units which include writing, with second and third grade students. This program has a stated aim of "movement from passive to active control of vocabulary", providing a list of design criteria incorporating the advice already cited in the research delineated above, including: providing multiple exposure through multiple modalities; explicit semantic networking; and

making connections between new and previously encountered and used terms through speaking and writing. The key points emerging from their work involve the time and incremental nature of word learning, due to the repetitions and multiple contexts needed; however, the authors discuss this as due to learners' word knowledge being on a continuum, from active to passive, as each repeated use in a variety of contexts brings new understanding of word meaning at a conceptual level. The authors derive this active knowledge view from Nation's work on kinds of word knowledge, which I discussed above.

Another study with secondary school ELLs presents specific interaction moves to be used with ELLs with a stated emphasis on context and socially situated practices, termed the 5R model, which the authors develop and present in detail (Oliveira and Weinburgh, 2019). The 5Rs refer to actions taken by the teacher during instruction to address academic language explicitly in the context of use to scaffold access to science content: *replace*, where an everyday term is replaced by the technical or academic term needed during discussion; *repeat*, meaning reused by the teacher; *reload*, for using terms in a different task; *reveal*, for introducing new terms without everyday equivalent; and *reposition*, meaning rephrasing a student's use of the new term "to talk more like a scientist". It can be said that these talk moves, and especially the final point, seem to involve metalanguage of a kind, although not exactly as defined by SFL proponents, as it is not about interpreting texts. These are very interesting actions, presented with very explicit examples and rationales. I will return to these points below in the context of discursive moves around text, as I consider the design of participant interactions in my intervention.

However, I note that these studies do not consider the changes in their respective programs that may emerge as the participants gain expertise and move along the continuum of word knowledge. Questions arise about going more deeply i.e. high involvement load, meaning-making and activating strategy use, the nature of the dialogue and release of responsibility, for instance. In these studies, the focus is on the teacher, and not the students' knowledge construction and conceptual growth: for example, Oliveira and Weinburgh's 5R model highlights the visibility of language use, but does so mainly from the teacher's perspective as it is the teacher who identifies the concepts to be taught and plans the 5R moves to support and scaffold activities. The 5R model authors state that it focuses on communication, but it

is characterized in terms of planning and implementation, not regarding the dialogic features of the participant interaction. Similarly, August and associates' (2009; 2014) programs are centred on teacher moves for scaffolding during reading and vocabulary work where science inquiry is foregrounded.

Although the programs' stated aim is to help students master science practices and therefore the requisite academic language, the emphasis is on outcomes, which are reported as post-test aggregates on vocabulary performance (e.g. August et al. 2014, p. 77). These authors state that there was variability in ELLs results, attributed to more time being needed to "acquire science content taught in their second language"(p. 77). However, students' appropriation of practices is not investigated as such, although context and social practices were mentioned. These studies therefore do not seem to consider language as a tool for thinking and learning, as noted above (Nagy and Townsend, 2012) or as a semiotic tool in activity to rehearse meaning (e.g. Wells, 1999; Resnick, et al., 2010; Scott, 1998), although the academic language is discussed as such by the teachers. Bravo and associates's (2006) program, designed for a thematic curriculum unit, seems more oriented toward a longitudinal intervention and a process design, revealing students' developing word knowledge through use of taught vocabulary in writing over time in a science inquiry context.

I turn to more recent interventions drawing on Bravo and colleagues's (2006) passive to active continuum design for integrated literacy and science, by Haug and Ødegaard (2014) (working in Norwegian as L1), by Cervetti et al. (2012) and by Bravo and Cervetti (2014), as these interventions take place in science inquiry contexts with 9-10 year old students, and the latter including ELLs. The former authors set out to obtain insight into the moment-by-moment teaching and learning interaction as it occurs in two classrooms, drawing on the teacher's talk and the students' developing word use as data and evidence of progression and success for the intervention (p. 779). Based on Bravo et al's (2006) continuum of word knowledge cited above, they present a table describing the cognitive processes being developed by the students which observably characterize the stages along the passive to active continuum of word knowledge: from recognition through application and synthesis (p. 781). I note Haug and Ødegaard's identification of these processes as showing how word

knowledge gradually develops to conceptual knowledge: these definitions relate to writing and talking for knowledge construction, and so are helpful in design, observation and evaluation of student activities. I will return to the point of conceptual knowledge development, and observable characteristics, in the section on knowledge construction.

Bravo and Cervetti (2014) also observed participant interactions and teacher use of vocabulary instruction, with adaptations and scaffolds included in a teacher guide to the science unit, with step by step instructions (p. 236). They worked with ELLs in heterogenous groups across ten classrooms with a control group, implementing an intervention that they designed aiming to develop both science knowledge and vocabulary in a science inquiry unit, including reading, writing and discussion, scaffolded by visuals and explicit attention to the science vocabulary. Of particular interest to me in these scaffolds is their use of a word wall: as the unit progresses, words are added by the teachers to a "Science/Everyday Word Chart", through conversations about the differences in the word pairs (p.237). However, other reading and writing tasks are not described: an important point to me is the reading to support the inquiry activities, but no details are given on the helpful features of the reading activities or how these were enacted. The word wall, as they describe it, is very relevant for my work with anchor texts in my practice.

The key finding in Haug and Ødegaard's (2014) report, through a comparison of data from two classrooms, is that one teacher supplied new science words and required students to use them in their activities, while the other teacher prioritized completing tasks, resulting in only passive word recognition by those students. The authors conclude that "conceptual learning occurs when students are *required to apply key concepts in their talk* throughout all phases of inquiry, with the teacher closely scaffolding the students' use of language" (my emphasis) (p. 797), but not when the teacher does the talking, doing the work of rephrasing the students' answers into acceptable wording. This finding seems to contrast with the 5R moves from Oliveira and Weinburgh's program, which involved the teachers doing the "replacing" and "repositioning"of new vocabulary items; it seems in accord with Laufer's (2017) advice on input, instruction and involvement. These reports seem to be pointing to practices for constructing a language of science, through pointing out and enacting it in context, as discussed by Lemke and others (e.g. Gee, 2004; Pearson and Billman, 2016;

Lemke, 1990), which I will review below within the discussion of productive engagement (e.g. Engle and Conant, 2002; Greeno, et al., 1999) teacher responsiveness and dialogic discourse (e.g. Aguiar, Mortimer and Scott, 2010; Hammer, Goldberg and Fargason, 2012) and formation of intersubjectivity (Wertsch and Addison-Stone, 1985; Wells, 1999), in the context of situative perspectives. I will also turn to reports with more detailed accounts of tasks being carried out, including sequencing of these tasks in the intervention.

For my design, it is important to keep in mind the synergy of writing and science, as well as the reciprocity of reading and writing processes, which the above reports do not address clearly. I also note the differences in programs addressed to elementary (K-5) grades and secondary grades, since my work is with 9-10 year olds. Programs for K-5 students provide more detail on their instructional models, especially the use of scaffolds and descriptions of interactions around them, to which I now turn for concrete examples. This will lead me to a review of definitions of disciplinary literacies at different ages, to help me define age-appropriate features for my design.

The report by Cervetti and associates (2012) focuses explicitly on the synergy of reading and writing in inquiry based education, using the term "reading infusion" to describe their program, with the purpose of "integration with science as an opportunity to situate literacy instruction in a powerful knowledge-building domain" (p. 634), as science and literacy instruction draw on shared goals of sense-making and comprehension of complex ideas, and "mature word knowledge in science can be described as conceptual knowledge" (p. 635). Hence, their intervention included reading science books as well as first-hand investigations. Other programs working with ELLs, such as by Irby et al. (2018), refer to "literacy infused science", involving a diverse set of intervention components: they include hands-on activities based on the 5E Instructional Model (Bybee, 2009) which incorporate daily writing and reading; a list of questioning strategies; scaffolding strategies including visuals and manipulatives; and notably the use of integrated technology, which other reports have not mentioned (Irby, et al., 2018). This report provides detailed notes which I will be able to draw on in designing my intervention tasks.

Further evidence from established research on literacy integrated science in K-5 settings is presented by Romance and Vitale's "Science IDEAS" model, which the authors present as an

integrated instructional model "as a viable replacement for more traditional reading and language arts/literacy programs" (Romance and Vitale, 2006, p. 396). The model consists of six instructional elements, including hands-on, inquiry based science activities, daily writing activities and the consistent use of informational reading materials in various forms, such as trade books and internet sites. The model is used to build curricular units or themes in a way that fosters conceptual growth in the main concepts of the theme, through a designed sequence of activities where students relate their reading to the hands-on investigations and attendant writing. The authors delineate a sample sequence of thirteen different activities, providing a rationale and details for each. These include: accessing prior knowledge; hands-on teacher demonstrations and student activities involving observation and writing; reading comprehension; propositional concept map construction; and other writing activities (pp. 398-401). The authors emphasize the knowledge construction orientation of their model, as it is organized around core concepts and the multiple opportunities for students to keep writing and reflecting on their understandings of these concepts while examining instances of them in different ways. Therefore, they state, it is a model for developing expertise on the concepts as a form of mastery learning through dynamic "extensive and repeated practice" (p. 401). Hence, I have another source of tested DPs for literacy and knowledge construction practices over time in K-5 settings.

Returning to the questions at the start of this section, regarding disciplinary literacy instruction, genres, registers, and a focus on accessing knowledge in the disciplines, I note that the reports I have reviewed here for K-5 settings refer to science as a subject, and literacy in terms of decoding and fluency, and content area reading comprehension, without always identifying the particular literacies features of the science activities as such. Varelas and Pappas (Varelas and Pappas, 2006; Varelas, et al., 2014) report on an integrated science and literacy unit that leads to appropriation of scientific language over time by primary grade students, as they perform read-alouds of information books and carry out science hands-on activities. The authors give details of specific scientific genre features being explored and incorporated by the students, and refer to the "new ways of talking as appropriating a new cultural tool" (2006, p. 242). Of particular interest is their uses of academic and everyday literacies in a continuum: using Vygotsky's terms of spontaneous concepts, the authors report that the students moved toward a more systematic and

intentional use of scientific language to negotiate scientific understandings (p. 252). The reported design features, carried out in primary grade classrooms, are very interesting and relevant for my work with slightly older students, especially as regards interaction with texts fostering the emergence of thought and language over time. I will return to the notion of cultural tool as I discuss knowledge construction and situative perspectives in section 2.2.5.

Research discussing disciplinary literacies reviewed in this section reports on secondary school students and practices for adolescent literacy, e.g. Fang and Schleppegrell, (2010), Oliveira and Weinburgh (2019), August, et al., (2009; 2014). Research on ELLs refers mainly to access to content through vocabulary teaching such as the 5R model of Oliveira and Weinburgh, or academic language learning as domain specific words and phrases (August et al. 2014). Research on K-5 contexts may refer to literacy integration, e.g. Irby et al. (2019), and early literacy development Romance and Vitale (2006); however, Varelas and Pappas (2006) refer to scientific genre features and characteristics of scientific language. In other research with elementary students by Lee et al. (2019), science classrooms are characterized as using modalities and registers of language, with registers being shown on a continuum of everyday talk and text to specialized talk and text, and movement along the continuum being described as students increasingly using a specialized register of talk and text, exhibited by the same students in the course of the 9 week intervention. As noted above, I aim to focus on the construction of artifacts through collaboration which includes forms of talk, rather than only on accessing difficult content through discussion.

The view of register as on a continuum of use of specialized features being achieved by grade 5 students contrasts with the definition by early researchers in disciplinary literacy, such as Moje (2008) and Shanahan and Shanahan (2008, 2014, 2017). These authors focused on secondary students, adopting a view of literacy as being defined by student age and reading material: “as children advance through school, literacy instruction should shift from general literacy strategies to the more specific or specialized ones from each discipline” (Shanahan and Shanahan, 2014, p. 636). Hence, there is a linear progression: proceeding from basic literacy or decoding and print awareness in the early years of schooling, on to intermediate literacy, meaning cognitive strategies such as summarizing and predicting as mentioned above, and finally to disciplinary literacy, meaning learning to engage in the

subjects in secondary school, with discipline specific habits of mind, routines and practices more like the professionals in each field (Shanahan and Shanahan, 2008, p. 43). In this report, the authors state the need for explicit instruction of "sophisticated genres, specialized language conventions...". Their advice consists in expanding literacy instruction "upward" on these genres and language skills, for older students, in the form of "more sophisticated and appropriate reading skills".

In a later article, Shanahan and Shanahan (2017) reaffirm the linearity of progression in literacy, citing a lack of disciplinary literacy standards for elementary grades, which in turn is due to texts in elementary level information books not exhibiting the features of disciplinary literacy: "teaching students to deal with the specialized properties of disciplinary texts can wait until the students are reading texts that have such properties" (p. 20). However, Osborne (2014) refers to U.S: Common Core State Standards published in 2010, which include literacy standards for each K-12 grade-level about informational and expository texts, and which therefore foreground the importance of language in science instruction (p. 188): I will return to this point in the next section.

These views are in line with the genre-based approach to reading and writing processes discussed in advice by T. Shanahan (2013) on teaching the reciprocity of those processes through genre-based instruction. As such, the emphasis throughout is on the individual student's cognitive resources, which are added to with time, as they move beyond "basic aspects of literacy.. adding more sophisticated routines and responses to their reading repertoires" (p. 44). The sophisticated skills are modelled on those of adult experts in each field, and teachers are advised to show students how to write for different purposes, with the relevant structures from the fields (Shanahan and Shanahan, 2008, p. 51). Applications of new reading strategies are suggested, and yet the processes and interactions by which students come to add these new cognitive resources as outcomes are not specified, although this would be helpful for designing an intervention.

Condie and Ippolito (2016), however, argue for a view of disciplinary literacy in elementary grades that promotes authenticity, interconnected reading, writing and learning, and opportunities to foster scientific thinking and habits of mind for younger students. Ippolito et al. (2017) also refer to their recent research on disciplinary literacy with younger learners,

suggesting it should be conceptualized as "the merging of content knowledge acquisition with the adoption of discipline specific ways of thinking, learning and communicating" (p. 17). The authors provide an example of a kindergarten class, where they observed "literacy practices used to develop young students' scientific habits of mind" involving students observing, questioning and writing in journals. They quote the teacher, who taught them that "scientists have to write because they have to record the information that they find so that they can share it with others". Hence, they conclude that the young students had the opportunity to engage in the core standard of "obtaining, evaluating and communicating information" (p. 18). Notably, the authors describe the teacher carrying out an "interweaving" of foundational, intermediate and disciplinary skills instruction: during the same day, she was observed teaching decoding sight words, crafting good questions, and refining a question with a "biology word", respectively. The authors refer to this instruction as a "layering" of these types of skills, and indicate that their adoption should therefore not be considered as transpiring through a linear progression, but rather pointing to a broader conceptualization of disciplinary literacy instruction. This layering view of skills acquisition is intriguing, as it seems to correspond to L2 situations which I observe in my work with ELLs, such as students decoding in a script relatively new to them (i.e. Roman alphabet based for English), while applying cognitive reading strategies already learned in a different writing system, and discussing these in new ways in L2.

Integrated science and literacy programs reviewed here have been implemented with ELLs, including at K-5 levels, and have been found to help all students "situate reading, writing, and other language practices as tools that can enhance the acquisition of conceptual knowledge and inquiry in science" (Cervetti and Pearson, 2018, p. 86) in the context of views of knowledge construction, with useful advice noted for my DPs. However, I am interested in the development of these tools viewed as practices to be enacted, so as to inform my design. Hence, in the next section, I return to the research on integrated science and literacy instruction, viewed as appropriation of discourse practices in a process mediated by cultural artifacts (e.g. Lantolf, 2000; Street, 2017), and so move the discussion of linguistic and genre views of literacies to exploring views of literacies as social practices.

2.2.3 *"New Literacies" and science-as-practice*

In this section, I turn to research in views of literacies as social practices by exploring New Literacies, views of science literacy and classroom interaction. I re-evaluate the concept of science as a disciplinary register, by examining "doing science": science-as-practices (e.g. (Osborne, 2014; Lehrer and Schauble, 2015; 2019; Scott, 1998), constructed around artifacts through language-in-use (Gee and Green, 1998; Gee, 2004; Bloome, Carvalho and Ryu, 2018; Kelly, 2017; Coyle, et al., 2018), where participants are learning to talk the "language of science" (Lemke, 1990; Osborne, 2002) through increased participation in the practices of science, forming a community of practice (Greeno, et al., 1999; Gee and Green, 1998; Greeno and Engeström, 2014; Kelly, 2017).

To further explore the relationship between language and learning so as to inform my practice and my design for my intervention, I consider research in New Literacies, or new literacy studies (NLS). Street (2017) explains this approach as the " study of literacy not as an issue of measurement of skills but as social practices that vary from one context to another" (p. 4). He points out implications for the participants, whose conceptions of knowledge, identity and being arise through reading and writing: literacies studies should focus on the ways that the participants take hold of the new tools being presented to them. These tools and ways of using them are of central interest to my practice, as I work with a diverse student group transitioning to more independence in the mainstream academic subjects. Street refers to multimodality, in the work of Kress et al. (2001), as providing a larger view of meaning-making tools beyond speech and writing which is inherent in considering diverse social contexts, such as the visual and technological (Kress, et al., 2001; Bezemer and Kress, 2020). He views multiliteracies as constructing cultural artifacts and worlds, citing Bartlett and Holland (2002): "An artefact can assume a material aspect (...a spoken word or ... a book) and/or an ideal or conceptual aspect. These objects are constructed as a part of and in relation to recognized activities" (Street, 2017, pp. 7-8).

In this view of literacy, objects provide a continuity and expression of this cultural world, which can be studied ethnographically as expressions of local purposes. These points are discussed further in the section on knowledge construction below. Moreover, the use of the plural, "literacies", designates the range of practices through which these cultural artifacts

are constructed, so that writing in academic contexts is conceptualized as an epistemology, not merely a cognitive skill, with implications for "what counts as knowledge" in the social context (Lea, 2015, p. 2). Lea considers that an academic literacies model views writing not only as a process, whereby students are acculturated into the discourses and genres of particular disciplines, but also with a focus on the meaning-making and authority of the student, i.e. the epistemic agency of the participants in the practices. I will examine student agency and authority below, as I review research on discourses in the classroom.

Bloome, Carvalho and Ryu (2018) make the distinction of "academic literacy" in the singular, as referring to the autonomous view of written language use in academic contexts, where literacy is defined as cognitive skills and processes independent from social activity, and "literacies" in the sense noted by Street, namely the specific practices for writing by participants in a specific community. Goldman (2018) has also pointed out the difficulty with the academic literacy view for students attempting to access texts, due to "the focus on content and not on the *practices that generate* that content" (my emphasis) (p. 434). This point emerged in the review of reading and writing as a progression of skills, discussed above. Here, Bloome and colleagues (2018), noting that writing in different fields has been characterized as very distinct, discuss research in academic literacies as "focused on describing the literacy practices within disciplinary fields and how those literacy practices might be acquired" (p. 890). They go on to define "literacy practice" as "a way of using written language in a specific type of social situation that is shared with others and learned". The key implication for research, they point out, is that the unit of analysis is therefore the interaction of the participants around the uses of written language, in ways that are culturally established. As a consequence, engaging in the literacy practices of a community in a public manner results in gaining the social identity of membership in the community. Research in academic literacies therefore entails describing how people are socialized into the practices of a community, including literacies practices. I will return to these points in the discussion of selection of methodologies, chapter 3.

These practices are carried out through a social language which helps define membership and identity for its users, which Gee (2005) refers to as a social language code, marked by specific features. He notes that science requires students to use language in ways that are

distinctly different, both orally and in print, as well as using representation systems and attendant practices that are central to success in academic contexts. This social language derives its meaning through being experienced in the midst of practices. Gee states that the social language may be understood as either verbal or situated: an instance of scientific social language may be understood verbally as general definitions related through general grammatical patterns; alternatively, its meaning is being assembled on the spot during a situated action being experienced. Therefore, situated meanings are "rooted in embodied experience", which are needed for future action: Gee cites work in cognitive psychology to develop the notion of situatedness, namely "comprehension is grounded in perceptual simulations that prepare agents for situated action" (p. 25) and also "to a particular person, the meaning of an object, event or sentence is *what the person can do with the object, event or sentence*" (my emphasis) (p. 25). These explanations of the situatedness of meaning-making are consistent with my perception of my ELL students, as they work with language in the context of an activity that I prepared so as to practice a specific content and practices objective. I also note a connection with the involvement and depth of processing or quality of attention discussed in research on effective vocabulary learning.

Therefore, Gee (2005) pinpoints the importance of embodied practices and activities, as these anchor the situated meanings of words and phrases emerging in interaction and dialogue during the practices. This dialogue is the social language which more advanced users impart to others i.e. learners, in the midst of practice, where the latter learn to use it through imitative perspective taking and learning (p. 28). Gee characterizes this dialogue as interactive and intersubjective, as learners "come to use linguistic symbols as perspective taking devices on the world...meaning for words, grammar and objects comes out of intersubjective dialogue and interaction" (p. 30). Hence, practices and activities should involve discussions where learners are required to present and extend their reasoning, making connections with preceding turns, being scaffolded in their use of the social language. The manner in which these discussions may take place is explored below in the review of research on discourse practices and knowledge construction.

Gee (2005) also strongly advocates that learners work with "expanded texts, displaying the fuller forms of the language they are to acquire, placed in the midst of practice and

discussion, not just assigned as reading outside of these" (p. 36). He states that this entails explicit instruction in how to read such texts including the language and genre conventions, but also how these conventions relate to the practices being engaged in. This advice adds greatly to that discussed in the genre approach to disciplinary literacies, the characteristics of good readers and balanced comprehension instruction (Duke and Pearson 2008/2009), by specifying the context, noted in a general way by Pearson and Cervetti (2015): the overt discussion around text is involves the formation of intersubjectivity during reasoning with the text, which anchors the situated meaning in the experience of the learner, coming to form a mental simulation to be imitated later in speech or writing. Hence, I see a clearer connection of practices and content for my design, as well as a mechanism for knowledge construction and characterizing a learning progression, which I will explore below in a discussion of collaborative work on forms of text as cultural artifacts in the context of situative approaches (e.g. Wells, 1999).

Considering views of this social language use in the practices of science, I turn to a discussion on scientific literacy by Norris and Phillips (2003), who state that these practices, as undertaken in western science, would not be possible without text. They go on to make a distinction between what they term the fundamental and the derived senses of scientific literacy: the former refers to reading and writing when the content is science, while the latter concerns being knowledgeable and educated in science. The authors state that clarity in this distinction is important, as "the fundamental sense of literacy is central to scientific literacy". I consider this notion crucial to inform my reading and writing practice with my ELLs, as I design tasks and interactions to foster their academic literacies. The authors review a list of authors and sources on scientific literacy, many of which define it as the ability to read popular press science articles with understanding, possessing a certain amount of learning acquired from reading, or the ability to apply some of that learning in problem solving. The authors point out a reference to reading and writing in science which considers these as functional means "used to accomplish a task in science" (p. 226). However, they state, reading and writing are not merely for transmission or storage of knowledge: they "are inextricably linked to the very nature and fabric of science, and, by extension, to learning science". They go on to delineate their views on reading, which they describe as iterative, interactive and principled; that is, it involves constructing meaning

actively and in a considered way through repeated reading. This implies that the reader adopts an essential view of text as a "creative product", which is an object of discussion and critique, i.e. an artifact (p. 229). This view seems consistent with Street, discussing cultural artifacts.

Norris and Phillips (2003) point to a shift in science education trending prior to the time of writing away from reading science content to a focus on teaching the process of inquiry: they ascribe this to a contemporary perception of reading as passive and a matter of word recognition (p. 227). In their review of literacy and science literacy, Yore, Bisanz and Hand, (2003) also raise this point: they refer to both oral and written work in science education as having been widely "ignored or portrayed as unidirectional processes" until more recent developments (p. 689). The authors concur with Norris and Phillips's definitions of the fundamental and derived senses of science literacy, going on to affirm the centrality of language: "language is an integral part of science and science literacy – language is a means to doing science and to construct science understandings...also as an end in that it is used to communicate" (p. 691). They also contrast the view of written text in science as a transcription of what has been done, with their view of writing as a constitutive process, enabling reflection and evaluation on inquiry. The latter view helps form my rationale in working with text with my students, as I formulate ways of designing interactions around text going beyond "unlocking" it, or rehearsing new vocabulary, so as to be more warranted in terms of aims for academic literacies.

Therefore, it is interesting to note that Yore et al. (2003) describe the interaction in the science classroom as benefiting from developments toward constructivist approaches, which foreground verbal discourse. They cite Lemke (1990), whose work showed that "talk and action are central social processes in science learning", especially when carried out in small group discussions (2003, p. 697). In discussing writing, Yore et al. refer to their own work with writing-to-learn science programs, as argued by Keys (1999) and noted above: these kinds of tasks provide explicit instruction in genres of science writing, which at the same time clarifies language as a symbol system and tool (2003, p. 700). Regarding the interaction around the writing in science classrooms, however, Yore et al. (2003) state that the recommended strategies and tasks in their review did not present evidence of effectiveness,

especially lacking in establishing connections between progression in oral language and science literacy (p. 703). They refer to research exploring teacher and student questions as providing interesting possibilities, since the goal of constructivist teachers is to have students initiate and guide their own questionings and knowledge construction. I investigate the role of questions below, and note these points as important in my DPs, as desired outcomes and for which favourable conditions should be investigated as part of the intervention.

Certain design suggestions are provided in Yore et al.'s (2003) recommendations on explicit instruction for promoting student questions, which can be used to help structure and guide students in small-group activities, especially referring to the work of Wellington and Osborne (2001). These authors provide clear examples and rationales for writing tasks during discussion, particularly regarding forms of note-taking, which they insist must be explicitly taught and properly scaffolded, as well as given a clear purpose (Wellington and Osborne, 2001, p. 79). The authors state that the criterion of effective note-taking instruction involves teaching students how to locate salient aspects in the material, which then should be noted in various forms such as tables, charts and concept maps, which the authors demonstrate in detail. Furthermore, they present the forms of note-taking as located in a continuum of passive to active student engagement, where the expected outcome of instruction is given as movement from passive responses (e.g. dictation) on the far left, to the active and independent form on the far right, where the students are free and able to select their own note-taking methods (Wellington and Osborne, 2001, p. 81). Rationales include not only promoting students' work with content, but imparting essential life skills for all walks of life. These points are of interest for my intervention design and considerations of a learning progression and conjectured outcomes.

Other recommendations by Wellington and Osborne (2001) involve discussion work around claims of science presented in a text or other form of representation, to "focus on the issues of *how* we know rather than *what* we know" (original italics) (p. 99). The focus on thinking and reasoning has implications for language use individually and in the classroom, and Chin and Osborne (2018) show how student questions may be developed to enable higher order thinking for these kinds of discussion, as noted also with Yore et al. (2003).

Outlining further developments in views of science learning, Lehrer and Schauble (2015) present a more recent detailed discussion of science education as "studying the development of scientific thinking". The authors present three "images of science" or research perspectives in science learning and education, namely "science-as-reasoning", "science-as-conceptual change", and "science-as-practice". The first approach is explained as the development of domain-general reasoning and skills, so that learning to think scientifically is defined as understanding the logic of experimental design, and learning how to transfer these skills to other contexts. A problem the authors point to is the lack of cumulative knowledge in participants studied, however. The second approach views science learning as the conceptual reorganization that occurs as learners acquire reasoning strategies and accumulate disciplinary knowledge. The authors note that this approach is applied to work with older students and adults, whereas with younger children, few longitudinal studies are undertaken and so less is known about children's development from holding "naïve frameworks" to more canonical models.

Finally, the image of science-as-practice, held by Lehrer and Schauble (2015), considers participants working within a wider sphere of activity, with reasoning and conceptual development as one component in concert with material procedures and explanatory models. Hence, they consider these concerted activities as a "community of practice", where participants are learning ways of talking about phenomena and uses of text; that is, "inventing and appropriating display technologies, sometimes called representational competence" (p. 675).

This perspective on learning in science requires a longitudinal view of investigation, to track changes in participation: "learning in science is conceptualized as the appropriation of a particular way of making sense of the world, of conceptualizing, evaluating and representing the world" (Lehrer and Schauble, 2015, p. 675). Lehrer and Shauble go on to specify the practices of science, citing eight interrelated practices which students should undertake from the earliest years of schooling, including asking questions, developing and using models, constructing explanations, and obtaining, evaluating and communicating information. These points are recommended for young students, for "understanding the

epistemic grounds of science, that is, an appreciation for how scientific knowledge is made, critiqued and revised", which is also as advised by Wellington and Osborne.

Representations and modelling are considered as text or semiotic resources as noted above, and are foregrounded by Lehrer and Schauble (2015), which is therefore of interest to my design. The authors discuss the epistemic function of representation, which can change as an activity progresses and as the representation is refined. Moreover, representations are both mobile and permanent, and so can become objects of reflection, to be edited by accentuating or reducing features (Latour, 1990, cited in p. 680). The practices around representation construction are therefore a form of language that is constitutive of science; hence, studying these practices is a warranted focus for determining the development of academic literacies in children. Lehrer and Schauble (2015) also consider essential reading, writing and talking about science information from sources which make visible the epistemic practices that generated them. They advocate for classroom environments that "are organized as epistemic communities, where participants share epistemic goals, norms methods and values, so that children develop enduring dispositions rather than ... isolated skills and concepts" (p. 707).

Hence, as I explore views of literacies as social practices, I am focusing on the social language of science and the perspective of science-as-practice, as relevant to my intervention for academic literacies with ELLs in my small group setting. I have noted the centrality of language and text as cultural artifacts constructed as part of recognized activities, i.e. the participants recognize the meaning of carrying out the practices as constructing a local culture. It is clear, as Osborne (2002) states, that "a core feature of science is that it is a cultural activity undertaken through the medium of language" (p. 204). This is a social language, used by the participants in a community of practice. Sutton (1992) argues that "learning science involves learning to see in new ways", which entails "selecting new metaphors" (p. 41). Sutton points out that new ways of seeing have an associated way of talking, and that "it is possible to be persuaded into new ways of seeing, using a combination of words and evidence" (p. 40). For my design, I consider that these new ways of seeing may be mediated by epistemic work on representation constructions; these are objects of reflection through talk, and constitutive of science practices.

2.2.4 *Learning metaphors: views of knowledge construction through object-oriented collaboration*

In the preceding section, I explored views of literacies as social practices, with academic literacies as situated in embodied practices and activities which anchor the meanings of words and phrases for the participants (e.g. Gee, 2005). I noted that the view of science-as-practices involves an activity system of reasoning and conceptual development, material procedures and explanatory models (e.g. Lehrer and Schauble, 2015), which entails culturally determined construction of artifacts and practices enacted through language and communication (e.g. Bloome, Carvalho and Ryu, 2018).

In order to anchor my DPs and intervention within a theoretical learning framework appropriate to investigating these views of literacies, I turn to a review of learning metaphors and theoretical approaches or perspectives (e.g. Chinn and Iordanou, 2023; Danish and Gresalfi, 2018; Wertsch, 1985) with the aim of designing conditions for learning academic literacies in my small-group setting. Sfard (2014) explains that research on learning employs metaphors as mechanisms helping "..us to think about different types of learning", such as apprenticeship, or offering "answers to the question of what learning is", such as construction or transmission of knowledge (p. 636). In this section, I review prominent learning metaphors in education research in order to help define a theoretical basis for views on learning in this study.

I focus on theories grouped into approaches known as cognitivist and participationist, as these are more prominent in recent research as discussed in a recent review by Chinn and Iordanou (2023). These authors explain that cognitivist learning theories view learners as individually acquiring knowledge or mental models in a process which is therefore termed the acquisition metaphor, citing Sfard (1998). In the process of learning, students bring to bear strategies which are on a continuum from passive to more active or constructive ways of acquiring knowledge, so that learners are positioned as recipients or agents. Teachers are accordingly seen as acting as providers or facilitators, depending on the degree of agency ascribed to students in the particular approach. The authors point out that the emphasis is on learning viewed as changes in cognition in the individual, specifically in the long-term memory of the individual as a mental model which is filled out with knowledge individually

acquired in social interaction. Sfard (2006), discussing the "acquisitionist discourse on learning", refers to the " underlying metaphor of learning as an act of increasing individual possession" (p. 153). Furthermore, this takes place through processes viewed by the proponents as invariable across contexts, with the implication that research design is a search for a generality: "...individual minds are the principal source of their own development, whereas the task of the researcher is to discover the universal blueprint of the process". Hence, such research involves measuring knowledge and cognitive performance in the individual based on observable behaviours, which may be modelled and tested to verify predictions of the cognitive processes being inferred (Danish and Gresalfi, 2018, p. 35).

Theories grouped as participationist, however, view learning as changes in how students participate and engage with one another in joint activity over time, hence the participation metaphor posited by Sfard (1998) as cited by Chinn and Iordanou. Learning is therefore not looked for in changes in the individual's mental models of an activity or text, but seen in the learner's action; that is, the learner's emerging knowledge is visible as appropriate participation in recognized activities with others of the community. Sfard (2006) argues that this view considers learning as a process of individualization, as the learner takes part in collective activity and gradually begins to carry out tasks in a personal as well as self-directed way, in an "individual reenactment of collective activities" which in turn affects the collective in a bi-directional or dialectical process . For Sfard, becoming a participant in collective forms of activities therefore precedes the activities of the individual developmentally, conversely to the acquisitionist view. It is about adapting to the discursive ways of others in carrying out tasks such as in mathematics in a process which is initially "a thoughtful imitation of grownups' ways with words" but is essentially about making sense of the view of the world *seen by others* through these ways with *words,* in my emphasis (p. 166).

I note that Sfard (1998), in her earlier analysis, emphasizes that the two perspectives differ in their ontology or worldview arising from these definitions of learning, but is careful to note that the difference in the perspective on the role of the individual and the social results in a different view of the *mechanism* of learning (my emphasis) (p. 7). She argues that searching for common ground is a desirable and necessary endeavour, due to key issues such as prior knowledge, transfer of learning across domains, and clearly defined content,

which are raised by assertions of knowledge being meaningful in context only, and as a consequence, the acquisitionist metaphor has advantages as well. Other researchers discuss these issues, which I examine for design recommendations.

The participationist view of learning is also described as the individual progressing in a trajectory of participation in activity, emphasizing that the learner gains membership and identity in a community of practice. Greeno and Gresalfi (2008) describe this trajectory as beginning with limited or peripheral participation by the novice learner, and through opportunities presented by the community, the learner gains knowledge in the form of expertise on the activities, and so moves to central participation in the community, drawing on Lave and Wenger's (1991) situative framework on learning. The implication for research noted by Danish and Gresalfi (2018) is that "cognition and knowing are *joint accomplishments* between the individual and the rich context..." (original emphasis) (p. 36) and it is therefore relevant to investigate how the context came to be and may transform over time, meaning that the unit of analysis is expanded beyond the individual to include mediators in the local context. This description, however, does not seem to consider the bi-directionality, or dialectical interrelation in the "forms of doing" of the individual and the collective, as noted by Sfard (2006, p. 158). Danish and Gresalfi do not offer clear solutions to the problem of transfer of learning except through suggested exploration of the role of context in learning. I return to the point of redefining context and transfer further below.

Chinn and Iordanou summarize the key differences in these two general approaches which appear to cause essential divergences in grounding instructional design as essentially the choice of focus on the individual's internal cognitive processes, or on learning in the community setting as activity system, as also noted by Danish and Gresalfi (2018). However, other researchers note that the approaches also entail different views not restricted to units of analysis, context or transfer of knowledge, but on the emergence of thinking, all of which must be taken into account in designing (Cobb and Bowers, 1999). In their analysis, Cobb and Bowers review the implications of the cognitive and situated learning perspectives to inform classroom-based research, and note that context for the former consists of the experimental setting with specific features and tasks presented to the students. The authors emphasize that, as a consequence, the physical place, together with the features and tasks,

are all variables which may be considered independently. The cognitivist view of the individual's mental process as unit of analysis entails understanding change in the individual's knowledge across situations, i.e. learning transfer, with the context as a variable, and its components being treated as distinct and measurable. Cobb and Bowers refer to this as a reductionist strategy, aimed at studying mental processes through behaviour occurring as a result of a stimulus environment, which excludes consideration of broader units of analysis.

Cobb and Bowers (1999) state that situated perspectives view context as defined in terms of the actual participation in a social practice, not a specific location only. Hence, practices can take place individually or interacting with others, noting that the individual is not only drawing on internal cognitive resources. Learning is therefore not only about mental processes being shaped by the activity, but is defined as "synonymous with changes in the ways the individual participates in social activities" (p. 6). Hence, the participation may be observed over time, and analysed according to different units. The authors go on to discuss units of analysis in examples of research where the context is a participatory framework: individual students' reasoning about mathematics practices was taken as a unit of analysis, which then enabled analysis at the individual level as well as on "acts of participation in evolving communal practices". Transfer was looked for through the evolving participation of the students in different instructional settings, through designing for commensurability across the settings. I take note of this point on commensurability, and the possibility of both individual and group level analysis. I also note the authors' interest in the explicit focus on individual students' reasoning, which they analyse as an act of participation in the communal mathematical practices, and also taking place reflexively, since the individuals influence the development of the communal practices, according to the study. I find these points relevant for my design, as I aim to study literacies practices at the individual and group level.

Before turning to more recent research on construction and transfer of knowledge through finding areas of convergence in these approaches, I consider a discussion by Bransford and Schwartz (1999) on redefining transfer as "preparation for future learning" (p. 68). The authors note that at the time of writing, even cognitivist research had not presented many clear examples of transfer. The problem is in applying criteria of expert performance, which

is unsuitable for "studying the smaller changes in learning that lead to the development of expertise". The authors draw on Broudy's notion of "knowing with" as an interpretive function that may be used by the learner in noticing contrasting cases, which in their studies was found to lead to habits of mind, or dispositions, and learning trajectories with increasingly sophisticated student questions through opportunities that were presented. These are interesting points for my design: the authors recommend creating opportunities for students to contrast their own thinking with that of others as they first generate their own ideas about a topic. I return to this kind of practice in discussing collaboration for knowledge construction and "noticing" as a view of transfer of learning process below (e.g. Lobato, 2008; Engle, et al., 2012; Hammer, et al., 2005; Hickey and Lam, 2018; Hickey, Chartrand and Andrews, 2020).

In their more recent discussion of cognitive and sociocultural approaches to learning, Webb and Whitlow (2019) focus on the problem of transfer: reviewing possible means of integrating such approaches, they note examples of research on productive discussion which have provided apparent results of transfer across domains, although involving a key component of sociocultural practices. The authors emphasize that transferability is acknowledged as a key feature of teaching and learning, and research should "create interventions that appear to promote far transfer, (i.e. across domains), and then look for evidence of changes in cognitive machinery" as a way to benefit from both approaches (p. 24). I turn to research on dialogic forms of teaching and learning (e.g. Resnick, Michaels, and O'Connor, 2010; Aguiar, Mortimer and Scott, 2010; Mercer, 1995; Rojas-Drummond, 2019) in the following section.

In addressing these issues of compatibility, Paavola, Lipponen and Hakkarainen (2004) have developed a solution inspired by other models of communities of knowledge, including Engeström's model of expansive learning, and Bereiter's model of knowledge building (p. 558). Paavola and associates suggest that these models are examples of a third metaphor of learning, which they propose as the knowledge creation model of learning. Paavola and associates discuss the acquisition and participation metaphors of learning citing Sfard (1998) and focus on the dichotomy of the cognitive and situative views of learning and human activity. They present the acquisition perspective as knowledge acquisition through pre-set

"developmental rules or phases", not leading to construction of anything "new", while the participation perspective is explained as viewing learning through appropriating knowledge in the form of pre-existing cultural practices of the community without adding to or transforming it. They suggest that these approaches are not able to fully account for learning in a collaborative setting involving creative processes resulting in novel artifacts or other knowledge objects. Hence, they argue, a third metaphor is required, which is presented as theorizing an aspect which the other metaphors do not, by foregrounding "collective knowledge creation for developing shared objects of activity". The shared object is defined as including material artifacts, as well as conceptual artifacts and practices.

This metaphor emerged out of the authors' work on learning and inquiry processes in technology-assisted environments, therefore motivated by addressing "modern epistemic practices" (Paavola and Hakkarainen, 2009, p. 86). The authors characterize these processes as "trialogical", to designate the individuals, the practices, and the material aspect of artifacts. They emphasize the temporal aspect in their model, noting that the shared objects are developed and modified interactively through sustained collaboration. The authors draw on Knorr-Cetina's views on modern knowledge work as "epistemic objects and epistemic practices" (p. 85), stating that their model refers to this kind of work with these objects and practices as trialogical processes. These processes correspond to the enactment taking place in my design.

The term "trialogical" is proposed by the authors as the extension of dialogues: the shared object provides a grounding, a common goal and shared history for the participants, through the work of jointly constructing the external representations, practices and artifacts that build the community over time. They explain that interaction is not limited to words (or dialogic interaction) or to individual acquisition of concepts, but involves modifying external representations as well as practices in jointly developed objects which form resources for later use. This approach is therefore advanced as a solution to the abovementioned dichotomy of the individual's cognition or the community, by considering individual agency and collective activity as based on forms of mediation by work on shared objects as the external social focus. This dual aspect of shared objects is very interesting for my design purposes, as I consider my work with text and representations. I link to it in the discussion

on semiotic mechanisms (Wertsch and Addison-Stone, 1985) and situative views of learning (Sawyer and Greeno, 2008) below.

I also have questions on the sequence of activities and the nature of the participant interaction around the shared objects: the focus on the object-oriented activities and their iterative transformation has shifted to the resulting creative and useful objects, and away from a concern for the dialogic practices which are essential to epistemic work as noted in the disciplinary literacies section. For my small-group setting, I am committed to designing for learning progressions for each participant, such that their epistemic work results in transferable knowledge and academic literacies. In more recent research, Paavola and Hakkarainen (2014; 2021) suggest DPs for organizing this work, which I note include "supporting the integration of personal and collective agency and work through developing shared objects", as well as "emphasizing transformations and reflection" through this process (2021, p. 248). Paavola et al. (2011) report on a project designed using a set of six DPs, with the intention of further developing these through successive revisions as the project progressed. For my design, I note the formulations and the points cited above as examples for my DBR design, discussed in chapter 3.

However, to reconsider the individual participant in the joint activity around epistemic work, I turn to discussions on semiotic tools as including material artifacts as well as language, which through the means of "inner speech", mediate "the individual mental activities of remembering, thinking and reasoning" (Wells, 1999, p. 136). Mediational processes which involve uses of signs and tools are also discussed by Wertsch (1997), Lantolf (2000) and Säljö (1998). The concept of mediation is essential to sociocultural perspectives drawing on Vygotsky's work (Säljö, 1998, p. 54), which presents thinking in the individual as emerging out of collective action, through interaction with the world by means of tools and signs provided by the local culture. Säljö states that language is the most important tool, as it is "the prime device for rendering the world intelligible and for communicating with others" and should be considered as a semiotic resource for signs that may be used creatively in social practice. He goes on to argue that thinking is therefore a discursive process, and that learning is appropriating the tools and conceptual resources to carry out the activities in this process. Citing Goodwin, he affirms that thinking is therefore seen as carried out in

conjunction with artifacts in a "situated activity system" (p. 63), and expertise develops and is visible in the social context of activities, rather than residing in changing mental structures. The task for analysis, according to the author, is investigating such a system of action shared between individuals and mediational means. So as to investigate the processes taking place both in the individual and the group in my small group setting, I now turn to the mechanism by which individuals internalize changes in the social plane to the individual mental plane to account for emerging individual thinking, according to Vygotsky's approach (Wertsch and Addison-Stone, 1985).

Wertsch and Addison Stone (1985) discuss Vygotsky's work on semiotic mechanisms, which enable higher mental functions to be developed: all higher mental functions appear first on the interpsychological plane and then on the intrapsychological plane, through a social process of internalization mediated by semiotic mechanisms (p. 164). Furthermore, this process is not a simple form of acquisition: they cite Vygotsky, who states that "...internalization transforms the process itself and changes its structure and functions" (p. 167). The authors explain that this is possible due to the nature of the semiotic mechanism which they define as "the emergence of control over external sign forms" (p. 167). The authors explain that, according to Vygotsky, a child's initial use of a word in participating with others is an "entry point" to social participation and constitutes an "agreement on reference" but is not evidence of understanding meaning. This social use is followed by "egocentric speech", which is the first link between activity in the external social plane and the internal, mental plane, and not clearly different from the social speech. The authors point out that Vygotsky's use of the term "egocentric speech" differs from that of Piaget, in that the latter argued for a gradual disappearance of it as evidence of the child's socialization; they state that Vygotsky proposed that egocentric speech develops into "inner speech", or "inner dialogue", as "a unique form of collaboration with oneself" (p. 173). This takes place when the child has understood "the full significance of the sign" and its use in the task setting. The authors define this process of emerging control of external sign forms as mastery of socially defined activity through the child's gradually understanding the full meaning of the signs and their uses in social activity. This is relevant to defining a learning progression in academic literacies in my small-group setting.

The process of internalization as argued by Vygotsky is not achieved in a sudden moment, however, as Wertsch (1985) notes, but undergoes levels of transition, in part due to the developing situation definition of the participants (p. 158). The transition is induced by sign mediation, or forms of the semiotic mechanism, which the author also goes on to delineate. I find this analysis relevant, as I wish to develop analytic means to pinpoint moments in the participant interaction and epistemic work as evidence of stages of internalization and control of sign forms. To first analyse the situation definition as understood by the participants, Wertsch employs the notion of intersubjectivity as developed by Rommetveit (p. 159), which he explains as existing "when interlocutors share some aspect of their situation definitions". He draws on Rommetveit's view that individuals joining in a communicative event may initially have different understandings of the utterances being made: "Through semiotically mediated 'negotiation', however, they create a temporarily shared world, a state of intersubjectivity" (p. 161). I will connect this point with Wells's work on the centrality and functions of written text and his discussion of text as an improvable object (Wells, 1999), then further relate it to participants' emerging definitions of academic literacies through sign mediation.

I first pursue Wertsch's (1985) explanation of the strategic steps that mark the transition from intermental to intramental functioning; I follow Wertsch's use of these terms in his subsequent work, as being more manageable (Wertsch, 1997). They are steps by which objects – spoken or written words, or artifacts – come to be understood by participants, so that they may gradually "come to define the task setting in a new, culturally appropriate way" (p. 161). Wertsch (1985) argues that such steps are recognizable as points of intersubjectivity in the zone of proximal development, or area of adult-child interaction as defined by Vygotsky. Such points are therefore levels in the transition: the child progresses from a lack of understanding of the objects and goals of the task proposed by the adults, to participating with only partial inferencing of the goal, to a state of apparently making appropriate inferences about the task as seen by the child's performing without prompts. Wertsch defines this state as evidence of intramental functioning, as the external interaction is not required, having been internalized. The final level designates a near complete intersubjectivity, shown by egocentric speech. Wertsch emphasizes that participation takes place initially in the intermental plane, with the child coming to see the significance of the

actions *only later* (p. 166). I therefore note that time is an important factor, as well as the order of development, and providing opportunities for participation in various forms, for my design and learning progression analysis.

According to Wertsch (1985), the child's process of transitioning from intermental to intramental functioning is induced by the adult's encouraging the child to increase participation as an integral aspect of socialization, and especially through devices posing semiotic challenges. Wertsch argues that these behaviours are semiotic mechanisms enabling a child to "think differently by talking differently" (p. 176). Wertsch suggests that analysis of interaction in which these three types of referring expressions occur is useful for gaining insight into the participants' attainment of intersubjectivity and a situation definition. Therefore, Wertsch's indications for investigating a situated activity system are very relevant for my design and analysis of emerging literacies practices in my small-group setting.

I finally turn to the work of achieving intersubjectivity in the science class around text and representation practices, as discussed by Mortimer and Wertsch (2003). These authors discuss the negotiation of intersubjectivity in pedagogical settings, involving transitioning from everyday language to scientific discourse. The authors state that the teacher's way of talking about the world uses rules of categorization and attribution in explaining processes and phenomena. Students do not initially share an awareness of these rules and so are unable to attain a level of intersubjectivity necessary for appropriate participation. The authors go on to describe lessons where the teacher required the students to generalize about properties of gases from instances of observation in a laboratory activity. The authors interpret this case as the participants not sharing the situation definition, and staying in their "private world" (p. 243). The authors therefore ask, "How can one make scientific explanations meaningful for students? And how can one turn the questions of science into real questions for them?" (p. 243).

In my design intervention, I propose solutions to these questions, connecting these with the views of knowledge construction and object-oriented collaboration reviewed above, mediated by the central role of writing, as argued by Wells (1999). In this section, I have discussed research with clearer grounds for designing small group work, by defining it as a

system of activity: language work is made visible mediated by objects of discussion, rather than in the discussion only, or the material evidence of academic terms applied in pieces of correct writing in a genre. The question arises concerning design features for participant engagement in practices for construction of knowledge objects in my small group setting, consistent with aims of progression in academic literacies as discussed in this review. In the next section, I turn to Wells' work on discourse practices around writing, in the next section, connecting this with language in the science classroom (Wells, 1999; Scott, 1998; Gee, 1999; Scott, Mortimer and Aguiar, 2006; Scott, 2008; Kelly, 2017), and opportunities to learn (Greeno and Gresalfi, 2008; Bloome, Carvalho and Ryu, 2018).

2.2.5 *Sociocultural and situative perspectives on teaching and learning: constructing the research design*

In the preceding sections, I discussed research on language and literacies relevant to my research questions, focused on designing for a learning environment fostering student progression in academic literacies. I discussed views of language learning as meaning-making situated in social practices, and academic literacies as centred on written forms constructed through social practices. In this section, I review the sociocultural and situative perspectives on learning as taking place through participation in socially constructed practices, and individual learning defined as the participant's increasing effectiveness and agency in participation and construction of those practices over time (Greeno, 2005; Sawyer and Greeno, 2008; Greeno and Engeström, 2014).

In this study, I adopt a situative perspective on learning in activity, explicated by Greeno (2005) as focusing analysis on activity systems, not only on individual learners. Greeno states that situative analyses concern hypotheses about how communication and reasoning are related and take place in activity systems, especially involving the construction of meaning and understanding (p. 79). As a consequence, he argues that analysis of an individual's learning on any topic is meaningless without an account of the kind of activity system in which the learning in question is to be evaluated. Hence, the aim of the researcher is to focus observation on changes over time: "The study of learning in activity requires us to develop concepts and principles that can explain how and why activities in a setting result in changes in what people can do" (p. 80).

In this study, I drew on the participation and knowledge construction metaphors to design activities around knowledge objects, so that I could test hypotheses on the effectiveness of the principles for the system design. Greeno (2005) states that a situative explanation of the interaction of individuals in a system takes into consideration the interactive principles coordinating the activities and the semiotic structures of information employed in the activities: "the goal is to understand cognition as the interaction among participants and tools in the context of an activity" (p. 84). In more recent research, Engeström (2022) defines an activity system as "a relatively durable collective formation directed at and motivated by a continuously evolving object" (p. 134). These activity systems, he states,

develop over long periods of time, so that activities that recur are called practices, and the participants in those recurring practices are defined as participating in a community of practices.

The focus in this study is on developing academic literacies through disciplinary practices in science topics, by designing activities drawing on a view of science-as-practices (Lehrer and Schauble, 2015), involving discourse practices and semiotic sign-making around representation challenges (Tytler, et al., 2020; Cirkony, Tytler and Hubber, 2022) and other forms of science text (Cervetti, Jaynes and Hiebert, 2008; Lehrer and Schauble, 2019). As suggested by the knowledge construction metaphor, these representations and texts are conceptualized as knowledge objects, which are improved through joint collaboration in successive revisions as a collaborative goal of the activity system or community of practice.

The joint collaboration takes place through discourse moves involving classroom talk enacted on a continuum of dialogic and authoritative forms, as suggested by Scott, Mortimer and Aguiar (2006). The authors state that the teacher must foster pedagogical link-making in students, fostering more explicit connections between their prior knowledge and new concepts being formed. Enacting these link-making practices must first take place in the social plane, as suggested by Vygotsky, according to Scott and colleagues, and through opportunities in repeated practices, a transition to the personal plane of the student is made possible. In this study, I will argue that the link-making involves talk around the knowledge objects being constructed, during which a process of joint activity is developed: noticing of gaps to be filled (Scott, 2008) in knowledge and thus problematizing (Engle and Conant, 2002) aspects of the representation or text being improved. The process of noticing involves establishing increasing levels of intersubjectivity among the participants. through the joint development of sign-making in science practices, which in this study is conceptualized as the semiotic mechanism enabling the participants to transition their understanding of science-as-practices from the social plane to the mental plane (Wertsch, 1985).

Engle and Conant (2002) suggest the idea of problematizing intellectual problems as the object of activity, requiring that students be given authority to address such problems and raise their own points for consideration. The intellectual work must be undertaken

according to disciplinary norms, and thus a sense of accountability to the practices i.e. developed in the students, and finally, the practices involve the use and development of resources, which must be made available to the students.

Wells (1999) also explicates the act of knowing as inherently social, drawing on Vygotsky's views on social interactions and cultural tools as mediational means in individual learning, stating that fostering understanding should be the goal of education, achieved through engaging in joint activities, and hence the teacher's guiding principle is to foster

> the activity of knowing through the making and using of representational artifacts as a means of guiding joint action and enhancing collective understanding... knowledge objects are of no value unless and until they are used as tools to mediate activity, including the activity of knowing. (p. 92).

This is made visible by changes in participation in these practices, characterized by increasing agency in epistemic work, as suggested by Damșa (2014). Hence, my study investigates the collaborative learning process taking place around knowledge objects as a process of constructing a community of practice. However, due to my focus on language and academic literacies, I will argue for an explanation of the learning trajectory documented in this study as an emerging local culture of language and literacies practices defined and constructed by the participants.

In the next section, I conclude the chapter by presenting the table summarizing the conceptual framework for this study, containing the salient points delineated in this chapter, but especially in this section.

2.3 Summary: the conceptual framework of the study

Table 2-1 below presents the key concepts for the study, drawn as noted in each section of this chapter. This Framework is reconstructed in chapter 3 in conjunction with the methodology for the design, restating the concepts as *actionable* DPs: these DPs constitute design advice, which, together with their theoretical rationales for the purposes of explicating the choice of methodology, link goals with the means and processes for how these should be achieved (Bakker, 2018; 2019; Kali and Hoadley, 2021; Dohn and Spence, 2024). These actionable DPs are presented in table 3-2 in the next chapter.

Conceptual Framework for the study:
1. Situative view of learning: embed learning in activity over time 2. Social practices: ways that people are initiated into the frames of reference of the community, through o language o participation in cultural practices 3. Situated activity is mediated by artifacts: o material: equipment and devices o semiotic: language, notation, representation 4. Science discourse: orchestrated by apprenticeship in practices through o a words-to-concepts continuum o a representation construction approach: drawing to learn o conceptual link-making strategies 5. Literacy and science integrated through: o hands-on activities o vocabulary, reading and writing activities 6. Science ideas form the basis of talk, anchored by text 7. Different modes of teacher-student interaction: a dialogic – authoritative discourse continuum

Table 2-1 Conceptual Framework for the study, applied to formulate actionable Design Principles

3 Methodology

This study adopts a pragmatic and constructivist qualitative paradigm for researching teaching and learning in the classroom and designing the intervention reported here (Cohen, Manion and Morrison, 2017). Focusing on devising and testing DPs for a learning environment fostering academic literacies in a small group setting, I designed and developed an intervention which is informed by sociocultural theory and situative perspectives on studying academic literacies practices as meaning making in the social context of the classroom (Bloome, Carvalho and Ryu, 2018). The intervention was designed to investigate the overarching question: *How can a learning environment be constructed in order to support ELL students appropriating academic literacies and disciplinary practices?* By selecting qualitative research methods, I set out to document classroom literacies events (Bloome, et al., 2004) in a small-group setting across a school year and identify the meanings about those events as constructed and attributed by the participants (Erickson, 2012). Analysing these events through microethnographic video and discourse analytic methods (Baker, Green, and Skukauskaitė, 2008), I tested the application of my DPs across four iterations, so as to determine pragmatic and theoretical outcomes (Barab, 2022) for the intervention.

The design draws on the knowledge construction metaphor of learning (Paavola and Hakkarainen, 2005; 2009; Paavola, Engeström, and Hakkarainen, 2012) to organize activities around shared objects, which are conceptualized as including artifacts as well as the practices of epistemic work around the artifact construction. The artifacts and practices are the object of activity and also mediate the emerging literacies practices over time, fostering a learning progression defined as learners' increasing participation in the practices of the disciplinary literacies of school science through mastery and agency in the use of semiotic resources for knowledge construction in the discipline.

For this study, I have selected microethnographic discourse analysis methodologies (e.g. Green, et al., 2020; Bloome, Carvalho and Ryu, 2018; Baker, Green, and Skukauskaitė, 2008) as appropriate for this investigation: examining the situations and literacies practices of

individual and collaborative meaning making of participants, in the context of joint activity around knowledge objects, through a design which I constructed and developed across four iterations. The focus is therefore on the interaction of participants as unit of analysis through three main discourse moves, where I follow the language-in-use of the participants and apply microgenetic methods to analyse "the moment-by-moment processes of learning and reasoning" (e.g. Sherin and Chinn, 2022, p. 217; Erickson, 1995). This analysis draws on extensive video recordings made in the context of student activity around artifacts, together with my daily notes, to study the socially constructed, moment by moment unfolding of emerging disciplinary practices in systematic ways (Powell, Francisco and Maher, 2003; Erickson, 2006; Baker, 2019; Kelly and Green, 2018).

For the dual purpose of understanding how this learning occurs across time and also obtaining knowledge of how to design learning environments and address problems in practice (Greeno, 2005, p. 92; McKenney and Reeves, 2014, p. 18), I have selected design-based research (DBR) methods, which enable me to construct an intervention drawing on a toolkit for an iterative design process (Gravemeijer and Cobb, 2013; Bakker, 2018; Barab, 2014; 2022). DBR methods assist in studying the learning environment through recursive, abductive and inductive analyses of data collected through video and student artifacts so as to test conjectures about the effectiveness of the design solution, derived from DPs (e.g. Reichertz, 2014; Sandoval, 2014; Hammersley and Atkinson, 2019;). Therefore, this study not only develops a case for an understanding of the designed learning environment but also innovates: arguments are presented for contributions to "new [local] theories, artifacts and practices that can be used to inform research and learning in other related contexts" (Barab, 2022, p. 177).

This chapter is organized into sections containing discussions of

- the selection of microethnographic and discourse analysis methodologies;
- the selection of DBR methods; application of selected methods for the study through the initial conjecture mapping;
- the outline of the DFs with explication of artifacts and interactions; explication of the iterations and procedures of data organization and analysis;
- credibility and trustworthiness of the research findings, design and processes outlined, through rich rigor, context and thick description.

3.1 A microethnographic discourse analysis approach

In this study, I set out to investigate the enactment of a set of DPs, derived from theory, research and prior empirical work, in order to understand and characterize the conditions fostering a learning progression in academic literacies for ELLs in a small-group setting. Adopting a sociocultural perspective on learning, I view thinking and learning as mediated by discourse processes that are interconnected and situated in a culture or community of practice, developing over time (Mercer, 2004; 2008). Hence, knowledge is shaped by participants engaging in collective tasks where they are building their understanding of this shared experience (Gee and Green, 1998). In doing so, they are engaging in talk which has been termed "a social mode of thinking" by Mercer (2004), so as to carry out disciplinary practices of knowledge construction. In the classroom, this talk around disciplinary practices is guided by teachers, who induct students into new ways of using language, mediated by a sequence of related educational activities, as a dynamic process (Kelly, Brown, and Jiménez-Aleixandre, 2023). These new ways of using language therefore develop over time, and require analysis that takes into account the dynamic process as well as the social context of use (Mercer, 2008; Kelly, 2014; Baker, 2019; Green, et al., 2020).

My intervention is designed to study language use in classroom activities in a small-group setting. To determine the characteristics of a productive learning environment and investigate the designed features of this intervention requires the analytic tools and methods that enable a view of the situated social practices which shape and are shaped by the participants (Baker, 2019; Kelly, 2023). Hence, ethnographic description, through a discourse analytic and video-enabled methodology, provides the means to represent the social action and practices in the classroom setting, by "zooming in" to view key instances in the action, and "zooming out" to establish patterns of activity (Kelly, 2014, p. 354; Green et al. 2020, p. 181). A microethnographic discourse analysis approach provides methodologies to identify social processes of knowledge construction through joint activity in a local setting, by undertaking multiple levels of analysis of cycles of activity, from the insider or *emic* view of the participants (Green, et al., 2020, p. 186; Gee and Green, 1998, p. 126). Green et al. (2020) define the microethnographic discourse analysis approach as an interdisciplinary logic of inquiry through which the researcher engages in a logic-of-inquiry to understand what is

being constructed in the moment as well as over time by the interactions of the students and their teacher, so as to develop warranted accounts (p. 165). The authors argue that microethnographic research involves undertaking multiple levels of analysis of participant phenomena, constructing data from video recordings of participant interaction, transcriptions, and participant artifacts, including

- multiple forms of transcripts
- tracing student interactions, actions and discourse
- contrastive analyses across groups or time

so as to develop a grounded theory of what constitutes social and discourse processes for the participants. In the sociocultural perspective, as noted, language use by participants in a setting involves constructing social identities, which are brought into being through joint activity on knowledge objects defined through individual and collective goal setting. These processes are temporally organized, and constitute trajectories which may be documented and analysed in an iterative process, as suggested by Green et al. (2020). These authors state that researchers engage not only in description of the above-mentioned data, but in an analytic process: it is a

> complex iterative, recursive and abductive logic of inquiry ... to gain emic or insider understandings of what is being heard, seen and thus observed. ...microethnography is an *epistemological approach*, which supports researchers in studying a particular group or phenomenon within a social context, e.g. literacy practices... (original emphasis) (p. 186).

Kennedy and Thornberg (2018) explicate the iterative process of engaging in abduction. The authors state that abduction is "about discovering new concepts, ideas and explanations by finding surprising phenomena, data or events that cannot be explained by pre-existing knowledge" (p. 52). Furthermore, the process must be iterative, as there is a dynamic connection between data collection and analysis, and referring to theory: analysis through abduction recognizes a surprising anomaly, then suggests plausible hypotheses or explanations, which are then used to re-think prior ideas and theory. The plausible hypotheses are pursued through further investigation, which may be through recursive actions, searching backwards as well as forwards in the data to locate possible sequences of events related to the anomaly. Inductive analysis is then applied, according to the authors, to identify patterns and categories emerging from the data and the investigation of the surprising phenomena, in a process by which researchers interact with the data while

attempting to suspend prior suppositions, or "a stepping back from the known" to learn from other's perspectives, as suggested by Green and colleagues (2020, p. 164). However, prior knowledge also guides the researchers through theoretical research and prior empirical findings, which enables them to determine the initial research questions to direct the data collection and observations.

Skukauskaitė and Green (2022) define the anomaly or surprising phenomenon as a 'Rich Point', citing Agar (2013), since there is a potential for new discoveries and understandings. The authors state that Rich Points are investigated iteratively, repeating the process of observing the video and other data, so as to find the meanings signaled by members of the group and thus foreground the *emic* or insider perspective (Green, et al., 2020). Powell, Francisco and Maher (2003) refer to 'critical events' in a similar manner. The authors define these as a connected series of utterances and actions, which appears to be relevant to the research question, according to the researcher: "An event is called *critical* when it demonstrates a significant or contrasting change from previous understanding, a conceptual leap from earlier understanding" (original emphasis) (p. 416). The authors suggest expanding the analytical focus of video based analysis to include the students' written work in the recording frame, so as to enable consideration of the students' activity, which was about mathematics in their study. The authors cite other research suggesting that a video portfolio may be developed to trace the students' cognitive evolution on mathematical thinking over time: it would consist of episodes or a series of episodes, associated written work of students, and researcher notes (p. 141). Drawing on this research, I discuss video collection and analysis for this study in additional detail below, including the points on camera work (section 3.8). I will use the term 'Rich Point' in this study as incorporating the ideas of Powell and associates as well as Skukauskaitė and Green.

Engaging in the process of applying ethnographic logic-in-use and using Rich Points to anchor analysis is delineated by Green, Skukauskaitė and Baker (2012) as drawing from a range of decisions, including

- selecting phenomena drawn from classroom literacy events
- constructing a conceptual framework to guide observations
- selecting methods of recording phenomena: collecting artifacts, making video recordings, taking photographs, taking field notes

- labelling and archiving the records
- identifying Rich Points as anchors of analysis
- producing data sets from the archived records
- constructing accounts to develop explanations of the observed events
- making transparent the logic-in-use: the iterative, recursive and abductive logic applied in developing the explanatory accounts (p. 309).

Hence, in keeping with the sociocultural and situative perspective on language as cultural practices situated in a local context, enacted by the members of the community, the unit of analysis for this study is defined as interaction through a set of three main discourse moves engaged in by the participants, as they construct their cultural activities which are the classroom literacy practices developed in this intervention. These discourse moves are studied as they take place in activity around the participant artifacts, and characterized according to the types of meaning-making taking place during the interaction. Rich points are identified abductively and recursively, and the data set for the study is produced by constructing a series of episodes from recorded (photo and video records) classroom events containing these Rich Points, presented as an ethnographic narrative (Emerson, Fretz, and Shaw, 2011; Derry, et al., 2010).

The resulting episodes are transcribed (Erickson, 2006; Bezemer and Mavers, 2011; Derry, et al., 2010; Hammersley and Atkinson, 2019) and analysed in detail using microgenetic methods (Sherin and Chinn, 2022). In order to analyze learning as a mediated process through time, Sherin and Chinn (2022) refer to critical or precipitating events, which I take to be identical to Rich Points. The authors state that it is necessary to capture dense observations of events of rapidly changing student activity around what they term "critical events that precipitate learning": researchers must begin to collect observations at a point *before* students' competence begins to emerge, as well as *continue to follow the development of the competence*, so as to characterize and construct an account of these events as learning trajectories (my emphasis) (p. 227). This enables the construction of a rich (also known as thick) description, which enables researchers to determine the "variability or stability across time in how learners use strategies or express particular conceptions" (p. 226). However, the learning activities and participants artifacts are constructed using DPs which must be delineated to understand the events being observed. Furthermore, the events must be organized so as to represent changes in participation and

facilitate iterative and recursive analysis. As noted, I delineate the data collection and data analysis, explicating the levels of analysis, and the application of recursive, abductive and inductive methods, in section 3.8.

In the next section, I present the DBR methods selected for this study. This is followed by the sections on pilot projects, designing the intervention, data collection and analysis, as well as a discussion of criteria for credibility and trustworthiness of the research process and findings reported in this study (Tracy, 2013; Gravemeijer and Cobb, 2013; Cohen, Manion and Morrison, 2017).

3.2 Selection and application of DBR methods

Educational research projects that focus on both research and practice in the classroom were originally proposed by Brown (1992). In this early research, the author states that classic research methods, requiring "strictly controlled laboratory settings", are difficult to implement so as to study "… learning in the blooming, buzzing confusion of inner-city classrooms." (p. 141). The author notes the many factors at work in such settings, including curriculum, students, teachers, parents, technology, which she termed inputs in a working whole, or a system. Brown defines her research as aimed at outcomes intended to influence theories of learning as well as classroom practice.

Collins, Joseph and Bielaczyc (2004) state their view of "design research" as a "particular kind of formative research", and concur with Brown on the need to study learning phenomena in the real world rather than in the laboratory. The authors define this kind of research as

> a way to test and refine educational research designs based on theoretical principles derived from prior research. This approach of *progressive refinement* in design involves putting a first version of a design into the world to see how it works. Then, the design is constantly revised based on experience, until all the bugs are worked out. (original emphasis) (p. 18)

The authors note that such progressive refinement enables researchers to develop robust designs over time. However, they affirm that DBR has the dual goals of refining practice as well as theory through an assessment of the critical design elements. Cobb et al. (2003) emphasize the innovative character of DBR, with its intent to bring about new ways of learning through experimenting: "...the purpose of design experimentation is to develop a class of theories about both the process of learning and the means that are designed to support that learning" (p. 10).

Reimann (2011) states that theories derived from DBR are domain-specific and instructional, consisting of "a description of a learning trajectory that leads to achieving significant learning goals in a particular domain, as well as the demonstrated means of supporting the learning process" (p. 42). Therefore, the author affirms that the focus of DBR is on improving the design by testing and revising conjectures about the learning process and its mediating means, and not on proving that the learning trajectory is achieved as predicted. The author explains that the learning trajectory is analyzed by relating the specific activities

of the Enactment Processes (EPs) to changes in student reasoning, and showing that these changes would not have occurred but for the support of the instructional design. This is achieved through a clear interpretive framework, which is applied to explain as well as characterize the changes. The design experiment is enacted in cycles of modifications, enabling a detailed documentation of students' emerging forms of reasoning as resulting from a reorganizing of prior understandings. Reimann states that comparing the different design versions enables one to determine necessary and contingent design elements for the achievement of the intended learning goals (2011, p. 44).

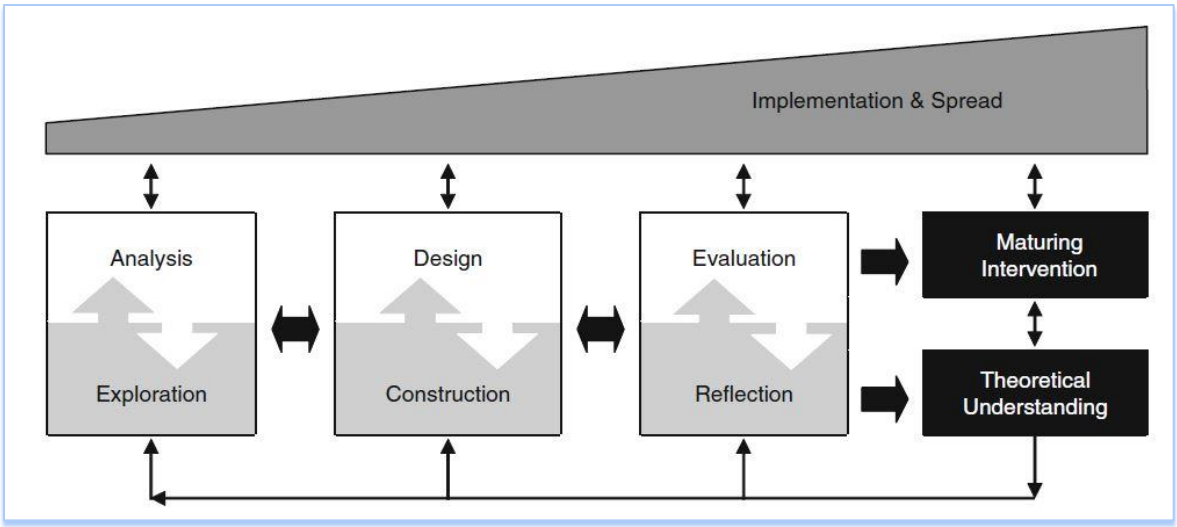


Figure 3-1 Overview of the general DBR iterative process of refining a design solution to achieve a desired learning outcome, and the design knowledge to support that learning (McKenney and Reeves, 2014).

These cycles in the DBR intervention are shown in figure 3-1, showing the iterative process of refining a design solution to address a specific learning competence, with the dual goals of attaining a maturing intervention, i.e. a practical design, and theoretical understanding of the underlying mechanism of the mediating means supporting the learning. DBR is therefore defined as focused on interventions enacted in the context of an authentic instructional setting, as noted by Barab (2022). The author states that the iterative design process provides the researcher with tools to not only understand the design elements and their effects, but to carry out change during the intervention itself in a manner responsive to the participants. Barab suggests that DBR not only considers the immediate effect being investigated through the intervention, but a longer term impact through the agency and contribution of the participants. The author states that the participants are to be considered agents of change, not objects to be changed, so that the intervention outcomes are openly

considered as "shared accomplishments distributed across the design, the learner the implementation context and the future contexts of use..." (p. 186). He emphasizes that the design and the context are to be considered together, i.e. the design is not *in* an authentic context; the setting and the design *together* constitute the ecosystem.

Design-based research differs from empirical experiments therefore in conjecturing about the effectiveness of a particular design, rather than formulating hypotheses (Bakker, 2018). Van den Akker, et al. (2006) suggest defining the research question for a DBR investigation as a High-level Conjecture (HLC), which is implemented in an intervention according to DPs derived from theoretical research and empirical work. This conjecture is formulated so as to indicate the proposed solution of the intervention: it states the goal and the suggested means for supporting it. These means are then stated as design features (DFs), which are designed according to the heuristic guidelines provided by the selected DPs.

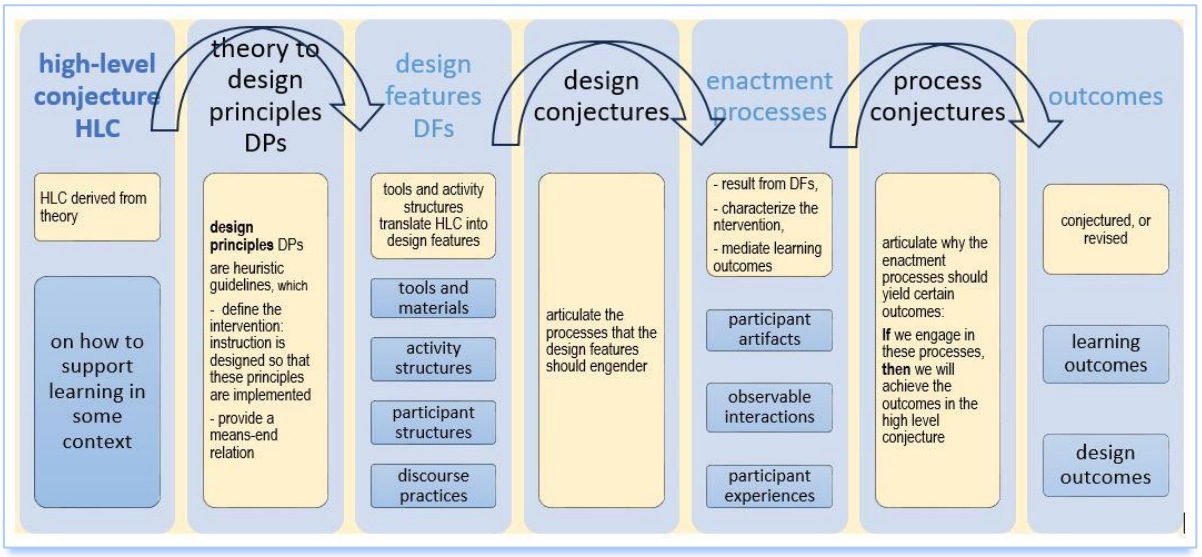


Figure 3-2 Schematic (own figure) for the conjecture maps used for the intervention, adapted from Sandoval (2014) and Boelens, De Wever and McKenney (2020)

Sandoval (2014) provides the technique of conjecture mapping, which serves to map out the components of a DBR intervention, and their interrelations, so as to relate the means to the conjectured outcome and thereby assess the effectiveness of the design principles across iterations of refinement. Figure 3-2 presents my schematic for the design in this study, which I prepared by combining Sandoval's (2014) components with the process of conjecturing on the DFs and the ensuing EPs, as suggested by Boelens, De Wever and

McKenney (2020). Boelens and colleagues report on work with post-secondary students; however, their study is highly informative in delineating the processes of engaging in DBR, with a detailed presentation of the components of their design through the use of conjecture mapping.

Pierson, Clark and Brady (2020) likewise employ DBR in their study on supporting science learning with elementary age students, and show a conjecture map as a tool for reporting their final design revisions (p. 788). These revisions were determined upon conclusion of their fourth iteration through retrospective analysis only. Hence, practitioners are not provided notes on conjectures for these changes as guidance for transferability, as these are not shown through intermediate analysis during implementation. In this study, however, I provide analytic notes for intermediate outcomes as signposts in the learning progression during the intervention seen in figure 4-2 and at the start of each iteration.

Moore, Schleppegrell and Palincsar (2018) also report on a DBR intervention to support ELLs in a middle school setting. The authors delineate a theory of change to be studied, detailing concepts drawn from research, such as interaction through explicit talk about language, which were then given as design principles, namely "support explicit, meaningful attention to language"and "support meaningful interaction between students and teachers" (2018, p. 1029). The authors do not set out their design in a conjecture map to make their design transparent and guide other practitioners, to produce "actionable knowledge" (Kali and Hoadley, 2021, p. 487) and do "real design work" (diSessa and Cobb, 2004). Furthermore, the design principles cited above are not *actionable*; that is, as noted in section 2.3 and shown in table 3-2, they do not contain advice on the enactment or mediating processes of the design features; thus, the means-end relation is not clearly established (Bakker, 2019). In this study, I follow DBR practice advised by Kali and Hoadley (2021), Sandoval (2014), and Bakker (2018; 2019) in providing DPs formulated as actionable knowledge providing pragmatic and theoretical grounding for my design, seen in table 3-2. I return to these points below, in discussing my Conjecture Map preparations, as well as in the review of the credibility and trustworthiness of the research findings, design and processes outlined through the DBR methods applied (Barab, 2022).

For this study, therefore, I prepared a schematic to use as a heuristic for constructing the conjecture maps for this intervention (Bakker, 2018; Kali and Hoadley, 2021) as stated, in figure 3-2. The schematic is to be read from left to right, indicating the process of preparing and testing the design, but not the cyclic nature, which is shown by figure 3-1. In their work, Boelens and associates (2020) explicate clearly the manner in which the design is assessed: data were collected on the EPs, which were then assessed according to design conjectures and process conjectures. The authors delineate their initial formulation of their HLC based on their prior empirical work on the practical teaching problem that had been identified. Then they provide the DPs to be used in their intervention, derived from research (see below), which are formulated to indicate a means-end relation, of the form, "designing with this feature will led to this desired outcome" (Bakker, 2018; 2019). Hence, figure 3-2 shows an arched arrow to indicate the list of DPs which were drawn from research and the conceptual framework, and embodied in DFs, shown next. DFs, as noted by Boelens and colleagues, are usually studied in isolation from other intervention elements, and therefore do not indicate the joint activity of the elements and their respective impact on the outcomes. These authors, however, provide the means to articulate a connection between DFs and EPs, by stating design conjectures, namely processes that specific DFs should engender, of the form "the design feature will yield a specific process during enactment".

EPs therefore result from DFs, and are conjectured to lead to the learning outcomes, as suggested by the HLC. These are the processes that will be the focus of data collection in this study, in the form of participant artifacts, observable interactions and participant experiences. Process conjectures have the analogous function of design conjectures, namely affirming why the EPs should result in certain outcomes, of the form "engaging in this process will achieve this outcome, as suggested by the HLC". EPs thus mediate learning outcomes as well as design outcomes, as shown in the last column in figure 3-2.

Having described the generic features of my DBR design through the schematized representation of the components, I next discuss the elements and steps which I undertook to construct the Initial Conjecture Map for the intervention seen in figure 3-9.

Figure 3-3 below presents the preliminary Conjecture Map that I constructed based on prior empirical work, delineated next in section 3.3. This map indicates my initial HLC as a

reformulation of my overarching research question stated at the start of the chapter, namely, *How can a learning environment be constructed in order to support ELL students appropriating science discourse and practices?* As indicated, I have reformulated this as a preliminary HLC, namely: *Students' knowledge and use of the Everyday Language and Academic Language continuum requires their appropriation of disciplinary discourse practices, including describing, explaining, representing phenomena and processes in science topics*.

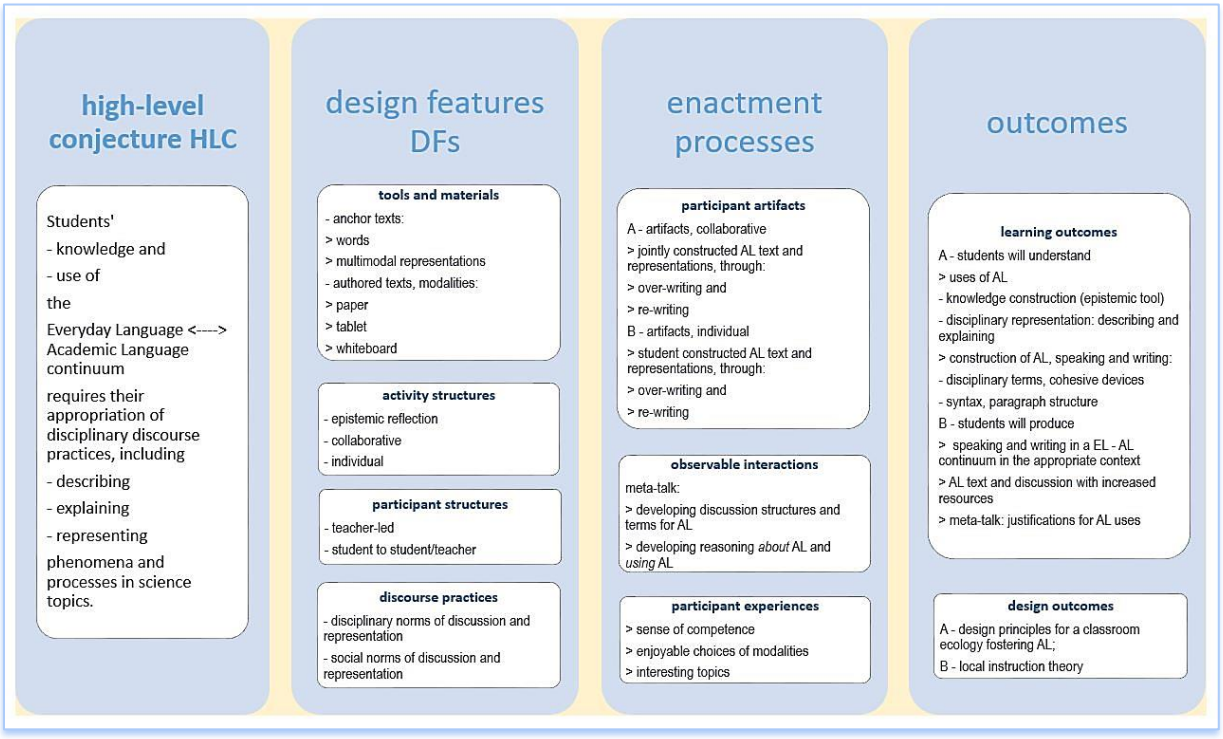


Figure 3-3 Preliminary Conjecture Map for the intervention, drawing on prior empirical work (section 3.3), outlined during research preparing for the formulation of actionable Design Principles (table 3-2), design conjectures and process conjectures, as schematized in figure 3-2.

This HLC is derived from research delineated in chapter 2, and also my prior empirical work, which I describe below in section 3.3. According to DBR practices, the HLC is expected to be modified during the course of the iterations of the design; I discuss this in chapter 5 during retrospective analysis, and present a Revised Conjecture Map in figure 5-5, including a revised HLC and Outcomes. Abductive and recursive analysis is applied during the iterations to determine intermediate outcomes by relating changes in student participation to process conjectures and thereby to design conjectures. As DFs are maintained across the iterations, this analytic process enables pinpointing salient events signposting these changes in participation. In retrospective analysis (chapter 5), these signposts enable a learning

trajectory to be delineated as evidence toward the HLC and the design effectiveness in achieving the desired outcomes. The HLC and Outcomes are therefore refined through this analysis, shown in figure 5-5, chapter 5.

Here, in the preliminary Conjecture Map, figure 3-3, the elements of the EPs constitute the starting point for constructing the design, so as to obtain the desired outcomes, as advised by Boelens and colleagues (2020, p. 435). Through research outlined in chapter 2, I prepared the conceptual framework for the study, set out in table 3-1 below. This list of concepts provides the theoretical basis for the DPs used to design the first iteration of the intervention. In section 3.3, I delineate the empirical elements for the design conjectures and the process conjectures, which I applied to construct the Initial Conjecture Map to guide the intervention, shown in figure 3-9, which I explicate in section 3-5.

Conceptual Framework for the study:
1. Situative view of learning: learning in activity over time 2. Social practices: ways that people are initiated into the frames of reference of the community, through o language o participation in cultural practices 3. Situated activity is mediated by artifacts: o material: tools and devices o semiotic: language, notation, representation 4. Science discourse: orchestrated by apprenticeship in practices, through o a words-to-concepts continuum o a representation construction approach: drawing to learn o conceptual link-making strategies 5. Literacy and science integrated through: o hands-on activities o vocabulary, reading and writing activities 6. Science ideas form the basis of talk, anchored by text 7. Different modes of teacher-student interaction: a dialogic – authoritative discourse continuum

Table 3-1 Conceptual Framework summary for this study, derived from research presented in the Literature review, chapter 2, applied to formulate actionable Design Principles in table 3-2..

The list of concepts in table 3-1 are reformulated as *actionable* DPs in table 3-2, in the next section: these set out the theory and guide the designer by "anchoring them in practical and experiential knowledge, forming "a bridge between theories of learning and pragmatic aspects of learning", as noted by Paavola and associates (2011). This process of formulating actionable DPs from theory and prior empirical knowledge therefore ensures an accountability and trustworthiness in the design process: the appropriate theoretical basis is stated and connected with the setting, the participants, and the conjectured learning and design outcomes, as suggested by Bakker (2019).

Boelens, De Wever and McKenney (2020) explain the application of DPs, as noted above. Drawing on that work, I will elaborate on my DPs in section 3.3, where I delineate the prior empirical work used to inform the development of the initial DFs and EPs, as shown in figure 3-3: I reformulate the DPs as actionable, to guide design, in table 3-2. This is followed by section 3.4, where I present the Initial Conjecture Map and outline the general DFs and EPs of the intervention. This in turn is followed by sections on the timeline of the iterations, data collection and procedures.

3.3 Pilot projects: determining preliminary Design Features and Enactment Processes

In this section, I briefly describe the prior instruction that I conducted in the context of this setting, which helped me formulate my initial views on the practical problems of teaching academic language to ELLs in this context. This prior empirical work, delineated here as pilot projects, constitutes the empirical knowledge that I drew on, together with the theoretical basis shown in table 3-1 formulated as actionable DPs in table 3-2 below, to formulate my Initial Conjecture Map for the intervention, as presented in figure 3.9 below.

During the course of two school years, prior to formally conducting research for this intervention, I informally collected classroom artifacts and took personal notes on the setting and classroom interactions centred on the central problem of this study as outlined in chapter 1. These artifacts and notes on their EPs enabled me to prepare the preliminary Conjecture Map (figure 3-3), through which I began to clarify the desired outcomes and explore my conjectures on the means for attaining these outcomes. As stated by Sandoval (2014), conjecture mapping is a means to clarify the relationships between the elements by "reifying specific conjectures and how they are expected to function in interaction" (p. 20). Hence, constructing the preliminary Conjecture Map enabled me to determine the elements that I had been implementing in my instruction as empirical prior knowledge, and also define the initial research questions through the work of defining desired outcomes. Bakker (2018) describes the usefulness of conjecture mapping at the beginning of a project as a heuristic, after cycles of empirical work, permitting the formulation of conjectures about the design to be tested through the intervention (p. 57).

In designing the intervention to be enacted in this study, I built on methods that I developed through several years of work with ELLs enacting tasks and interactions around texts of various kinds. The aim of these tasks and interactions was always that of assisting these students to attain a level of language proficiency meeting the program goals, namely enabling them to transition to the mainstream class environment, as I discussed in chapter 1. These tasks and interactions involved using artifacts as a basis for interaction and activities intended to add vocabulary and eventually sentence work, so as to practice languaging the

new forms in different ways and in different content areas, but particularly in school science, as I noted. I develop my use of the term *languaging* for this study, below, figure 3-7.

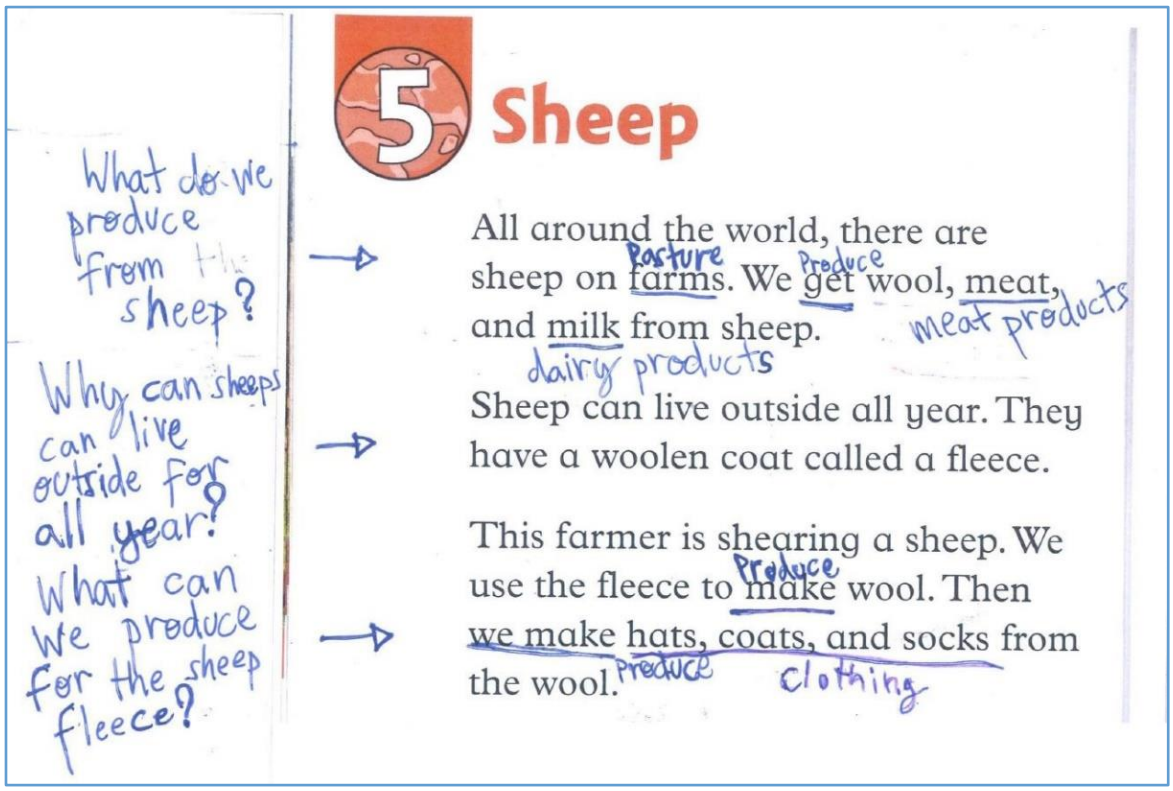


Figure 3-4 Pilot work with anchor text, October 2017, showing the student's own study questions on the left, with arrows indicating the target sentence; annotations with Academic Language (AL) and underlinings made through discussion i.e. *meta-talk*, in a process termed *over-writing* in the study.

As seen in the DFs in the preliminary Conjecture Map, figure 3-3, the classroom interaction is based on anchor texts and writing, including annotation. Figure 3-4 shows a detail from a student's work, dated October 2017. It shows the student's work on a photocopy of the anchor text, with a chapter on sheep, where the student has carried out three of the practices that will form the basis of the interactions in this study, namely writing study questions, annotating the text with Academic Language (AL) terms, and reformulating study questions using the AL terms. Study questions are written by the student and formulated to refer to a sentence on the page, which is selected by the student. This task follows a read-aloud performance in the small group (Lennox, 2013; Lapp, Fisher and Grant, 2008), during which students identify Everyday Language (EL) words on the page, which should be replaced with disciplinary terms (e.g. Heisey and Kucan, 2010). Those EL words are underlined, and AL terms are added through discussion, as part of engaging more deeply with the meaning of the text. This process is termed *over-writing*. The study questions are

formulated and reformulated, as the student attempts to incorporate the new terms in these own questions: the page shows erasures, as erasable pens are used. These activities are noted in the enactment process, as participant artifacts, item A.

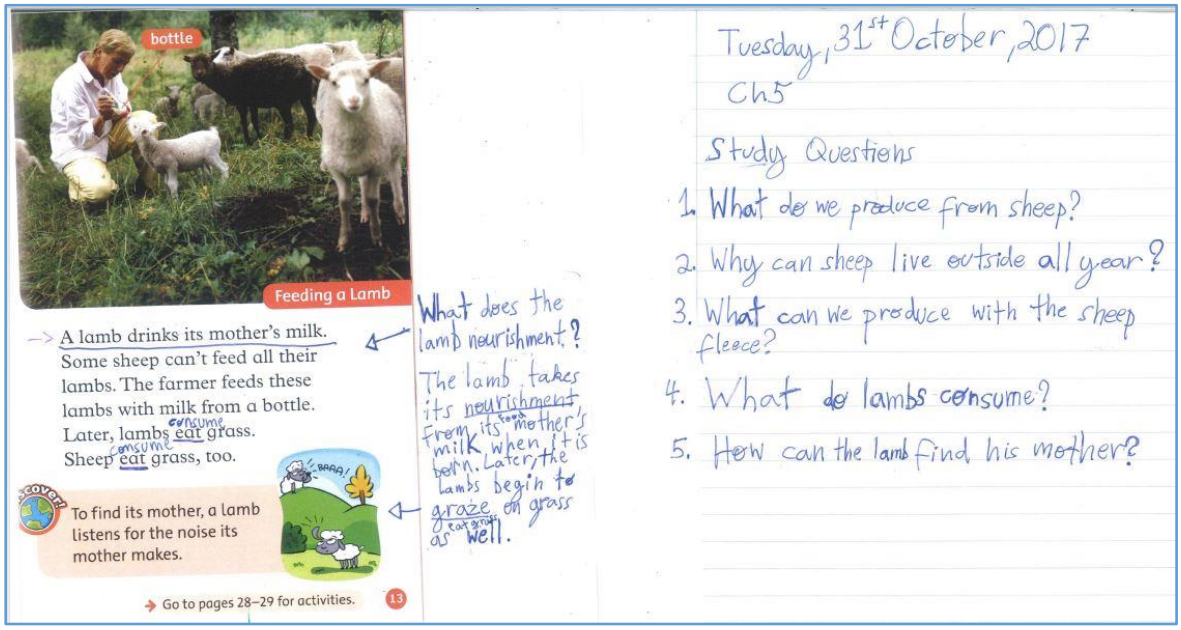


Figure 3-5 Pilot work with anchor text, October 2017, showing the second page from figure 3-4, together with recopying of the study questions in the student's notebook. The student has answered his study question with an elaborated sentence derived from the anchor text and the *over-writing* process, so as to do his own *re-writing*, which will also later be termed *authoring* in the study.

In my experience, students enjoy performing read-alouds from a paper text, which I judged from their eagerness to take turns, and their commitment to pronouncing words properly and learning a suitable prosody. Hence, over the years, through discussions with students about the meanings in expository text during read-alouds (Heisey and Kucan, 2010; Lennox, 2008), I developed the practice of adding new terms and requesting annotations, which I taught through discussion and modelling on the classroom whiteboard (WB), with examples copied by the student seen in figures 3-4 and 3-5.

Discussion also took place on diagrams in these anchor texts, with annotations and elaborations written by the student, as shown below in figure 3-6. These annotations are considered another form of *authoring* in this study, as the student is appropriating the representation by effectively *re-constructing* it. This process is referred to in the enactment process, participant artifacts item A, as the representation work is jointly constructed and discussed. The mechanisms mediating the reasoning processes that are involved in this representation work help constitute the learning trajectory argued in this study.

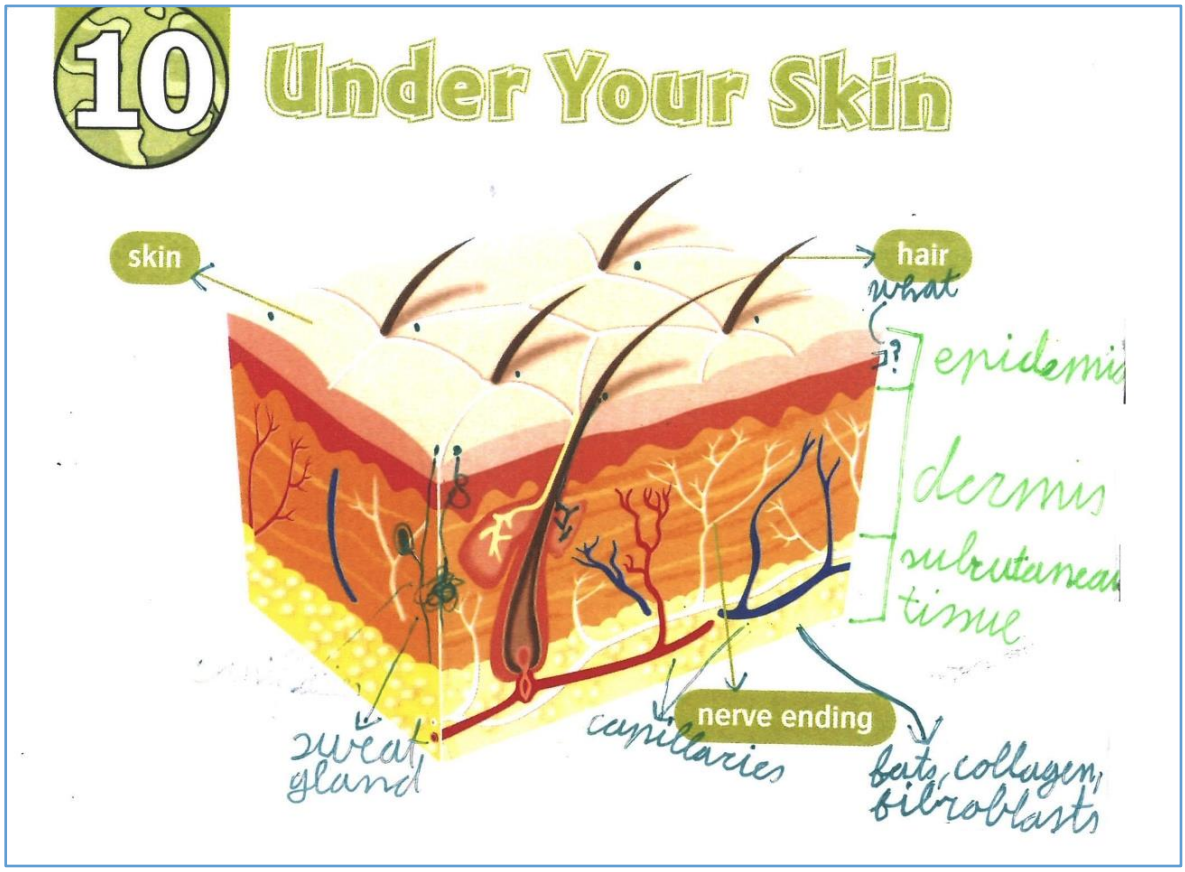


Figure 3-6 Pilot work with anchor text, December 2018, showing the student's annotation and elaboration of the anchor text diagram through discussion, i.e. *meta-talk*. He has drawn arrows to indicate the references for the green text boxes, which were not clear; added more terms drawn from the chapter; added labels for the layers, from an internet source, and a question mark identifying a remaining point to be discussed. These annotations are examples of *epistemic work* in this study.

Other discourse processes also take place about the language forms, which involve another form of *re-writing*, taking place at the word and sentence level, shown next in figure 3-7.

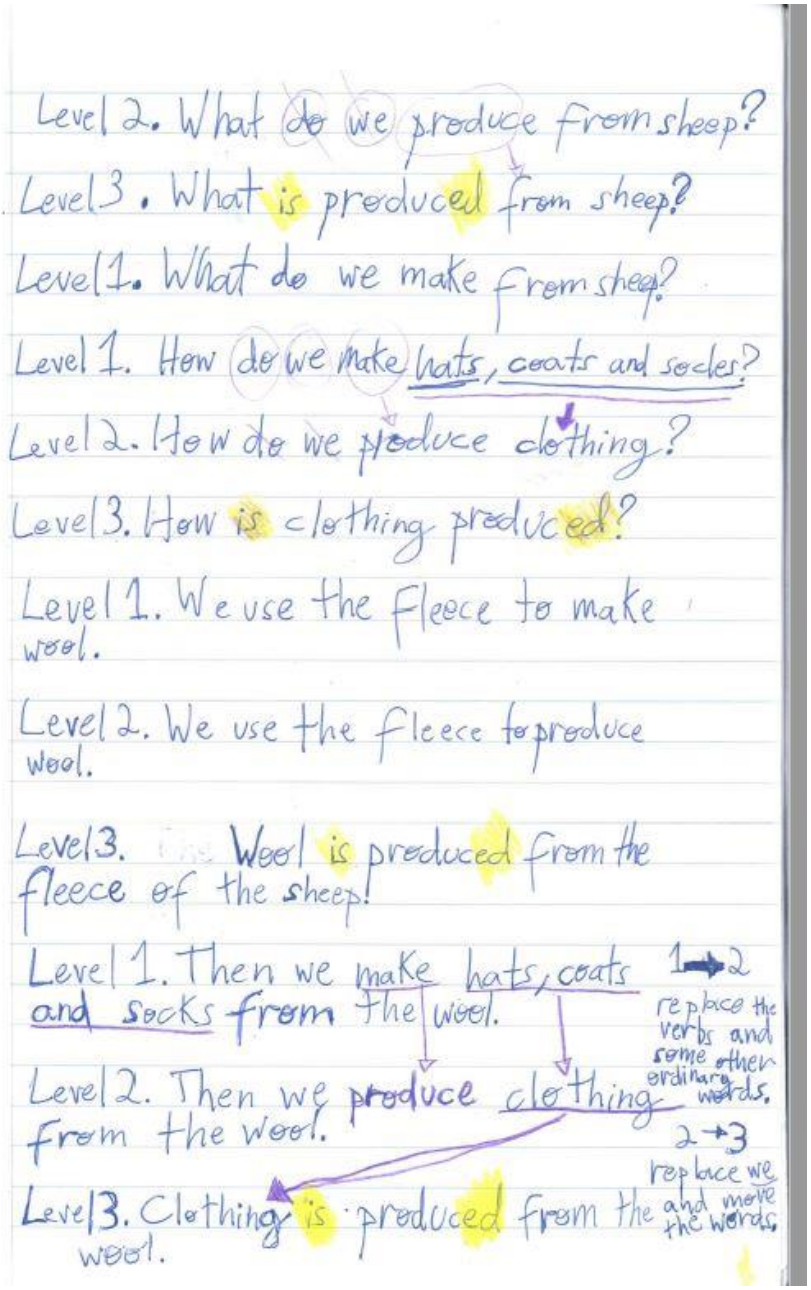


Figure 3-7 Pilot work with anchor text, October 2017, showing the student's reworking of the anchor text in three steps, through discussion. This page shows the first instance of these discourse moves in my pilot work. Level 1 is the sentence from the anchor text, level 2 replaces the EL with AL, and level 3 is the re-written sentence in the passive voice. This *re-writing* is termed *languaging*. Yellow highlights indicate the features of the passive voice, for the student. The page shows the development of this process during the lesson, as a colour code and notes are added by the student toward the end, through discourse that I term *meta-talk*.

The page shown in figure 3-7, dating from October 2017 (produced by the same student from figures 3-4 and 3-5), indicates the first instance of *meta-talk* around language forms for disciplinary work that I identified in my notes. The written part of the discourse move is termed *languaging*, in this study. I hyphenate the term meta-talk to indicate my use of this discourse move in this study, which I will elaborate on in the Outcomes section of iteration I

in chapter 4, Part A, section 4.2.1. This meta-talk is referred to in the EPs under observable interactions, in figure 3-3. The second point of note here is that this page is also a record, mediating our reasoning process on language forms, as suggested by Wells (1999). These notes trace the talk and thinking for the disciplinary work which I later come to term *epistemic work*, during the course of Iteration I, in the Intermediate Outcomes and Analysis, section 4.2.1.

During the subsequent school year, the student whose work in shown in figure 3-6 also produced the work below in figure 3.8.

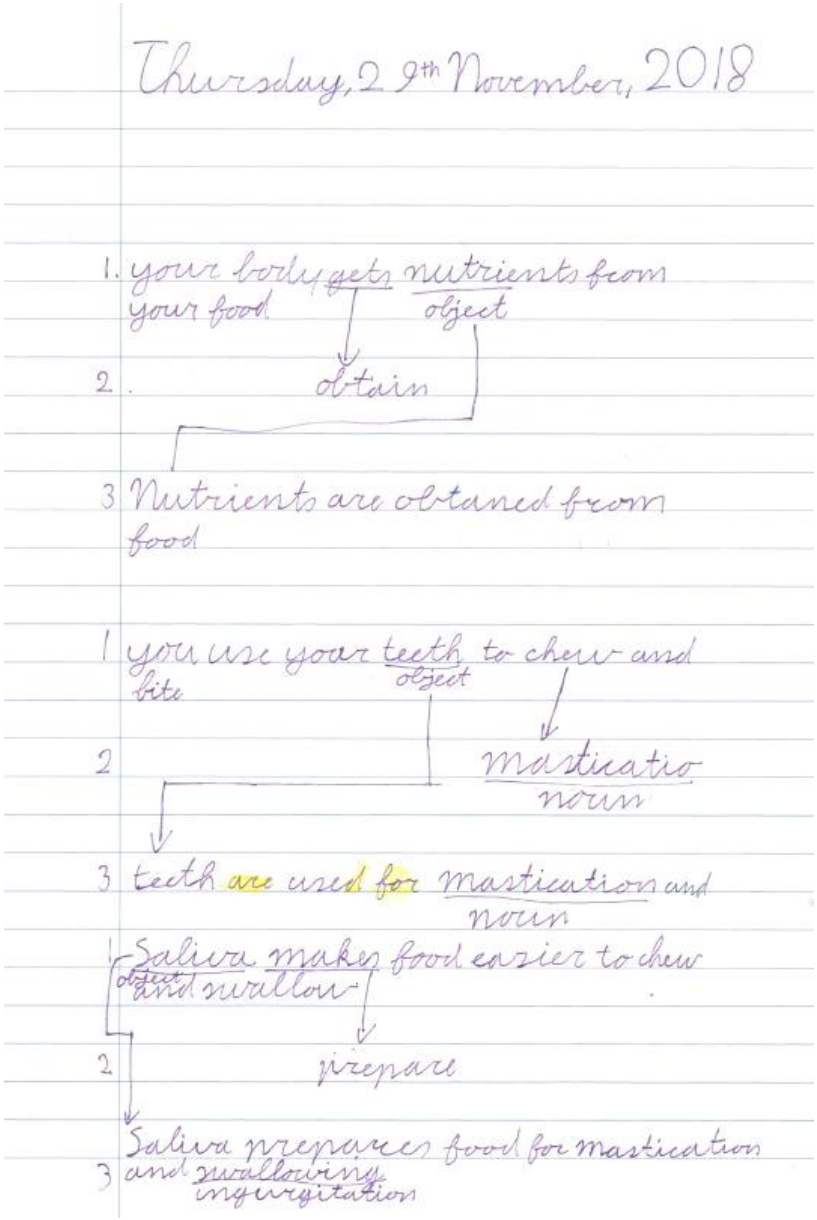


Figure 3-8 Pilot work with anchor text, December 2018, showing the student's own *languaging* work:repeating the steps for *re-writing* the anchor text, independently applying terms that were used and annotated during the read-aloud and discussion, i.e. *meta-talk* around the chapter text.

Hence, the work seen in figures 3.4 – 3-8 delineates the core elements from the pilot projects, which I carried over and implemented in the first iteration of the intervention: these are noted under the EPs in figure 3-9. In addition to this work on paper, I also had many personal notes, and material from my prior research (Eerikäinen, 2015) on student work with technology supporting their learning. I was an early adopter of these tools in this school, noting that students enjoyed learning and using multimodal tools. I was pragmatically motivated to incorporate these tools in my instruction, as a means to provide students with more choices in writing tasks. For instance, working with a favourite colour to type on a PowerPoint seemed to engage students who struggled with scribing for various reasons. Thus, well before preparations for the current intervention, I was already designing activities where students were constructing artifacts across modalities, and adding images of their own drawings or models, as this practice appeared to help student focus and persist to make their meaning more clear through revision, over time (Gilbert, 2013). Therefore, in preparing the conceptual framework for this intervention, I was motivated by both empirical and theoretical considerations to engage in representation construction and computer supported work with digital note-taking tools.

Having prepared the conceptual framework shown in table 3-1, and discussed examples of the pilot work supported by this theoretical research, I now present the initial formulation of the DPs for the intervention in table 3-2, shown with their associated theoretical bases. These are written as actionable DPs, guiding the construction of the Initial Conjecture Map for this intervention, as suggested by Sandoval (2014), Wozniak (2015), Bakker (2018; 2019), Spence, (2025), Dohn and Spence (2024), and Paavola et al. (2011), in order to do “real design work for innovation” of theory and practice, as argued by diSessa and Cobb (2004).

Design Principles (DPs) : Designing instruction with	Associated objectives: is, according to theoretical bases, research, and prior empirical work, predicted
1. activities using a variety of modalities	to stimulate and engage students
2. activities using science anchor texts	to enable students to o perform read-aloud tasks o have access to challenging content and ideas o engage with models for disciplinary literacies o experience a disciplinary context for language activities
3. daily activities involving reading and writing, and discussions for connection making between these	to foster habits of mind for the disciplines
4. activities integrating literacy and science content and practices	to provide students with meaningful contexts for engaging in o language tasks o representation tasks o disciplinary practices
5. discourse moves orchestration by the teacher for o purposeful shifts in interactions, o shifts in dialogic< --> authoritative discourses, o connection-making	to provide students with o opportunities to enact AL in disciplinary ways o a growing sense of agency o a growing sense of a community of practice

Table 3-2 Design Principles formulated as *actionable*, stating rationales and processes, both research-based and empirically (drawing on pilot projects), prior to formulating these in table 3-3 for the design of the Initial Conjecture Map, figure 3-9. Each row is to be read from left to right, repeating the headings.

3.4 Designing the intervention: applying Design Principles and constructing the Conjecture Map

During the course of carrying out the pilot projects as delineated in section 3.3, I determined to investigate learning of academic literacies conceptualized as a continuum, so as to characterize the features of a learning environment fostering a learning progression for ELLs in a small-group setting. This context is set out in section 1.1, where I formulated the initial research question as a practical problem in my teaching practice.

By investigating more closely the language use involved in knowledge construction around science inquiry tasks, I shifted the focus from the genres of various science reports and other writing tasks, to the discourse processes and interactions around these tasks. I reconceptualized these processes and interactions as semiotic processes for knowledge construction on improvable objects through jointly constructed activity (Prain and Hand, 2016; Tytler, et al., 2020; Damşa and Muukkonen, 2020; Paavola and Hakkarainen, 2009). I aimed to focus on the language of the text, diagram or other representation of the content so as to understand the processes of discourse-in-use being developed by the participants to accomplish individual and collective epistemic goals (Bloome and Clark, 2012; Prain and Tytler, 2012; Pierson, Clark and Kelly, 2019; Paavola and Hakkarainen, 2005).

I began work on the design of materials and activities focusing on the language of science, by means of interaction centred on disciplinary text and representations as development of epistemic practices (Kelly, Brown, and Jiménez-Aleixandre, 2023). This initially involved two main types of activities in the form of explicit language work and various note-taking tasks, as noted in the pilot work. Within the context of read-alouds of graded readers, I developed ways of incorporating grammar points and vocabulary teaching, rather than returning to doing grammar and vocabulary work separately. This work in terms of writing is exemplified in figures 3-4 to 3-8, as discussed in the preceding section. Drawing on the Pluriliteracies methodologies for designing tasks and developing materials through the formation of learning partnerships between teachers and learners (Coyle and Meyer, 2021, p. 129), I began to develop shared writing strategies with the students, foregrounding talk about language choices including grammar and vocabulary (Myhill and Newman, 2016; 2019; Myhill, Newman and Watson, 2020). These talking-about-writing activities were

contextualized in the read-alouds of non-fiction graded readers, as part of the collaborative work of constructing and applying academic language and thinking about it in meaningful interaction. I developed strategies for annotating and re-writing the anchor texts, in tandem with representation construction, which I initially considered as another note-taking strategy. These were generative learning strategies suggested by Fiorella and Mayer (2015), which I progressively developed into knowledge construction through the framework for representation construction suggested by Prain and Tytler (2012) and Tytler et al. (2020).

I therefore begin to develop a theory of practice, taking a situative perspective on learning as legitimate peripheral participation, developing and changing over time to increased levels of mastery of cultural tools of meaning-making and knowledge construction (Greeno, 2005).

I began my study by identifying the following areas of research:

1. How can language learning practices foster the learning of disciplinary literacies for language learners in middle school settings?
2. What are the characteristics of the learning environment conducive to language learning practices about disciplinary literacies?

Hence, the overarching research question with which I began this investigation is *How can a learning environment be constructed in order to support ELL students appropriating academic literacies and disciplinary practices?* To operationalize this question in the format suggested by design based research practices, I reformulated this question as a preliminary High-level Conjecture (Bakker, 2018; Sandoval, 2014; Van den Akker, et al., 2006), namely, *Students' knowledge and use of the Everyday Language (EL) and Academic Language (AL) continuum requires their appropriation of disciplinary discourse practices, including organizing, explaining, and representing about phenomena and processes in school science topics*. This High-level Conjecture is refined through retrospective analysis, in chapter 5, as a result of new practical and theoretical knowledge emerging from the study (McKenney and Reeves, 2018; Wozniak, 2015).

3.4.1 Applying Design Principles

The list of DPs which I developed during my research phase as shown in chapter 2, are stated in table 3-3 below, and applied in constructing the Initial Conjecture Map shown in figure 3.9. The process of mapping the DPs into DFs is part of the DBR process (e.g. McKenney and Reeves, 2012; Bakker, 2018; 2019), drawing on microethnographic methods (e.g. Baker, Green and Skukauskaitė, 2008; Green et al., 2020) and social-semiotic perspectives (e.g. Tytler, et al., 2020), so as to obtain actionable knowledge about the design of learning environments with the desired learning outcomes through enactment in the intervention. This actionable knowledge is therefore a frame of reference for adaptations to other situations, as shown in the iterations, i.e. an "empirically grounded local instruction theory that underpins the instructional sequence" (Gravemeijer and Cobb, 2013, p. 103).

Design Principles : preparing for the intervention, Iteration I

Designing instruction with

1. a variety of modalities will stimulate and engage students
2. science anchor texts will provide students with
   - read-aloud tasks
   - challenging content and ideas
   - models for disciplinary literacies
   - context for language activities
3. daily reading and writing, and connection making between these, will foster habits of mind for the discipline
4. integrated literacy and science will provide students with meaningful contexts for
   - language tasks
   - representation tasks
   - disciplinary practices
5. teacher orchestration of discourse for
   - purposeful shifts in interactions,
   - shifts in dialogic< --> authoritative discourses,
   - connection-making
     a. will help foster a sense of disciplinary practices
     b. will help generate motivation in students,
     c. will help students to enact AL in disciplinary ways

Table 3-3 Design Principles derived from research and pilot projects, formulated as a means-end relation shown in yellow highlight, and applied in preparation for the intervention: designing for Iteration I. These are applied in constructing the Initial Conjecture Map, figure 3.9

I have chosen to follow Boelens and associates (2020) in formulating the DPs as statements not in the "If-then" format (Plomp, 2013, p. 24) but as a statement connecting specific means to a particular end, so as to provide concretely testable conditions (Bakker 2019) and actionable knowledge, as noted above. These DPs are refined through the process of testing across multiple iterations (Linn, Bell and Davis, 2003), as will be discussed through inductive analysis during the sections on Intermediate Outcomes (Erickson, 2012) in chapter 4 Parts A and B, and in the retrospective analysis in chapter 5 (Bakker, 2018).

3.3.2 Constructing the Conjecture Map

The Initial Conjecture Map in figure 3-9 is shown firstly so as to present an overview of the intervention. Its practical purpose is to facilitate design and cyclic analysis during the intervention (Sandoval, 2014; Wozniak, 2015; Bakker, 2018). The theoretical aim of setting out the elements of the research design through conjecture mapping is to facilitate analysis to determine the "...mechanisms that explain how particular design characteristics can lead to certain effects, processes or outcomes" (Bakker, 2018, p. 56). Boelens, De Wever, and McKenney state the usefulness of conjecture mapping to the research process: "A conjecture map reveals specific hypothesized relationships between DFs, the processes they engender during enactment, and the resulting outcomes" (Boelens, De Wever, and McKenney, 2020, p. 433). I noted the benefits in my discussion of the Preliminary Conjecture Map for this study in the section on pilot projects, also drawing on Bakker, who states the usefulness of conjecture mapping at the start as well as at the end of an intervention, for retrospective analysis (Bakker, 2018, p. 61). I therefore return to that point in chapter 5.

The DFs and EPs articulate how the DPs are implemented, as noted in section 3.2. The EPs point to the sources of evidence for the necessary tools, interactions and conditions to achieve the dual outcomes of DBR: supporting the learners to achieve the desired learning outcomes, and deriving actionable knowledge of how to design for learning, as conjectured in the High Level Conjecture for the intervention design (Boelens, De Wever, and McKenney, 2020; Kali and Hoadley, 2021). These Outcomes are conjectured at the starting point, and discussed below.

Figure 3-9 Initial Conjecture Map for the Design-Based Intervention, Iteration I starting point

High-Level Conjecture :

Students' knowledge and use of the Everyday Language <---> Academic Language continuum requires their appropriation of disciplinary discourse practices, including

- describing
- explaining
- representing

about phenomena and processes in school science topics.

Design principles

- are heuristic guidelines,
- define the intervention: instruction is designed through application of these principles
- provide a means-end relation

Design Features: DFs

(Embodiment of the design)

Physical Artifacts

TOOLS:

- paper notebooks
- tablets, chromebooks
- whiteboard, personal and classroom (WB)

MATERIALS :

- anchor texts
- worksheets
- worked examples: exemplars
- internet: images, information

Activity Structures : (main events)

- performing read-alouds of anchor texts
- presenting own artifacts
- attending to read-alouds and presentations
- writing:
  - new words in AL
  - study questions
  - words in representations
  - worksheets
  - idea generation tasks
- worked examples jointly constructed
- constructing representations
- note-taking in digital notebooks using interactive features
- editing: comparing, modifying
- peer- and self-assessment

Discursive Practices

- norms for reading and writing tasks
- discussion: authoritative <---> dialogic patterns established
- daily opportunities for experiencing AL in disciplinary ways
- making connections to
  - prior knowledge
  - newly/recently used terms in AL

Design conjectures:

articulate the Processes that the Design Features should engender

The process of

1. making learning visible through multimodal tools will help students to engage with cognitively challenging tasks in disciplinary practices
2. performing and attending to *read-alouds* will help students to
   a. engage with content
   b. experience science discourse
3. authoring artifacts will help students to explore uses of AL in disciplinary ways
4. problematizing AL through discourse and authoring artifacts will help students to explore the connection of words and concepts in disciplinary ways
5. being able to engage in and contribute to activity design at task level will help students to achieve a sense of participation and identity in the ccommunity of practice

Conceptual Framework :

1. Situative view of learning: learning in activity over time
2. Social practices: ways that people are initiated into the frames of reference of the community, through
   - language
   - participation in cultural practices
3. Situated action is mediated by artifacts:
   - material: tools and devices
   - semiotic: language, notation, representation
4. Science discourse: orchestrated by apprenticeship in practices through
   - a words to concepts continuum
   - representations: drawing to learn
   - conceptual link-making strategies
5. Literacy and science integrated through:
   - hands-on activities
   - vocabulary, reading and writing activities
6. Science ideas form the basis of talk, anchored by text
7. Different modes of teacher-student interaction: dialogic or authoritative

Designing instruction with :

1. a variety of modalities will stimulate and engage
2. science anchor texts will provide students with
   - read-aloud tasks
   - challenging content and ideas
   - models for disciplinary literacies
   - context for language activities
3. daily reading and writing, and connection making between these, will foster habits of mind for the discipline
4. integrated literacy and science will provide students with meaningful contexts for
   - language tasks
   - representation tasks
   - disciplinary practices
5. teacher orchestration of discourse for
   - purposeful shifts in interactions
   - dialogic < --> authoritative
   - connection-making

a. will help foster a sense of identity in science practices
b. will help promote agency in students,
c. will help students to enact AL in disciplinary ways

Note: highlights indicate a conjectured means-end relation

Enactment Processes:
(Mediating Processes)

- state the basic characteristics of the intervention
- result from Design Features (DFs)
- mediate learning outcomes

Participant Artifacts

1. shared writing: AL anchor texts
   a. annotated through *over-writing*
   b. adding notes and visuals
   c. *re-writing* jointly and individually
2. authoring own digital texts
3. sketches: note-taking
4. completing and editing worksheets
5. representations: concept maps, diagrams, symbols
6. shared writing: a word wall

Observable Interactions

7. performing read-alouds and presentations
8. attending to read-alouds and presentations
9. discussion around:
   a. text-based questions
   b. editing moves
   c. note-taking moves
   d. presenting notes
   e. giving peer feedback on notes and edits
   f. reflecting on own and other's edits

Participants Experiences

10. increasing initiative in task design
11. sense of expertise, authority
12. accumulation of visible authored artifacts
13. participation in community of practice, identity
14. engagement with and personal interest in the content

Process conjectures:

articulate why the Enactment Processes should yield certain Outcomes: *if* we engage in these processes, *then* we will achieve / yield autonomy in uses of AL

For Participant Artifacts: the process of

1. producing writing in disciplinary practices (not merely as procedural tasks) will help students achieve increased sense of mastery of AL
2. doing tasks through multimodal tools will help students
   a. to persist with challenging activities
   b. to feel greater control of the task process through exercising creative choices
3. constructing representations will help students to
   a. engage in disciplinary science practices
   b. engage in practices with more agency
   c. use the representations as conceptual resources and tools

For Observable Interactions: the process of

4. modelling of disciplinary practices of writing and discussion will help students to achieve uses of AL with more autonomy
5. modelling of language uses in disciplinary practices through engaging in *meta-talk* will help students achieve increasing agency in their uses of AL
6. using artifacts as tools for visible thinking will help students achieve the habits of mind for increased autonomy in AL
7. engaging in discourse will help students author artifacts, by enabling their thinking to become visible as an *object* of discussion

For Participant Experiences: the process of

8. engaging in discourse practices will help students feel a sense of confidence as they engage in writing to learn activities
9. building social practices that empower students to edit and author text and representations will help them achieve a sense of agency
10. enacting disciplinary practices will make students achieve a sense of identity in the community of practice
11. increasing agency in task design will help students achieve habits of study for lifelong learning
12. experiencing agency will help students achieve the means for deep conceptual learning

Outcomes:

conjectured

Learning outcomes

Participants will be able to

- appropriate
  - disciplinary discourse practices
  - academic vocabulary
- carry out practices in increasingly self-directed ways
- experience increased agency

Design outcomes

Designers of learning environments will be able to

- have principles and methods available for
  - designing activities
  - adapting material resources
- enact methods with the aim of fostering
  - students' learning progressions in academic language use,
  - disciplinary practices and
  - deep learning about phenomena and processes in school science topics.

3.5 Applying Conjecture Mapping to construct the design

In this section, I review the core elements of the intervention, namely the DFs and EPs, as they were designed and implemented for the starting point of the intervention in Iteration I. The headings and descriptions refer to figure 3-9. These core features are maintained throughout the intervention, in order to permit inductive and retrospective analysis on the design, and evaluate the conjectures on the functioning of the design and their connection with the conjectured outcomes (Cobb and Whitenack, 1996; diSessa and Cobb, 2004). Thus, rich rigor and trustworthiness are ensured, as I discuss in section 3.8. As noted for table 3-3, the yellow highlights indicate the conjectured means-end relations to be tested in the second level or intermediate analysis during iteration of the design. The design undergoes four iterations, as per the DBR process, during which adjustments are made to the descriptions of the EPs, as understanding of the design is deepened. These iterations span the school year, and are set out in table 3-5 below. The Initial Conjecture Map is therefore refined during the testing of the design through iteration; in chapter 5, I will present a Revised Conjecture Map and High-level Conjecture, a Learning Trajectory and refined DPs as actionable knowledge for a local instructional theory to guide design in other settings.

Design Features

Design Features (DFs) are also known as the embodiment of the design according to Sandoval (2014). However, I follow the notation developed by Boelens, De Wever, and McKenney, (2020), as delineated above. In keeping with the microethnographic approach adopted in this study (section 3.1), I now begin to refer to DFs and EPs as 'our processes' and 'our practices', and to consider myself as one of the participants co-designing the intervention, developing mutually agreed practices for jointly constructed epistemic goals (Barab, 2022).

Physical artifacts: Tools and materials

The selection of the materials is loosely based on the school curriculum theme units, and the iterations therefore are bounded by these units, and consist of activities enacted within the curriculum theme as context. However, the Iterations are named according to student ideas

emerging through the enactment process, as noted below and in chapter 4. For ease of reference, I use the term 'unit' when referring to the plan of activities in each iteration.

For each unit, I have selected texts related to the curriculum unit so as to provide models for knowledge representation and construction in the discipline and a basis for discussion activities in addition to the actual information content as such, as discussed in Chapter 2. These texts are centred on graded readers, which I will call our anchor texts, specially prepared for ELLs from the Oxford University Press series entitled *Oxford Read and Discover* (Oxford University Press, 2022). In addition, various websites are consulted during the lessons for relevant images and diagrams, prompted by our developing discussion in the unit.

In conjunction with each unit and its anchor text, tasks are carried out by the students in their paper notebook as well as in a digital notebook. These notebooks constitute part of our participant artifacts, as shown in the Conjecture Map. The modalities refer to our tools to support our ideas, namely paper, the digital tablet, and the small personal whiteboard or the large classroom whiteboard. I will use the abbreviation WB to refer to the large wall mounted whiteboard used in the lessons in this study. The first Design conjecture states that making learning visible through multimodal tools will help students to engage with cognitively challenging tasks in disciplinary practices. This and the following four design conjectures will be tested through intermediate abductive and recursive analysis of the data collected from the EPs in each iteration, as will be noted in chapter 4, in the Intermediate Analysis and Outcomes sections.

Activity/task structure

The activity structures include individual and jointly constructed activities around the anchor texts: performing read-alouds, presenting own artifacts, note-taking, writing and completing worksheets and constructing diagrams. Samples of these are shown in figures 3.4 to 3.8. The second Design conjecture therefore states that performing and attending to *read-alouds* will help students to engage with content experience science discourse. Concurrently, the third Design conjecture states that authoring artifacts will help students to explore uses of AL in disciplinary ways.

Discursive practices

The discursive practices aim to develop Academic Language (AL) use by gradually developing disciplinary discursive practices, which are modelled through the ways that the participants learn to structure their talk and production of texts, including visual representations, under my guidance. Therefore, the fourth Design conjecture states that problematizing AL through discourse and authoring artifacts will help students to explore the connection of words and concepts in disciplinary ways. Finally, the fifth Design conjecture states that being able to engage and contribute to activity design at task level will help students to achieve a sense of participation and identity in the community of practice.

Enactment Processes:

As stated by Boelens and colleagues (2020), Enactment Processes (EPs) constitute the basic characteristics of the intervention, result from the DFs, and mediate the learning outcomes. The processes that I will come to refer to as our *epistemic work* emerge during Iteration I. In my pilot project work outlined in section 3.3, I delineate *meta-talk* and *languaging*, e.g. figure 3-4 and 3-7, as discourse processes being developed in the small-group activities through interaction around our anchor text, especially involving over-writing and re-writing for AL. However, drawing on the view of learning as focusing on epistemic practices (e.g. Kelly and Licona, 2018) due to my interest in relating language and conceptual understanding, I began to identify the third main type of discourse process being developed through our interaction, namely *epistemic work*, shown in figure 3-6. I discuss these processes below.

Participant artifacts and Observable interactions

In our work together, the participants are learning to represent information using the anchor text as a model, but also starting from basic ideas of note-taking, going on to drawing diagrams and constructing models both digitally and on paper. In this study, during Iteration I, I develop a discussion of this as *epistemic work*. In our interaction around text, the students and I explicitly discuss how information is extracted from the page of the anchor text, and how it should be represented in tables or diagrams *to better work with the concept*. In other words, we are explicitly constructing our own initial references – or initial models – of concepts in the form of representations, according to the practices of the discipline, so as

to have visible objects to mediate our language work and support our conceptual work, or as Tytler et al state "… the drawing made visible specific aspects of student thinking" (Tytler, et al., 2020, p. 221).

Our own models also involve instances of AL use. The anchor text uses certain AL terms in presenting information; however, these terms are few in number and only the most commonly used, due to the carefully considered number of headwords in the band of the anchor text. Furthermore, the register of the anchor text is a narrative, which again is designed by the editors and authors to promote a more personal engagement to a potentially very challenging topic through a more empathetic stance. Our observable interactions will involve what I will term *meta-talk*, through which we develop our sense of concept work through consideration of academic terms in the context of our epistemic work. As I discussed in chapter 1, Gibbons (2003) refers to a mode continuum, along which student contributions are transformed toward increasingly specialist discourses through "situationally embedded" interactions with their teacher as mediation (p. 259). I begin our language work at the word level, with the contingent mention of a term such as *tropical climate* where the text states "hot weather". The pilot project work for this is shown in figures 3.4 and 3.5. The *meta-talk* refers to interaction in our group occurring during reading and writing, when we pause the read-aloud and annotation work to consider the terms being used in the anchor text (e.g. Heisey and Kucan, 2010). We discuss how these match with the developing concept, such as crops requiring specific conditions for growth – hence my use of the expression "sense of concept work". Our *meta-talk* is the observable reasoning by the students about the concept and how the concept should be worded, concurrently. We then write the agreed upon AL term above the word in the text, a process which I term *over-writing*, which also helps us construct our written artifacts of AL use in a situated process of *epistemic work*.

Our work at the word level continues to the sentence level, as we develop our sense of *book words*. I introduce *re-writing* late in Iteration I, where I show how to write "the humanities sentence", as shown in the pilot project work, figures 3-7 and 3-8. In the selected episodes, I will present this kind of teaching sequence through an ethnographic narrative, describing the alternance between *meta-talk* and *epistemic work*. The steps used to re-write the anchor

text which is in the active voice, to the passive voice, is shown in section 3.3, and is based on Thomson and Martinet (1980).

In the EPs, writing also takes place individually, where the student attempts to carry out this *meta-talk* internally, while individually writing out activities set out in the anchor text to accompany the text. Drawing on research on teacher and student noticing and intersubjectivity, as discussed in chapter 2, I am interested in pointing out evidence for such internal processes, by examining how we express our *noticings* and act on them. I point out our talk where we decide what to write or draw next, based on a *noticing* in the context of our interaction around our task.

Hence, the context that prompted this noticing, and the interaction and participant structures that gave form to this noticing, must be studied as part of our emerging discourse practices as noted in my Initial Conjecture Map. In these emerging practices for disciplinary literacies, the individual writing task is not simply an act by the student's to record some piece of information but in fact the mediating process of the meta-talk, during which the epistemic work is made visible as the participants discuss and point to their work. The various processes in my design are therefore prepared so as to make student reasoning evident, as well as show the locus of the activity. In my design narratives below, I will identify key events involving student noticing and teacher noticing, and point to evidence that this exchange of noticing emerged as a development in our discourse practices, mediated by the activity structures and tasks.

In my design, I set out to explore and make explicit the instructional features of teacher orchestration of AL and student use of AL in order to see how writing as a learning tool really needs to work for conceptual learning activities in our school science themes. In chapter 2, I refer to studies involving explicit rhetorical structures during science activities, or teachers supplying science terms as needed during investigations. I felt, through my experience with language and content instruction, that a focus on meta-talk,– prompted, as noted above, by our practice of noticing – during the languaging and epistemic work of the instructional sequences was a key to understanding the development of our practices. I aim to document what this looks like (e.g. Kim and Bloome, 2021), how this takes place and evolves over time ,

in order to reveal it as a necessary feature of students' process of acquiring AL in an increasingly agentic way.

Hence, concerning Participant artifacts, the Process conjectures suggested to achieve the desired outcomes in academic literacies involve producing writing through disciplinary practices (not merely as procedural tasks). It is conjectured that will help students achieve increased sense of mastery of AL. This is conjectured to be fostered by carrying out tasks through multimodal tools, which it is argued will help students to persist with challenging activities and to feel greater control of the task process through exercising creative choices. Concurrently, concerning representations as text. Process conjectures suggest that constructing representations will help students to engage in disciplinary science practices and engage in practices with more agency, through using the representations as conceptual resources and tools.

Certain episodes contain extended talk by students around their tasks, which I will term student-initiated interaction in the Intermediate Outcomes section (for each iteration) and in the Table of Findings for each iteration (collected in Appendix B). Although our work in this group across the iterations consistently involved reflection on our tasks in the form of our meta-talk, and retrospection in the form of connections to previous instances of knowledge representation and language use, these interactions were entirely concerned with students explaining at length the nature of a task in terms of their epistemic work.

Participant experiences

Students in these specific interactions can be seen initiating the sequence of talk (e.g. Engle and Conant, 2002), either through opportunities that I have orchestrated, or through opportunities that they have themselves opened up. They refer to instances of this in their own work in the form of their artifacts and recollections, as well as new artifacts made by them in the moment of speaking. I will argue through analysis of the Rich Points according to my Process Conjectures, that this kind of discourse emerges from the developing sense of community and authority experienced by the participants as a result of the DFs and EPs.

Hence, for Participants experiences, the Process conjectures state that engaging in discourse practices will help students feel a sense of confidence as they engage in writing to learn

activities. Secondly, building social practices that empower students to edit and author text and representations will help them achieve a sense of agency. Thirdly, enacting disciplinary practices will make students achieve a sense of identity in the community of practice, and finally, increasing agency in task design will help students achieve habits of study for lifelong learning and deep conceptual learning.

Outcomes: conjectures for learning outcomes and design outcomes

My design therefore involves more explicit attention to language work during the epistemic work, as argued in chapter 1. In the selected episodes presented in chapter 4, it will be seen that there is an alternation between our writing on the ideas at hand, or epistemic work, and our meta-talk about the AL use that should be employed, as seen by the participants. In encouraging this kind of simultaneous effort, I am in part basing my design on the "writing to learn" and representation construction framework research work as discussed in chapter 2, (e.g. Hand and Prain, 2002), which refers to the epistemological nature of students' writing for knowledge construction and reasoning in science-as-practice (Lehrer and Schauble, 2015). The conjectures outlined in this section will be tested in the iterations of the design, as delineated out in chapter 4, so as to argue for the effectiveness of the design in achieving the desired outcomes as suggested by the HLC initially suggested for this intervention.

Therefore, the initial design for the intervention as shown in the Initial Conjecture Map, figure 3-9, indicates the Conjectured Outcomes, for achieving the desired learning outcomes and for design knowledge about how to support conditions fostering those learning outcomes. Hence, for Learning outcomes, the initial conjecture map states that Participants will be able to appropriate disciplinary discourse practices, including academic vocabulary, and carry out practices in increasingly self-directed ways and thereby experience increased agency. For Design outcomes, it is conjectured that Designers of learning environments will be able to have principles and methods available for designing activities, adapting material resources and enacting methods with the aim of fostering students' learning progressions in academic language use, resulting in their achieving disciplinary practices and deep learning about phenomena and processes in school science topics.

I now turn to the data collection procedures, where I discuss data collected on the EPs, in order to refute or confirm the conjectures set out in this section.

3.6 Data collection procedures

Setting

The setting of this study is the pull-out group for ELLs in year 5 (students aged 9-10 years), of which I am the specialist teacher, as discussed in section 1.1. Lessons documented in this intervention take place in my classroom, which is configured for small-group instruction to serve the specific needs of these students. I describe in more detail the physical setting and other material and social aspects of this classroom ecology in the Iterations sections in chapter 4. However, as shown in table 3-4, during Iteration IV, two months of data collection took place in an online setting using an online meeting space, Google Meet.

Participants: selection, individual characteristics and group dynamics

The students participating in this intervention are a group of 5 boys in year 5, aged 9 - 10, who are designated as ELLs as through school admissions procedures as described in section 1.1. Hence, they are assigned out of pure circumstance to my teaching group, as specialist teacher for the year level at this school. Two of these joined at different times after the start of the intervention, due to being reassigned from a different course for reasons unrelated to this intervention. The starting points for these boys are noted in the data narrative.

The boys are starting their second year at the school, i.e. year 5; however, the school has determined that they are as yet unable to attend mainstream lessons full time, through criteria beyond the scope of this study. The boys have been in regular school attendance in their respective home countries, with satisfactory academic progression according to their school reports. Therefore, this study does not explicitly consider adaptations or accommodations for diverse learners with specific learning needs. The focus of the study, as noted in the DPs, is constructing opportunities for participation in social practices of semiotic work, including linking with prior knowledge. Hence, the DFs aim to provide opportunities for these students to bring to bear their various semiotic tools and prior epistemic work through explicit meta-talk, as validation of their meaning-making and epistemic agency.

With the focus on language and semiotic tools, I present the language profiles of the students, in alphabetical order using their pseudonyms for the study:

Pseudonym	home language and previous language of schooling
Dai	Mandarin
Kassim	Arabic and French
Quincy	Dutch
Ruslan	Russian
Ryu	Japanese

I note the diversity of language and semiotic systems brought to this group by the participants, with only Quincy being entirely schooled in a Roman alphabet based writing system. As a participant in this group, I share in the knowledge of spoken and written French, Dutch and Russian, in addition to English, with only theoretical knowledge about certain features of Mandarin and Japanese; my own language of schooling was Swedish. This diversity is representative of the student and adult populations in this school as a whole, with over 100 languages being spoken.

This group is therefore engaging in a multilingual classroom setting: although the goal of instruction in the pull-out group is fostering a progression in the English language proficiency of the participants, my DPs involve bringing to bear the prior knowledge of these students viewed as plurilingual repertoires (Coyle, 2020). During the intervention, I work to promote the representation construction skills of the students through meta-talk around semiotic tools, which I define as part of their language awareness. The students thus have opportunities to draw on each other's and their own work, and develop a variety of tools through a focus of awareness on their use for epistemic work. For example, Dai uses his prior reading of webtoons to develop and apply his own semiotic signs, seen in figure 10 Iteration IV, which constitutes a Rich Point; Quincy transposes AL meta-talk from English to Dutch, in figure 22, Iteration I, another Rich Point.

In enacting the DPs to construct a learning environment with a social semiotic perspective (e.g. Tytler, et al., 2020), I draw a similarity to a definition of a translanguaging classroom environment, where "a diverse array of linguistic, multimodal, and technological resources" are used "as part of the meaning-making repertoire" for knowledge construction (Tai, Li and Loh, 2025, p. 2). Hence, I orchestrate interaction which includes forms of translanguaging as drawing on a repertoire of semiotic and cognitive resources, as an encouragement to

students to develop habits of mind as epistemic agents, through the fluid practices of engaging in diverse meaning making systems, as suggested by Li (2018)

Data collection: sources

This study adopts a microethnographic approach to studying learning, which is defined as situated in activity, where meanings arise out of social interactions and are therefore inseparable from the context and the participants (Cohen, Manion and Morrison, 2017). This approach entails a practice-centred view of interaction (Green, et al., 2007). Hence, as shown in earlier sections, evidence of student learning is looked for in interaction, defined in EPs, with a focus on discourse moves as observable interactions anchored by participant artifacts being produced and elaborated through jointly established activity.

Since the focus of the research is to determine conditions fostering student learning in academic literacies, a design is implemented which is conjectured to present opportunities fostering a progression in appropriating academic literacies. Determining the effectiveness of the design requires implementing it over time; furthermore, DFs are held constant so as to make salient the changes in participation in the EPs. Hence, observational data are collected, showing the participants interacting on their own terms. These data are complemented by "the constructs of the participants" and giving importance to the accounts of the participants, in order to elicit the "emic native cultural knowledge" as suggested by Cohen, Manion and Morrison (2017). These authors state that observation in ethnographic research is prolonged and repetitive, in order to establish trustworthiness through rich rigor in the collected observational data. Hence, DBR methods are suited to establish these criteria of reliability through longitudinal application of the design for refinement across iterations.

Therefore, the longitudinal character of the intervention is established through the iterations, which are not simply a repetition of the DFs with "bugs" worked out as suggested by Collins, Joseph and Bielaczyc (2004) as noted above. The iterations represent an essential means to document changes in participant behaviour, through changes in content in new units: the participants have opportunities to present their interpretations of the discourse practices in increasingly articulate ways, by making comparisons with their own previous epistemic work, which took place regarding other concepts. Green and Chian (2018) refer to the construction of key events, which I term Rich Points in this study, as discussed in section 3.1 (Green, Skukauskaitė and Baker, 2012). Green and Chian state that these Rich Points are

used in ethnographic studies in 'ongoing triangulation' to trace the account being constructed:

> By tracing actors (individually and collectively) across times, events, and disciplinary areas within an educational context, the researcher makes transparent the ongoing process of triangulating theories, methods, data, investigator observations, and analysis processes and the iterative, recursive, and abductive nature of field-based research. (Green and Chian, 2018, p. 1719)

Hence, through the systematic and repetitive collection of observational data in terms of video and photo records, data may be constructed to test conjectures about the EPs and therefore the effectiveness of the DFs (Cobb and Whitenack, 1996, p 225; Boelens, de Wever, McKenney, 2020, p. 433). I will discuss the processes of 'ongoing triangulation' and transparency, in terms of trustworthiness and rich rigor, in section 3.8. As described in earlier sections, DBR involves ongoing viewing and labelling of material being collected, which constitutes a first level of analysis. Hence, I will also discuss considerations of camera work, which are relevant to transparency in constructing an account of the intervention. In the next section, I delineate the data organization and levels of analysis, returning to the discussion of Rich Points as anchors for constructing an ethnographic narrative: these Rich Points constitute signposts in the learning trajectory of the participants in the intervention.

3.7 Data organization: initial analysis

Data sources: types and labelling

As shown in table 3-4, video and photo material was collected daily, over the course of a school year (table 3-5), through the use of an iPad provided to me by the school, which operated exclusively on the secure local network. This material consisted of uninterrupted recordings of 2 to 3 daily lessons of 45 minutes each, as "a continuous and relatively comprehensive record of social interaction", as advised by Erickson (Erickson, 2006, p. 177). I uploaded the material for storage in the school cloud storage directly at the end of each day. The device was set to securely lock when not in use, with a password known only to me. It could be located by school technical staff if misplaced, through a tracking system. The practical aspects of the adoption and daily use of the iPad are described in the context of the iteration narratives, chapter 4; however, I will discuss uses of the iPad emerging as a tool in this ethnographic study, in section 3.8, camera work.

Participant artifacts such as notebook pages, worksheets or other material produced on paper were scanned using school devices, and similarly labelled and stored. I collected video screenshot material using the iPad, and similarly viewed, labelled and stored. All material was therefore subjected to initial levels of viewing and analysis, as noted by Hammersley and Atkinson (2019). My daily notes were produced promptly to ensure retention of insights in the moment, in conjunction with reviewing video material while labelling and uploading, during which I made the initial set of screenshots as part of the initial "process of discovery" (Hammersley and Atkinson, 2019, p. 164). These notes were in turn subject to review during abductive and recursive analysis, as I will detail in the next section.

Due to the pre-determined nature of the school year, the iterations were determined and bounded by the curriculum year and the units of the curriculum. Hence, this constitutes a level of data analysis, as events are clearly bounded and identified. Furthermore, this analysis is meaningful to the participants, as clear starting points and end points are discussed in the small group work, through instructional events explicitly marking the start and the end of each unit. The timeline for these units and data collection is shown next.

Type of data source	Details: amount and labelling
video recordings, screenshots and photos	• daily recordings of 2-3 lessons of 45 minutes each, iPad • screenshots from video recordings • stored daily in secure cloud storage • labelled by date and main lesson activity description
transcripts	• video recordings transcribed automatically using software • unedited transcripts stored in the cloud storage • selected material: copies made for editing and next levels of analysis
student-generated artifacts	• photos and scanned copies of student paper notebooks, with their o annotated text and representations o student-generated text and representations • digital notebooks, with their o annotated text and representations O student-generated text and representations
teacher log	• notes while storing video recordings: noting literacy events with, especially o key sequences of meta-talk o student initiated interactions o student connections with previous work, and o unexpected events: identifying Rich Points • reflections (notes to self) on the adjustments to the current unit

Table 3-4 Classroom material and notes collected as data sources

Iterations: overview and timeline

Table 3-5 presents the overview and timeline of the iterations for the designed intervention reported in this study, indicating data material collected for each iteration. The analytical process of constructing the episodes is discussed in the next section. The table shows the iterations, labelled by name, dates, settings and the number of episodes selected by me in subsequent levels of recursive and abductive analytic process, which I will describe below. Names for the units emerge during participant interactions, in phrases used by the students in the lessons (Hammersley and Atkinson, 2019, p. 173), as I will also delineate below.

Iteration and unit name	dates	setting	number of selected episodes
Iteration I - *Farming*	01.09.2019 – 31.10.2019	in-person classroom instruction	6 episodes
Iteration II - *Healthy*	01.11.2019 – 12.12.2019	in-person classroom instruction	5 episodes
Iteration III – *Kelp Forest*	06.01.2020 – 25.02.2020	in-person classroom instruction	6 episodes
Iteration IV – *Energy all around us*	04.03.2020 – 15.03.2020	in-person classroom instruction	4 episodes
	16.03.2020 – 15.05.2020	online video meeting instruction	3 episodes
	25.05.2020	in-person classroom instruction	1 episode

Table 3-5 Data collection starting and end points for the four iterations of the intervention

3.8 Methods of analysis: unit of analysis, coding

In this section, I discuss methods of analysis of video, photo and transcripts, as well as construction of these data through a presentation of camera work and transcription methods for literacy research aims. I consider camera work and transcription methods and treatment of these as socio-semiotic artifacts in developing insights into the construction of social reality (Bezemer and Mavers, 2011), and therefore evidence for the arguments being constructed in the Intermediate Analysis and Outcomes for each iteration.

Green and Bloome (2013) discuss the aims of literacy researchers:

> ... researchers... seek to examine how language and literacy processes are socially and linguistically constructed and function within a community, who has access to these practices, how use of particular language and literacy practices are consequential for members ... (Green and Bloome, 2013, p. 1)

Hence, material from classroom interaction and practices is collected, to examine how the group of participants made meaning through language use and emerging literacies practices. The view of literacies adopted in this study includes words, symbols and representations (Bezemer and Kress, 2020; Tytler, et al., 2020). These practices are defined as taking place through a knowledge construction perspective (Paavola and Hakkarainen, 2005), which considers participants, discursive practices and knowledge objects in a system of interaction over time. Knowledge objects are taken to include material artifacts as well as ideas, which for this study includes ideas of the epistemic practices enacted to construct knowledge objects. These practices take place in cycles of activity, situated in contexts defined by the participants, which are indissociable from the practices taking place in them, and therefore constitute part of the analysis. The interaction consists of three main discourse moves engaged in by the participants, which constitute the unit of analysis.

Iterative, recursive, and abductive processes in microethnographic research

The focus of data collection and data analysis has therefore been established as language use, in this study defined as discourse moves around knowledge objects, which are modified over time as part of the emerging disciplinary practices of the group. These discursive practices have been determined as *languaging*, *meta-talk* and *epistemic work*, through the

iterative, recursive, and abductive processes of microethnographic research methods conducted throughout the intervention and during pilot projects (Green, et al., 2020).

Iterative and recursive methods were employed to review the collected classroom material daily, in the process of preparing the material for storage. The digital material was labelled automatically by date due to the iPad settings, and I adopted an additional system identifying the student and the activity. The scanned material also automatically included the date, facilitating storage grouped with the lesson in which the scanned artifacts were produced by the students. During this initial viewing of the daily material, I also took certain screenshots while viewing the video recordings, while taking written notes on the moment by moment events in the recording. These notes are used to form the basis of the ethnographic narratives of each iteration, in chapter 4, through which the insider or emic perspective of the participants is constructed and presented (Bell, Hoadley and Linn, 2004). The notes therefore constitute a first level of analysis, together with the initial labeling of the material by date and activity: the notes indicate the occurrences of *meta-talk*, *languaging* and *epistemic work*, by noting the activity in which these discourse moves occurred.

Rich Points and construction of episodes

Through abduction, Rich Points and patterns were discovered in the classroom material, which had been labelled by activity, and for which notes had been written regarding discourse moves. Green and associates (2020) explicate the analytic processes to be carried out, stating that the iterative, recursive and abductive process

> ...requires the ethnographer to *step back* and begin to trace the pathways learning, and roots of, the processes being experienced by the ethnographer and participants, to develop a grounded understanding from the *point of view of the participants* – that is, the *perspectives*, not the perceptions of insiders (participants in the event). (original emphasis) (pp. 167-168)

Hence, in viewing and reviewing the video records, and concurrently consulting the student artifacts, I was able to step back and realize that a key event, or Rich Point, had taken place. I referred to Powell and associates (2003) in section 3.1: they employ the term 'critical event' and state that this refers to an interactional event demonstrating a conceptual leap from earlier understanding. I will employ the term 'Rich Point' in this study as incorporating the notions of Powell and associates as well as Green and associates.

These Rich Points took place in the moment by moment sequence of interaction, which therefore required careful consideration on reviewing the video record to see the point emerging in the discourse context, as noted by Sherin and Chinn (2022). In the activity as teacher, I was often concerned with orchestrating the task together with the participation of all the members of the group; hence it was not always possible to discern the Rich Point in the moment itself. However, as we became more accustomed to our practices, the participants and I began to discern these critical events in the moment, and these became objects of discussion in themselves. This process is in keeping with the knowledge construction perspective of knowledge artifacts as comprising ideas, as they are objects of discussion and improvement by the members of the group.

In the second level of recursive and abductive analysis, therefore, I identified these points as Rich Points, and identified the moment in the interaction on the video recording by taking a screenshot, with the additional label of Rich Point, together with the discourse move and the material artifact involved in the context. Hence, in chapter 4, the design narrative is constructed around photos and screenshots identified by discourse move, and in the case of the Rich Point, this is noted in bold font.

Emerging out of the Rich Point is the identification of the event in which it took place, i.e. the sequence of interactions indicating the situative meaning in the perspective of the participants, discernible through discourse moves and non-verbal communication (Green, et al., 2007). Hence, I have constructed episodes as data emerging out of the video and artifact material during the Rich Point and its surrounding interaction. The iterations are therefore constructed through this recursive and abductive process; the iterations and their respective episodes are set out in table 3-5 above.

Analytic induction processes in microethnographic research

To trace the development of the literacies practices of the participants, the Rich Points are viewed through the next level of analysis, namely inductively (Erickson, 2012), to determine patterns in the activity over time and thus make grounded inferences concerning the conjectured effectiveness of the design. Skinner (2022) explicates the usefulness of Rich Points, stating that these are spaces for locating cultural knowledge in the interactions. The

author delineates the application of this analytic method in her study. Thereby, Skinner illustrates how analysis anchored in following the pattern of Rich Points enables the researcher to determine changes in patterns in interaction over time, and the consequences for the participants and the activities, individually and as a group. Hence, in the discussion of Intermadiate Analysis and Outcomes for each iteration presented in chapter 4, I construct the analysis as a thread of Rich Points, concurrently referring to the Design and Process conjectures. This inductive analysis (Erickson, 2012) is then taken up in chapter 5, to discuss the learning trajectory as delineated by the sequence of Rich Points, and the means which created the opportunities for language use and literacies development for the participants.

Camera work

I selected the iPad as recording and photographic device for this study, based on practical reasons as well as extensive empirical work prior to designing for this intervention. My prior research cited in section 1.1 involved using the iPad, which provided me with familiarity and ease of operation and practical uses. Thus, I was familiar with procedures of viewing, storing and taking screenshots. In selecting moments from the recordings as screenshots, I retained the timestamp of the selected moment, so as to enable referencing to the corresponding moment in the transcript. Transcripts therefore contain links to screenshots used as figures in the design narrative as multimodal transcription, as explained below. In addition, the device is easily used for hand-held recording, allowing continued interaction while operating it. Furthermore, the iPad is well-known and popular as a personal device among the age group of the participants, and thus not unusual and awkward, which I judged by the many positive comments I received during the years of using such devices. In this study, the participants are aware that the iPad is recording or that I am taking photos with it, as it is part of our practices, as I discuss below.

My use of the iPad as recording device is theoretically oriented as both a lens and a mirror, as argued by Clarke and Chan (2019). The authors discuss the camera as a mirror of events, used in research as a reflection of practice. In episodes chosen for this study, I place the iPad on a stand, and orient it in such a way as to encompass the participants, the table at which we sit, and the classroom whiteboard (WB). It therefore records our practices in their

physical context, as suggested by Powell, Francisco and Maher (2003). When the WB is being used more intensively, the stand is placed so that the WB is faced more fully.

The authors discuss video recording as a lens, defining this as a form of classroom research enabling the researcher to focus on specific events, as an act constructing a representation of the classroom. In the course of certain episodes, I walk around with the iPad and point it at a student's work while interacting with him regarding the work, e.g. farming figure 22 and 24. It is thus an intentional use of the focusing ability of the camera, to aim it at selected and prioritized events or objects in a purposeful method for constructing intersubjectivity in context. I develop and discuss the intentional use of the iPad as a form of sign-making and as a component of our practices, during the iterations narratives in chapter 4.

Transcription methods

During reviewing and storage, I used NVivo transcription software to automatically produce transcripts for all video recordings. I stored these as word processing documents in the online storage. On determining the Rich Points, and the recordings during which these occurred, I made copies of the unedited transcripts and began a process of constructing transcripts as artifacts (Green, Skukauskaitė and Baker, 2012; Hammersley and Atkinson, 2019).

The software produced a transcription with speaker turns, which are timestamped on the onset of the turn. As a first level of transcription, I edited it to clarify words that the software did not identify correctly, in part due to the various accents of the participants. Then I replaced all instances of names of students with the pseudonyms adopted for the study, through the editing features of the word processing software. I followed this with the transcription choices suggested by the guidelines for video research edited by Derry in the Data Research and Development Center at the University of Chicago (2007).

Barron and Engle, writing in these guidelines, suggest that working with transcription involves creating intermediate representations, allowing the researcher to identify meaningful segments and to begin to see patterns. The authors state that these selections are used to produce transcripts that re-represent the events recorded in the video, which are then intensively revised in later stages of research (Data Research and Development

Center, 2007, p. 27). The authors state that this process therefore may be viewed as a progressive refinement of hypotheses, where questions are refined through viewing and reviewing the collected material.

In my uses of the suggested guidelines, I have therefore edited the transcripts with the following conventions: pauses are indicated, words in other languages are identified and indicated in italics, and errors in grammar and pronunciation are not corrected. These and other conventions are noted in the introduction to Appendix A, containing all transcripts.

Transcripts as artifacts: multimodal transcription with active links

Researchers also discuss transcription as generating artifacts for additional use providing insights and illustrations of learning, as noted by Ferguson, et al. (2019). Ferguson and colleagues argue that fine-grained ethnographic examination of classroom practices is necessary for providing insights concerning student-teacher interactions and teacher orchestration of instruction: transcription processes provide a heuristic, through purposefully selected and constructed examples of interventions. The authors state that indications of verbal as well as non-verbal communication, through gestures, are essential information in the analytic process. Hence, I have included information on gaze, gestures and actions in my transcription process, as adding meaning that I perceived as a participant in the situation.

I have also implemented multimodal transcription, as suggested by Bezemer and Mavers (2011). These authors discuss a perspective of transcription as semiotic work. They state that through this semiotic work, the transcriber has the agency to make representational choices, arising out of the social context of the event. These choices include framing, meaning the selection conveys a communicative meaning from the original interaction as well as the aim of making the selection. Highlighting is undertaken to draw attention to elements of focal interaction. The authors argue that transcription is translation to another mode, in a process they term re-making video: "It is through re-making video as a multimodal transcript that researchers come to see differently" (p. 196).

Hence, I have added highlights to excerpts of transcripts used in the narration of the episodes selected for each iteration. Furthermore, I have added links to screenshots which

are used as figures in the narrative. These links are reciprocal: the captions for screenshots include links to the relevant turn in the transcripts. These links are shown through different colours in the transcripts.

Through these processes, I delved more deeply into the situated meanings being developed by the participants, and attempted to convey these meanings through multimodal transcription, as a means of sharing the emic perspective with the readership (Tracy, 2013).

Design Narrative: ethnographic narrative with video, photo and transcript excerpts

I have selected these episodes and other resources through a process of viewing and re-viewing them while also consulting my field notes and DPs. This study seeks to examine the languaging and interactions of the participants to find what is meaningful to these participants as they develop their disciplinary practices over time, as outlined in Chapter 2, in order to test my design conjectures for the intervention design. Using a recursive and abductive process (Green, et al., 2020), I chart the patterns in the interaction with respect to the discourse moves around improvable objects, which constitute my designed intervention. The episodes are presented in chapter 4, Parts A and B, as an ethnographic design narrative (Bell, Hoadley and Linn, 2004), to provide the moment-by-moment decision-making and responses by the participants and thereby the insider perspective on the situated practices.

Summary of findings: Specific Design Principles

Episodes in the iterations are therefore selected through identification of Rich Points, and analysed to determine the discourse moves and knowledge objects involved in the construction of the Rich Point. These moves are summarized with each episode, together with the specific instances of literacies practices and discourse processes taking place to support the participation of the learners. These specific moves and practices will be termed Specific DPs, as suggested by Linn, Bell and Davis (2004). The authors suggest that findings from DBR studies may be presented as design narratives through which specific DPs are synthesized. These specific principles serve as detailed and evidence-based design information drawn from empirical results, available for other researchers investigating similar aims and wishing to design supportive environments. The authors state how these are formulated: “The specific principles emerge from iterative refinement of inquiry projects

in complex classroom contexts. These specific principles capture the lessons learned from the testing and refinement that has occurred" (p. 315).

Hence, in the design narrative for each iteration, episodes are presented selected through identification of Rich Points; discourse moves – languaging, meta-talk and epistemic work – are noted, together with contextual details. These are presented as summaries introducing each episode, to orient the design narrative. The complete findings are located in Appendix B. These findings, together with the Intermediate Analysis and Outcomes for each iteration, are used in chapter 5 during retrospective analysis to discuss the delineation of a learning trajectory and design knowledge emerging from this study.

Credibility and trustworthiness of the study

As this study adopts a constructivist, qualitative paradigm for researching learning, I apply Tracy's expansive "big tent" approach to criteria for qualitative quality, including a worthy topic, rich rigor, sincerity, credibility, resonance, significant contribution, ethics, and meaningful coherence (Tracy, 2013). These criteria are also cited in Cohen, Manion and Morrison (2017, p. 290). These authors elaborate on ethnographic research, stating that it involves "the production of descriptive cultural knowledge of a group, the provision of insider accounts, and the development of theory" (p. 293). I now review these points, referring to preceding sections of this chapter, with attention to quality in DBR processes.

As discussed throughout this chapter, DBR is conducted to show how theory does "real work", so as to impact in educational settings to address questions and suggest solutions for learning in a local context (Barab, 2022). This takes place through determining a real educational problem, situated in an educational context, with the aim of improving practice through implementing a design and testing it through an intervention, as I stated in sections 1.1 and 3.4. Through research, I developed a conceptual framework which I formulated as actionable DPs, to indicate the mechanisms by which I planned to enact learning activities. I designed my learning intervention by drawing on the knowledge construction metaphor (Paavola and Hakkarainen, 2004), so as to conceptualize learning as discourse moves around knowledge artifacts defined as improvable objects, which are developed by participants over time, who thus come to define a local culture of semiotic practices.

Rich Points, presented in the context of video episodes, narrated through thick description, provide detail of participant reflections and emic perspective on these practices, e.g. figure 38 and 41. This process has the aim of identifying this insider perspective, conceptualized as "cultural knowledge of what members need to know, understand, predict and produce" (Heath, 1982, cited in Green, Skukauskaitė and Baker, 2012, p. 309). I show that, together with material artifacts and my research notes, these Rich Points may be used to construct a reliable account of classroom events, to signpost the learning trajectory of the participants, and to discover the developing meanings that the participants attributed to their actions.

Through the heuristic of concept mapping, I show how the DPs are conjectured to lead to the suggested outcomes: the detailed descriptors serve to delineate the particular set of conditions in my chosen setting for transparency. By collecting data from many perspectives and modalities, and presenting these through a thick description, including the insider views of the participants, as noted, I ensure rich rigor and credibility in detailing the effects of my designed intervention. Iterating across time, and different units with different topics, while maintaining the structure and sequence of EPs, permits a detailed and reliable comparison across time, as shown in my inductive and retrospective levels of analysis, further enhancing my claims regarding the conjectured effects of my design for learning outcomes (Cobb and Whitenack, 1996; diSessa and Cobb, 2004).

The application of conjecture mapping is therefore also an assessment tool for analysis and reporting (Sandoval, 2014; Bakker, 1998). I show this in chapter 4, where, in my Intermediate Analysis and Outcomes for each iteration, I examine the conjectures in turn, with links to transcripts of student talk, and screenshots of their actions, gestures and expressions. In each iteration, I note the confirmation of the conjectures, and also new knowledge, in a column on results regarding the EPs, e.g. in figure 4-3. In the subsequent iterations, I note revisions to the DPs and the EPs as a result of the changes in participation of the students.

Gravemeijer and Cobb (2013) refer to ecological validity, in discussing the aims of design research, achieved through the description of the results which "…should provide a basis for adaptation to other situations." (p. 103). In keeping with this, I show through my Initial and Revised Conjecture Maps, figures 3-9 and 5-5, with the careful description and levels of

analysis, how DBR methods may be applied to make such design transparent and guide other practitioners, to produce "actionable knowledge" (Kali and Hoadley, 2021, p. 487) and do "real design work" (diSessa and Cobb, 2004). I delineated the preparation of design principles that are *actionable*; that is, as noted in section 2.3 and shown in table 3-2, they contain advice on the enactment or mediating processes of the design features; thus, the means-end relation is clearly established (Bakker, 2019).

As stated by Sandoval (2014), "educational design research is the dual commitment to improving educational practices and furthering our understanding of learning processes." (p. 20). I show through this study that by connecting theory and research, clearly establishing means end relations, documenting the means to achieve the desired result, testing the conjectures about the design features and process as relating to the suggested outcomes to produce design knowledge about the means to achieve that outcome.

Role of the researcher/teacher

As I am both Teacher and Researcher, I have taken steps to ensure transparency in context through the thick description of the intervention and detailed analysis of the design (Green et al. 2020; Sherin & Chinn, 2022). The Design Narrative (Bell, Hoadley and Linn, 2004) sections of the intervention present my own emic, insider view as participant in this microethnographic study (Tracy, 2013). I have included data about my interaction in the form of transcript excerpts and screenshots, as well as describing my in-the-moment decisions and sentiments, so as to convey the emic perspective of participating in our local culture (Bloome and Beauchemin, 2018). On the other hand, in the Intermediate Analysis sections and the retrospective analysis of chapter 5, I report as researcher, and apply criteria for trustworthiness and credibility through a transparent and detailed conceptual framework and actionable design principles (Bakker, 2018).

3.9 Confidentiality and ethical considerations

A complete Ethics Review was carried out and approved in October 2019, according to University of Edinburgh /BERA principles (Appendix C). The participating students are part of my regular teaching group, as stated in section 3.6. During this intervention, they undertook tasks which are all part of the course under normal circumstances, with or without electronic devices. The same students also carried out other tasks with me which were not a part of the present study but still part of their school curriculum.

The parents of the participating students met with me in one-to-one interviews at the start of the study; all provided their consent in written form, as per the Ethics Review requirements. The participant names used in this study are all pseudonyms which I assigned (section 3.6); the corresponding real names are known only to me. All the material collected during the intervention and used as data in this study has been modified by me as follows, to ensure student anonymity:

- transcripts of video recordings are edited with pseudonyms systematically applied using word processor editing tools,
- screenshots where the students' names appear in written form have been edited using photo editing tools,
- throughout this study, references to participating students are made using these pseudonyms,
- transcripts with references to any other individuals such as parents or other teachers have also been edited to ensure anonymity.

The complete set of materials collected during the intervention, including those recordings and digitized material artifacts not used in the construction of the data set for this study, are stored in a secure cloud storage managed by the school (the location of the intervention), accessible only to me and the thesis supervisors. This cloud storage adheres to Swiss compliance with General Data Protection Regulation (GDPR) (Horizon 2023 Framework Programme of the European Union, 2024).

3.10 Glossary of key terms

abductive, iterative and recursive analysis – requires the ethnographer to *step back* and begin to trace the pathways of learning, and roots of the processes being experienced by the ethnographer and participants, to develop a grounded understanding from the *point of view of the participants* (Green et al., 2020; Kennedy & Thornberg, 2018; Reichertz, 2014)

analytic induction; recursive, inductive analysis – The recursive process of reviewing evidence used in this study in discovering phenomena "post hoc" through analytic induction (Erickson, 2012, p. 1460). The recursive and inductive analysis enables the researcher to determine patterns in the Enactment Processes (EPs) by observing interaction across similar knowledge construction activities, over time, and noting changes in participation (Cobb & Whitenack, 1996; Green et al., 2020).

Conjecture Map (CM) – heuristic to enable design of a complex intervention (Sandoval, 2014) and to conjecture a means-end relation between design features, enactment processes and desired outcomes (Bakker, 2018; 2019)

Design Narrative – ethnographic presentation of data (Bell, Hoadley and Linn, 2004)

Design Principle (DP) – derived from research and empirical work to construct a designed intervention; refined through cycles of testing the design (Bakker, 2018; 2019; Barab, 2022)

epistemic work (EW)– discourse move developed in this study. In interaction around text, participants explicitly discuss how information is extracted from the page of the anchor text, and/or how it should be represented in tables or diagrams *to better work with the concept*, engaging in collective and individual work on the knowledge object as an artifact being improved over time, e.g. farming figure 14, figure 3-6

Ethnographic narrative – (Emerson, Fretz, and Shaw, 2011; Derry, et al., 2010).

High-level Conjecture (HLC) – a conjecture is formulated so as to indicate the proposed solution of the intervention: it states the learning goal and the suggested means for supporting it (Sandoval, 2014).

knowledge construction metaphor – conceptualizes learning as discourse moves around knowledge artifacts defined as improvable objects, which are developed by participants in joint collaboration over time, through both individual and collective action (Paavola and Hakkarainen, 2004).

languaging (L)– discourse move developed in this study, involving participants' individual work applying AL through words and other semiotic signs in writing and representation construction, section 3.3, section 3.5 and figure 3-7

metaphors for learning – research on learning employs metaphors as mechanisms helping us to think about different types of learning, or offering answers to the question of what learning is (Sfard, 2014).

meta-talk (MT) – discourse move developed in this study, through which participants develop their sense of disciplinary conceptual work through consideration of academic terms in the context of epistemic work; refers to interaction in the group occurring during reading and writing, when participants pause the read-aloud and do annotation work, to improve the terms being used in the anchor text. In the analysis, referred to as *reasoning aloud* around the *improvable objects,* as seen in e.g. figure 4-4, figure 3-6 and discussed section 3.3, section 3.5 and intermediate outcomes for each iteration, e.g., section 4.2.1.

over-writing – underlining text and writing AL terms over it, done through discussion i.e. *meta-talk*, in a process termed *over-writing* in the study; gradually internalized processes for *epistemic work*

re-writing – elaborated sentences derived from the anchor text and the *over-writing* process, resulting in student *re-writing* for AL, also termed *authoring* in the study

retrospective analysis – conducted at the end of a DBR intervention (Bakker, 2109)

Rich Point - the anomaly or surprising phenomenon as a 'Rich Point', (Green, Skukauskaitė and Baker, 2012), a potential for new discoveries and understandings; used to sequence the Design Narrative (Bell, Hoadley and Linn, 2004) constitute the salient and surprising events of each iteration

thick description - enables researchers to determine the "variability or stability across time in how learners use strategies or express particular conceptions" (Sherin and Chinn, 2022, p. 226). Intended to convey the immediacy of the participants' emic perspective (e.g. Green and Castanheira, 2012), with their moment-to-moment decisions and responsiveness including references to gestures and facial expressions

text - encompassing semiotic resources as cultural tools (e.g. Wells, 1999; Gee and Green, 1998), and *words* as included in a broader semiotic perspective of meaning making through representations and sign-making (Lemke, 1990; Kress, et al., 2001; Prain and Tytler, 2012).

situative perspectives - studying academic literacies practices as meaning making in the social context of the classroom (Bloome, Carvalho and Ryu, 2018; Sawyer and Greeno, 2008).

translanguaging – in this study, plurilingual students bringing to bear their semiotic repertoires in discourse moves for knowledge construction, as cultural and epistemic agents. (Coyle, 2020; Li, 2018; Tai, Li and Loh, 2025)

4 The intervention: data and findings

4.1 Overview: iterations and analysis

This chapter presents the data and findings from DBR intervention, a longitudinal study conducted across four iterations. In this study, I set out to investigate the iterative application of a set of DPs in an intervention that I designed in order to address problems that I have identified in the context of my teaching practice (McKenney and Reeves, 2014, p. 34). I set out the context and outlined these problems in chapter 1, where I formulated research questions for the study. In chapter 3, I discussed the selection of the design-based research methods to best investigate possible design solutions for this local context. I now review the design for the study, the unit of analysis and data collection, leading to a brief analytic preview of the iterations and their significance in the research design and outcomes, detailed in figure 4-2: it is shown that the iterations are presented in Parts A and B of the chapter. These contain the Analysis and Design Narrative sections (Bell, Hoadley and Linn, 2004; Barab, 2014; 2022) for each iteration in chronological order, allowing a clear reading of the situated practices of this group, and therefore the evidence affirming the conditions for the learning outcomes and the design that supported them. In chapter 5, I apply retrospective (Bakker, 2018) and inductive (Erickson, 2012) analysis to the Intermediate Outcomes for these iterations, in a discussion of the learning trajectory and revised DPs, shown in figure 5-5.

4.1.1 Review of DBR methods applied in the study

As discussed in chapter 3, by developing and applying a set of DPs in an intervention across time, through iterations, design-based researchers examine the Enactment Processes (EPs) and make responsive adjustments to help obtain a successful design product, while also concurrently developing a local theory (McKenney and Reeves, 2014, p. 39; Gravemeijer and Prediger, 2019; Gravemeijer and Cobb, 2013) or "theory-in-context", to account for the findings, as a goal (Barab, 2022, p. 181; Edelson, 2002, p. 112). The DPs that I compiled for this study, as noted in my research process in chapter 2, are set out in the Initial Conjecture Map (figure 3-9). The Conjecture Map is used to inform the design of the intervention by

indicating the relationship between the High Level Conjecture and the DFs for the EPs to obtain the suggested learning outcomes (Boelens, De Wever and McKenney, 2020, p. 433; Sandoval, 2014, p. 19). Hence, the DPs provide actionable knowledge (Bakker, 2019), and the Conjecture Map is not only a planning tool to enact the design through application of the DPs; it is a tool for testing these DPs across iterations. In so doing, the design knowledge obtained may be used to inform practice regarding the High Level Conjecture that emerged out of my problem analysis as per the DBR process (Sandoval, 2014, p. 22; Boelens, De Wever and McKenney. 2022; Edelson 2002). This study therefore provides a set of tested DPs, refined across four iterations, setting out a learning progression toward the desired learning outcomes conjectured at the outset for this local context.

My overarching research question in this study is *How can a learning environment be constructed in order to support ELL students appropriating science discourse and practices?* To operationalize this question in the format suggested by DBR practice, I reformulated this question as a High-level Conjecture (Bakker, 2018; Van den Akker, et al., 2006). In preliminary form, I stated this as, *Students' knowledge and use of the Everyday Language (EL) and Academic Language (AL) continuum requires their appropriation of disciplinary discourse practices, including doing, explaining and arguing about phenomena and processes in school science topics*. As delineated in chapter 3, through research and prior experience conducting pilot project work, I derived a set of DPs to support a design investigating this conjecture, and prepared DFs to mediate the process of obtaining the desired outcomes, presented in figure 3-9. Hence, the data set collected for this study consists of sources which report on these mediating processes, or EPs, as indicated in figure 3-9. These EPs and their analysis are reviewed next.

As set out in chapter 3, the Conceptual Framework for this study takes a situative view of learning, where the participants, i.e. as Kim and Bloome (2021) state, "teachers and students language into being classroom social practices in which thinking gets represented" (2021, p. 179). These processes take place over time using semiotic resources as cultural tools (e.g., 2021; Sawyer and Greeno, 2008; Wertsch and Kazak, 2005; Wells, 1999; Gee and Green, 1998). More concisely, Sawyer and Greeno (2008) refer to such processes as "learning as changes in participation over time". I therefore refer to the local context of this study as *our*

emerging local culture (e.g. Bloome and Beauchemin, 2018; Kelly, 2023) throughout this chapter and I develop this view further in chapter 5.

Hence, I draw on microethnographic approaches (Baker, Green, and Skukauskaitė, 2008; Erickson, 2012; Green, et al., 2020), to obtain participant or emic perspectives (e.g. Green, et al., 2012) on the design. I investigate the participants' AL development, that is, their disciplinary discourse practices as cultural practices established over time, so as to "identify social processes of knowledge construction" (Green, et al., 2020, p. 162). The unit of analysis is therefore interactional (Erickson, 2006; Green and Bloome, 2013), centered on participants' interaction around knowledge artifacts (Wells, 1999) and the development of practices for their use, namely interaction as a set of three main discourse moves engaged in by the participants, as they construct their cultural activities which are the classroom literacy practices developed in this intervention. Hence, I am considering artifacts and practices as "shared objects" mediating knowledge construction (Paavola and Hakkarainen, 2014, p. 57). The analysis of the participants' interactions around their *shared objects* focuses on examining the EPs, namely how the participants "publicly and interactionally display ways of thinking" (Kim and Bloome, 2021, p. 178) and so generate representations of that thinking as their *shared objects*, which they revise through collaborative and individual work over time. In this study, I have identified three main analytic categories of interaction, which I discuss next in the review of the data collection on the EPs.

4.1.2 Data set collection and coding

In keeping with microethnographic approaches (Baker, Green, and Skukauskaitė, 2008; Bloome, et al., 2004; Erickson, 2012) delineated in chapter 3, data on the EPs was generated through recursive and abductive analysis of video recordings of lessons, transcripts and screenshots from these recordings, as well as photos of the interactions and student generated artifacts, collected across the four iterations of the intervention. Hence, the data set emerged through a process of "zooming in" and "zooming out" (Kelly and Green, 2018, p. 17) during the analysis of the material. This process led to episodes being selected for each iteration by identifying key events or Rich Points through abductive and iterative analysis (Bloome, et al., 2004; Skinner, 2022) within these recordings or lessons. Each Rich Point emerges within interactions in the episode, which are characterized according to three main

kinds of Observable Interactions that I have identified as *social processes of knowledge construction*, namely *Epistemic Work*, *Meta-talk* and *Languaging*, shown in figure 4-1 and reviewed below. These interactions were defined in section 3.3 through pilot project work.

The data set from the iterations is located in the Narrative Description section for each iteration. It is presented as a sequence of episodes and narrated through thick descriptions (e.g. Rossman and Rallis, 2017; Bloome and Beauchemin, 2018; Bell, Hoadley and Linn, 2004, p. 78) of EPs. These are exemplified through instances of student talk, student action, and student artifacts, as well as my teacher talk, all of which are presented as Design Narratives (Bell, Hoadley and Linn, 2004). The thick description is intended to convey the immediacy of the participants' emic perspective (e.g. Green and Castanheira, 2012), with their moment-to-moment decisions and responsiveness including references to gestures and facial expressions (Reinhardtsen; Carlsen and Säljö, 2015; Van Zoest, et al., 2021). Such descriptions convey the lived moment of the Rich Point, which is where "meanings and practices are made visible" (Agar, 1994, cited in Green, Skukauskaitė and Baker, 2012, p 310). These instances are coded according to the *shared objects*: the above-mentioned *social processes* are used to identify the episode in question, along with the *mediating artifacts*, such as the anchor text or representation. Figure 4-1 shows an example Summary of Findings for an episode, with hyperlinks to figures included in the narrative; italics indicate key elements emerging in the episode.

Figure 4-1 Example of a Summary of Findings for an episode

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *noticing* words as ideas in the anchor text ▪ *authoring words as ideas*, student-generated text Meta-talk (MT) ▪ reading tasks are a context for *reasoning aloud*, Languaging ▪ *over-writing the AL terms on the anchor text*	Rich Point: talk about and writing AL words, in first over-writing, by students, in: ▪ *authoring over-writing for AL*: figure 6 ▪ study questions figure 4, figure 5	Specific Design Principles ▪ integrated language and literacy with representations ○ *text is an improvable object* ▪ emerging cultural practices: ○ *noticing* as practice ○ *AL* as practice

The episodes are analysed by the Enactment Process (column 1), with evidence of the emerging Rich Point and relevant evidence from the artifacts and the interaction (column 2).

Evidence is linked to the figures or the transcripts referenced in the narrative for ease of reference. The cited meta-talk containing the developing Rich Point is highlighted in yellow. The EPs and evidence are mapped onto the DPs (column 3). This order reverses the process of the Conjecture Mapping, to permit discussion of the validity of the conjectures and DPs for the intervention, as required by the DBR process, in the Intermediate analysis and Outcomes section.

It should be noted that in each summary figure, I interpreted the DPs in the context of the episode in order to present them as more detailed descriptors (Linn, Bell and Davis, 2004) arising out of the analysis of the particular episode. These specific descriptors constitute new design knowledge, one of the dual aims of DBR (Barab, 2014; 2022; Cobb, et al., 2003). I derive them from this analysis of my practical experience of enacting the general DPs in my Initial Conjecture Map, figure 3-9. In the summary figure for each episode, the newly emerging elements are in italics, while maintaining certain ongoing elements. This permits an overview of changes in our participation and provides the accompanying conditions during these changes, i.e. situating the learning as changes in participation across time (Sawyer and Greeno, 2008, p. 350). This is the practical knowledge derived from the study, which is the other aim of DBR: the retrospective analysis in chapter 5 discusses the overview of the findings in the context of the dual aims of DBR and the aims of the study (Cobb, et al., 2003). The complete findings for each episode of each iteration are given in Appendix B.

4.1.3 Iterations: sequence and sections

As discussed in chapter 3, the microethnographic approach adopted in this study entails a longitudinal examination of changes in participation and interaction, documenting an ongoing, emergent trajectory in learning as it emerges over time (e.g. Mercer, 2008; 2010; Sawyer, 2022; Littleton, Twiner and Gillen, 2010). Through iterative and recursive analysis (section 3.8), I determined that the trajectory presented in the collected data shows a clear change in the second half, i.e. transitioning to Iteration III, and continuing in strength in Iteration IV. Hence, the data set is presented in Parts A and B.

Each iteration is presented in two sections: the Analysis and Outcomes, and the Design Narrative. It is introduced by a map of the DPs and the EPs applied to the summarized

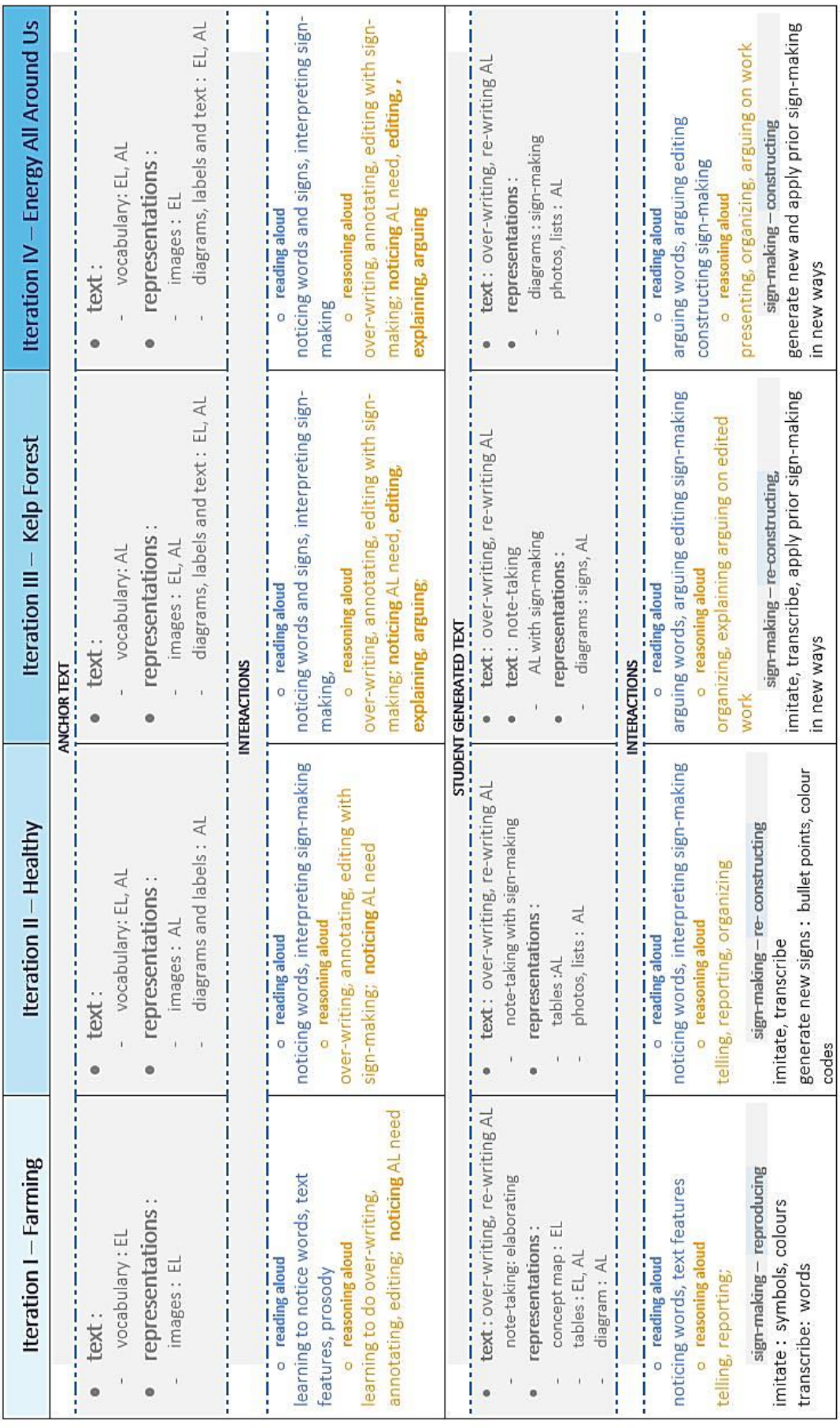
findings, points which are then discussed in the Analysis and Outcomes section. This is in turn followed by the Design Narrative, which through an ethnographic story (Emerson, Fretz and Shaw, 2011, p. 202) presents the emic perspective of the participants and social processes through which the Rich Points emerge, as noted above.

The Analysis and Outcomes section delineates and explicates the interaction analysis: the EPs of *Epistemic Work*, *Meta-talk* and *Languaging* are pointed out in the participants' action around the artifacts, anchor text and student generated text. As per the DBR analytic process, the Processes identified in the iteration are compared with the Process conjectures and Design Conjectures set out in the Initial Conjecture Map. Through this comparative process, the Analysis section determines the validity of the intervention design in working towards the HLC concerning the conjectured learning outcomes for the intervention.

The DPs must be applied across time, and to similar knowledge construction work; hence, the iterations present episodes with parallel activities following the same sequence (e.g. Cobb and Whitenack, 1996). As discussed in chapter 3, iterative application of the DPs permits the researcher to test them by collecting observations on their application, making adjustments through ongoing research and reflection, and testing these in turn in a process that integrates research and design activities, as noted by McKenney and Reeves (2018, p. 18). The recursive process of reviewing evidence used in this study follows Erickson, in discovering phenomena "post hoc" through analytic induction (Erickson, 2012, p. 1460). The recursive and inductive analysis enables me to determine patterns in the EPs by observing interaction across similar knowledge construction activities, over time, and noting changes in participation. These changes are noted first as Specific DPs for each episode, and discussed in the Outcomes section for each iteration; figure 4-2 presents an overview of the patterns resulting from this analysis.

The enactment of the DPs across the iterations is therefore presented in figure 4-2: each column indicates the findings by iteration, permitting a temporal overview of the elaboration and sophistication in the interaction around the *improvable objects* over time. These changes are characterized by increasing student reasoning mediated by the improvable objects, and AL use through sign-making for representation construction, which I explicate in each of the Intermediate Analysis and Outcomes for each Iteration.

Figure 4-2 Overview of findings: Design Principles applied in Enactment Processes across the iterations to foster a learning progression in academic literacies



These findings and the emerging Specific DPs are together discussed further in chapter 5, in order to present the revised Conjecture Map and DPs for the study through retrospective analysis, seen in figure 5-5. I apply retrospective analysis (Cobb, et al., 2003; Bakker, 2018) and analytic induction (Erickson, 2012) to discuss the validity of the conjectures in the Initial Conjecture Map for the study, and present arguments for the new design knowledge emerging from this design-based research intervention: these DPs are applied successfully so as to support

- learning as changes in participation in literacies practices over time
- learning as appropriation, sophistication and mastery of cultural sign-making and semiotic resources for knowledge construction
- learning as increasing proficiency of participation in a maturing culture of academic literacies for knowledge construction

fostering a progression in *Students' knowledge and use of the Everyday Language (EL) and Academic Language (AL) continuum*, as suggested in the High-level Conjecture for the DBR intervention presented in this study.

4 *PART A: Iterations I and II*

4.2 Iteration I – Farming

My design for *Iteration I Farming* initially concerns enacting activities around vocabulary work and reading comprehension using an anchor text. However, through recursive analysis of the Rich Points, specific discursive practices begin to emerge about AL during these activities, namely *epistemic work* (EW), m*eta-talk* (MT) and *languaging* (L). The emergence of these moves are discussed in the Outcomes section. Through activities aiming to investigate certain aspects on the humanities curriculum topic of *Farming*, a connection is established between vocabulary and the information in the topic; this connection comes to be defined explicitly as *humanities book words* by the students during this iteration.

In this study, I draw on a wide conceptualization of *text* as encompassing semiotic resources as cultural tools (e.g. Wells, 1999; Gee and Green, 1998), and *words* as included in a broader semiotic perspective of meaning making through representations and sign-making (Lemke, 1990; Kress, et al., 2001; Prain and Tytler, 2012), as delineated in chapter 3. Therefore, according to the DPs shown in column 1 in figure 4-3, I develop the activities to include student-generated representation construction, including diagrams, tables and drawings, and I investigate the discourse moves around these *improvable objects* as EW, MT and L.

In this iteration, the students and I begin this work of developing our concept of *text* for our practices culture as including written text in the form of words, sentences, images, drawings and other forms of representation. The various forms of written text that we use and construct in this iteration constitute the Participant Artifacts used for the DFs of the EP, shown in column 2. The Design Narrative for the iteration and each episode presents information about the implementation from the emic perspective: the artifacts themselves, together with the kinds of teacher and student interaction around these artifacts. These findings are summarized in column 3. The emerging Rich Point and findings are summarized with each episode, and appendix B contains the full summaries of findings. The full summaries provide the detailed conditions and evidence for the student progression during the iteration. The Analysis and Outcomes section explicates the situated emergence of the Rich Points identified in the Design Narrative, and applies these findings to the Process conjectures so as to begin to account for the Outcomes, as per the DBR process.

Figure 4-3 Map of Design Principles and Enactment Processes applied to findings for Iteration I



4.2.1 Iteration I Farming – Analysis and Outcomes

Introduction

I now turn to the analysis of the selected episodes and the Outcomes for the first iteration. I take up and develop the key points referenced during the course of the Design Narrative section, through a review of the EPs. I then compare these results with the Process Conjectures, so as to present Outcomes for the iteration, as per the DBR process, which are summarized in figure 4-3, column 3. These Outcomes will be referenced in turn in the analyses of each subsequent iteration in a cumulative fashion, to provide comparison and evidence for the intervention outcomes and the validity of the intervention design.

Farming weeks 1 – 3 : episodes 1-3

The first three episodes in this unit are designed to quickly establish the main interactions and task types in our group, through constructing routines for these processes and beginning to identify ourselves and our group. In episode 1, we immediately have instances of authoring and authority being given to the two students in the lesson, Quincy and Ryu. They carry out an idea generation task, which I overtly present as a "getting to know you" activity; however, the real purpose is to begin to show the students that their ideas matter, the ideas are shared and discussed seriously. I do not interfere in the content or the layout on the page of their writing. I use the iPad as an intentional tool (Clarke and Chan, 2019, p. 11), to create meaning (Reinhardtsen, Carlsen and Säljö, 2015): I take photos of the students presenting, showing them how to point with the pen, but importantly to begin to establish the joint object of attention (e.g. Sidnell, 2014). Taking a photo is therefore in many ways a form of interaction, as appreciative non-verbal expressions may also be made at the same time. Quincy writes elements that were perhaps not quite on the topic, but it is on his authority, and I find ways to interpret his points and extend his explanations to underscore this stance. This is my first instance of public noticing of student ideas (e.g. Van Zoest, et al., 2021), to make them the content of the interaction, which I will take further in episode 3

and in subsequent iterations. Ryu writes the words that he finds interesting from Quincy's concept map, as seen in figure 3, as his first instance of noticing. It is also a first instance of public epistemic work and sharing as a knowledge resource. Ryu also re-writes the concept map title, which I have taken as our first Rich Point: he has redefined the main focus of the lesson, and so taken the opportunity to exert epistemic agency and authority in the lesson (e.g. Damşa, et al., 2010; Scott, Mortimer and Aguiar, 2006).

The students may begin to notice that their ideas are visible in their writing, and that this is the content of our activity. Hence, they may begin to feel that their work is important because it is visible, inscribed and shared as an object that can be discussed, and becomes a resource for others. I continue working on these points in episode 2, where the students generate their own questions, based on the anchor text. However, in this episode, we first learn to conduct read-alouds and carry out text based discussion moves about the content, overtly as vocabulary discussion, but in fact as a first instance of editing and authoring text. I present a similar episode in each iteration, to enable comparison. The Rich Point here is seen in figure 6, which is a photo of Quincy, pen in hand, pausing as he is annotating the anchor text with our first over-writes, an act which I term *languaging*. Again, I am publicly signalling to the students the importance of their work, and thus carrying out sign-making to help us define our cultural practices in a noticeable way.

Although the episode does not contain video and transcript data excerpts, I draw on my field notes to characterize our interaction in this episode around the reading and writing. As presented in the narrative, the read aloud is a means to give voice to each student, and to engage them in the information in the anchor text; however, I construct the read-aloud as a situated epistemic practice, through *meta-talk* about the words used in the text. The meta-talk is a means to identify differences and gaps in meaning to be resolved (Ogborn et al. 1996, cited in Scott, 1998, p. 59; Kress, et al., 2001, p. 27). It also foregrounds problematizing (Engle and Conant, 2002, p. 401), as we interpret the words and discuss the ideas intended to be conveyed. This is our initial level of epistemic work in this study. I begin to point out vague and confusing words by discussing what the intention of the text seems to be, and so use this kind of *noticing* act as an overt means to provide vocabulary. The students immediately begin to accept this as an act of clarification and improvement,

which I perceive by the neatness of their annotations, and the persistence with which they discuss and apply the new terms. We are therefore beginning to construct our classroom conversation as being about knowledge construction and to that purpose, we begin to use text, here as words and sentences, as an *improvable object* (Wells, 1999, p. 113; Scardamalia and Bereiter 2021, p. 272).

In episode 3, we see more evidence of the students' conscious and deliberate use of our new practice of these over-writes as epistemic work: they state their view of what the practice consists of doing and its purpose, and thereby also define what constitutes participation here. The Rich Point in the episode is the unexpected expression of authority by Ruslan in excerpt 1: "is, you know, another word for the "water" like in "cool" is *temperate* and the "hot" is *tropical* ". The meta-talk containing the developing Rich Point is highlighted in yellow, here and in all excerpts. He shows that he has understood the work in episode 2, by carrying out over-writing on his own authority, and is now expressing that authority by publicly identifying a gap to be resolved and requesting that the point be taken up, as seen with the pen in the hand in figure 7. I now align the lesson to his point (Aguiar, Mortimer and Scott, 2010; Boyd, 2012), setting aside checking the students' written answers to the pre-set comprehension tasks on the page. He provides examples of the gap that he notices based on our prior work, thus articulating his full understanding of the over-writing practice and drawing on episode 2 as his new prior knowledge. He has looked for the possible new term in the chapter, which he has been consulting as seen in the screenshot. I press him to keep telling us how he found this point, to emphasize that we are reasoning publicly: I am pointing the iPad to his work, again indicating the locus of the shared reasoning space.

A few turns later, Ryu also provides reasoning about the words in the over-writing practice, naming them "humanities book words" in excerpt 2. Quincy states his view "how we know it is" and defines the process of determining "what's not a book word" and over-writing it. Ruslan again states a key idea in the practice: "it seems like a lot of times to remember, we're also writing and we're correcting to remember more". He seems to be stating his understanding of epistemic work as involving writing to make it permanent (Wells 1999, p. 268) after discussion. I take his view of "correcting" as meaning interpreting and authoring the new personal meaning as epistemic work. Furthermore, both Quincy and Ruslan discuss the practice using the term

"we are". Hence, as I write in the episode narrative, the students have given evidence of their understanding of this epistemic work, and defined it as a practice in our local culture, in their own terms. Ruslan's evaluation of our practice here is therefore a suitable title for this first section of the iteration and the study. I consider that he has stated an initial purpose for the practice, in terms of inscribing knowledge of vocabulary "to remember more"; he has not yet articulated any other goal for this activity in our group.

I now continue with the second section in the iteration, and in particular discuss more instances of *noticing* by the participants, which I will then relate to the Process Conjectures and the view of *noticing* as being developed in this study.

Farming weeks 4 – 6 : episodes 4-6

With episode 4, we begin new steps in our semiotic work, having established our essential practices of discussion and annotation around *text*, which I am at times referring to as our text-based practices or simply our *read-alouds*. The Rich Point in episode 4 emerges from representation work that I proposed to the students as a form note-taking, but which is really about constructing another kind of text as *idea elaboration*, through the intentional selection of various modalities and signs. Conducting our read-aloud on the chapter titled "Growing Crops", we add terms in over-writing to clarify vague words but also to elaborate on the farming process, adding information to the page. Hence, we are clearly authoring by adding information on the page (figure 10) that we derived through discussion on aspects of interest to the students, such as pesticides and the meaning of organic produce. However, I then point out that we can make lists and draw the information as pictures, to be more clear and take notes.

Hence, I introduce the digital notebook overtly as another note-taking tool for vocabulary, with more choices available to students, and ease of editing. I also ask the students to highlight in yellow those terms that involve the farming process, and prepare stick figure drawings for these on their whiteboards (figure 13). These note-taking tasks are, however, designed as representation challenges (Tytler, et al., 2023, p. 1163): they are intended as part of our epistemic practices where we explore meaning-making about text to re-represent our intepretation of it, through various symbolic representations constructed with

a range of tools. These tools mediate our discussion and idea elaboration, i.e. our *meta-talk*, *epistemic work* and *languaging*. Ryu's initial drawings on his board are revised by him and then expanded and elaborated at my suggestion on a larger blank paper, with the result seen in figure 14. This revision process takes place while we are conversing about it in the group: each step is a basis for further meta-talk about the languaging, in this case the semiotic sign-making with colour and symbolic drawings. As Wells states, "...the primary function of writing is to mediate recall and reflection" (1999, p. 268). Ryu's understandings, or thoughts, about the farming cycle are externalized as "worthy objects of contemplation" (Olson 1994, cited in Wells, 1999, p. 268), opening opportunities for him to act as an epistemic agent, exerting authoring through new semiotic cultural tools (Prain and Tytler, 2012).

This representation work through re-constructing a text by interpreting and idea elaboration is therefore another form of *improvable object* through which students gain opportunities for enacting our cultural practices. The EPs in this study involve ways that I designed with the purpose of fostering "the mastery of cultural tools" (Wertsch, 1997, p. 137). Our representation work in this episode is designed to lead to successive elaboration in the following episodes and iterations.

Episode 5 contains a Rich Point with our other forms of languaging through meta-talk, namely re-constructing sentences to improve the representation of meaning in text as words. We continue the work that Ruslan termed *correcting*, with authoring at the sentence level to improve the object, a process which mediates our understanding of the content, and the language that we now come to consider should represent it. I turn a grammar exercise into a set of steps for adding our new *humanities book words* into sentences that represent our understandings of *the ideas*; hence, these representations are again manipulable objects. The episode describes our tools for manipulating these ideas through colour coding and arrows as signs applied through discussion. Again, each revision of our thought, encoded through signs, becomes visible and a new object of thought, public and private, through a succession of collaborative acts that I have termed *shared writing*. In the study, I have termed the three steps as shown here of converting the EL sentence into an AL

sentence as *re-writing*, and with the students, I have called it *writing the humanities sentence*, in this iteration.

Episode 6 shows that the students have begun to consciously consider these meta-talk and languaging practices as our cultural tools. The evidence for this emerges in excerpt 4, shown also in the individual and shared writing in figures 24 through 27, where Ryu states the purpose of the shared writing, when I ask, "what should we do", and then goes on to carry out the steps, articulating as he does so. Quincy states again "how we know", by evaluating the anchor text sentence with "the whole sentence is wrong" in figure 26, because it is not with humanities words. The Rich Point is in the unexpected translanguaging, where Quincy, at my sudden suggestion, explains his re-writing using an example from his language, Dutch, seen in figure 22.

Outcomes – Iteration I Farming

Hence, according to the Process Conjectures (figure 3-9), the practices we have been engaging in, mediated by the artifacts, have been understood at this initial level as tools and conceptual resources (Säljö, 1998, p.59) for engaging in constructing AL in the form of words, sentences and early forms of representations based on interpretations of written text. These practices may therefore be considered to be features of our local culture, identified by the students through their *we* statements and their other evaluations. They have thereby shown a developing sense of identity and agency, seen in the more frequent instances of their initiatied interaction and epistemic work in languaging and representations.

The EPs were engendered by each of the Design Conjectures at this early stage, as noted in the preceding analysis. Students used multimodal tools, performed read-alouds, authored artifacts, as they problematized AL and suggested points for discussion or action. These social processes for knowledge construction are confirmed at this stage in the intervention. Students have time to apply practices thus sharing the authority of defining what to talk about and what it means, presented by opening opportunities with prompts, such as "so you feel..." and the student's point is taken up as a valid instance.

Hence, the Outcome of *Iteration I Farming* is the beginnings of a local culture, as discussed in the research for my DPs in chapter 2 (e.g. Green, et al., 2012; Kelly, 2023): the students engage in consistent goal oriented practices over time, which they are conscious of and help define in terms of their nature and purpose (e.g. Berland, et al., 2016).

In Iteration II *Healthy*, I attempt to enact these DPs through the study of another curriculum topic, presenting new opportunities for the students to apply these cultural tools through engaging in our practices around new *improvable objects*.

4.2.2 Iteration I Farming – Design Narrative

This section presents the ethnographic Design Narrative for the data selection in Iteration I *Farming*, presenting the participants' emic perspective through a narrative style which conveys their in-the-moment responsiveness and decisions, and thereby the insider perspective on the situated practices (Bell, Hoadley and Linn, 2004). This narrative style includes references to gestures and expressions of the participants, in addition to statements about my perceptions or feelings in the context of the interaction, as these impact my decision making for responsiveness to students' ideas (Berland, et al., 2020; Thompson, et al., 2016).

The data gathered in the Design Narrative section is in two parts, each containing three episodes presented in chronological order. Part 1 involves introducing the students to the basic forms of activities and interaction around artifacts, as featured in the intervention design. Part 2 involves more elaborate work and interaction initiated by the students. These parts are titled with the key expressions uttered by the students derived from the Rich Points in the section: Hammersley and Atkinson (2019) state that the participants' "situated vocabularies" provide insight into how they "organize their perceptions of the world and so engage in the social construction of reality" (p. 173). I will describe each of these in context. These titles are also hyperlinked to the relevant transcript.

Each episode is identified with the artifact and interaction around that artifact taking place in the episode, as noted in the EP, figure 4-3. A summary of the interaction, Rich Point and Specific DPs also signposts each episode as discussed in the Analysis and Outcomes section. The newly emerging elements are in italics, while maintaining certain ongoing elements; the evidence for the Rich Point contains links to the relevant material. The episodes are linked to the full summaries of findings in Appendix B. Appendix A contains the full transcripts referenced in the episodes. In all references and excerpts of transcripts, the *meta-talk* containing the developing Rich Point is highlighted in yellow.

Part 1 Farming – weeks 1 – 3 "… we're also writing and we're correcting it to remember more."

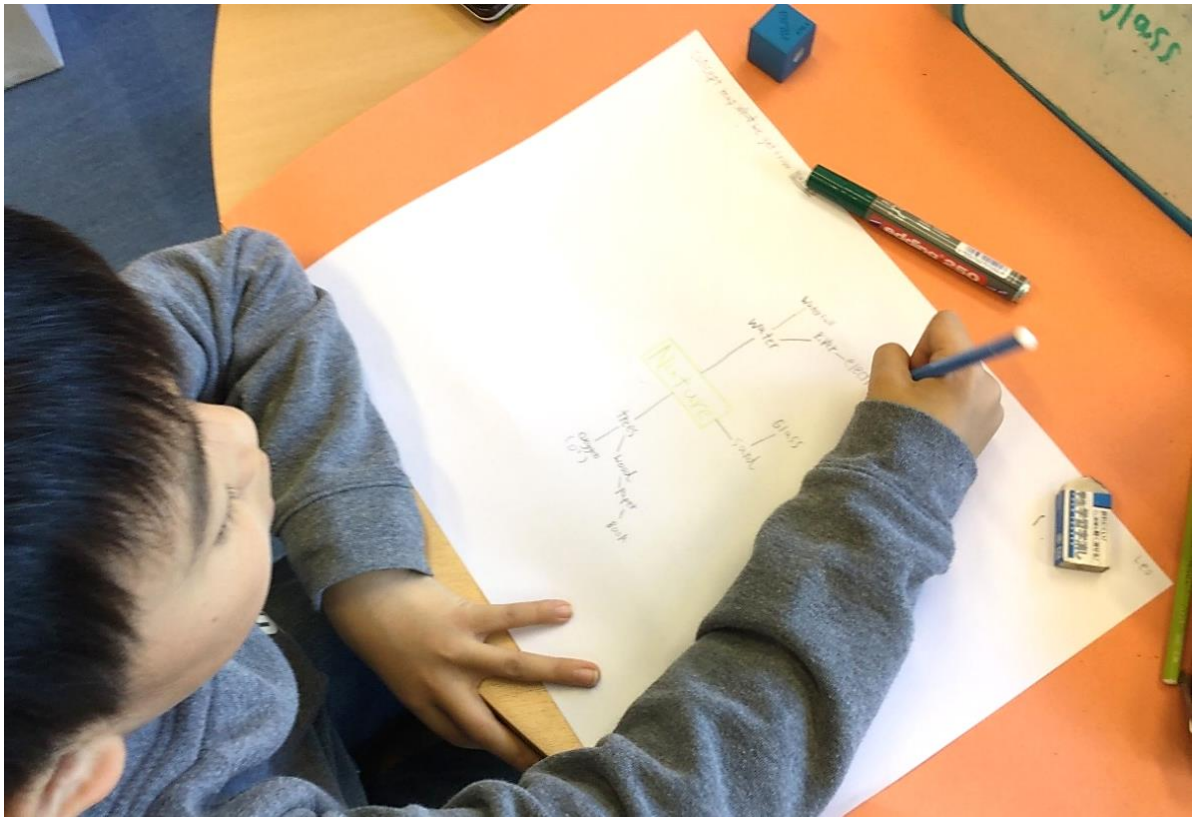
Episode 1 – Concept maps: Epistemic Work

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ words begin to be seen as ideas ○ Ss authoring choices ○ vocabulary work as meaning-making through authoring and presenting to others ▪ idea generation begins as a discourse practice	Rich Point: rewriting the concept map title, by Ryu ▪ Ryu rewrites the key concept and elaborates on it figure 3 ▪ Quincy presents unusual points figure 2	Specific Design Principles ▪ integrated language and literacy with representations ○ student thinking is "made public": accountable ○ knowledge is inscribed as a resource, shared ○ ideas are made visible: ○ are objects of discussion

In this first lesson, using the iPad photo material, I begin our topic work by introducing the concept *nature* and stating immediately that we will cover most of the same topics as the mainstream class, but in ways that interest us. I wish to make clear to the students that we are going to be deciding as a group what aspects of the curriculum we wish to focus on, but not haphazardly. In my design, it is about beginning the process to establish our local culture and student agency, concretely and immediately, through epistemic goal-setting: I discuss this point in the Outcomes section.

Starting to take photos has several purposes for my design, in addition to having the students become accustomed to the presence of the iPad. As I stand next to the students, taking photos, I am also giving verbal feedback on some aspect of their written work, based on our discussion points just prior to this. As discussed in chapter 3, I planned this interaction to happen concurrently with the iPad work so as to capture the emic point of view (e.g. Green and Castanheira, 2012) using the iPad as lens (Clarke and Chan, 2019): as participant, I am viewing the locus of our work and our local culture, with the round table (e.g. figure 4, figure 15), the students around it and our interactions, their notebooks and

whiteboards, the ideas which they are writing down, as well as the act of writing itself. To the students, I am beginning to situate our practices, by using the camera to point to our locus of work, as another means to establish joint attention (Bloome and Beauchemin, 2018). I discuss this point in the Outcomes section.



Farming figure 1 – Epistemic work: Ryu preparing a concept map, "nature", using his own words. He has checked the spelling of some of them by working on his whiteboard, top right corner, seen also in figure 3

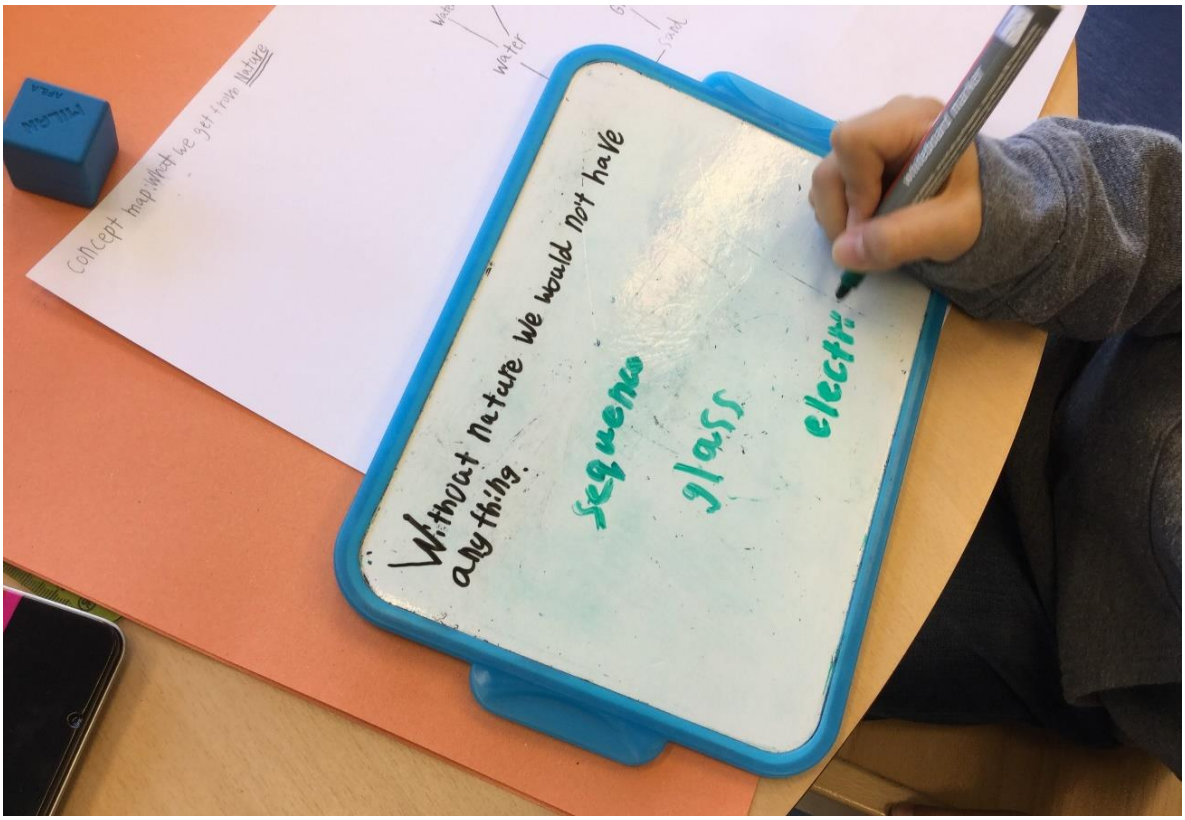
With the concept map work, and the intentionally open term, "nature", I intend to provide the opportunity for the students to interpret and respond in a variety of personal ways, prompted by this evocative word. I discussed concept maps as science activity in chapter 2 (Romance and Vitale, 2006); it can be implemented in different ways. In this study, as noted in chapter 3, interaction around a concept map task serves to set the boundary for each iteration. It helps define the context for the new knowledge goals of our group (e.g. Scardamalia and Bereiter, 1991; Cervetti, Jaynes and Hiebert, 2008, p. 93). In this first instance, I use it as a "getting to know you" activity: by presenting the concept maps, they presents themselves as well, by sharing their perspectives on a general concept through a first group discussion.



Farming figure 2 – Epistemic work: Quincy is presenting his ideas on *nature*, pointing to the word *glass*, linked to *sand*. The teacher's example concept map is on the whiteboard, in green

The important point here, according to my DPs, is that the activity of sharing words and ideas, mediated by a student-generated representation (Tytler, et al., 2020) as *text* (Wells, 1999), is promptly established as a characteristic practice of our group. Furthermore, this representation construction is the first instance of authoring through epistemic agency and authority, by Ryu and Quincy (Carlone, Mercier and Metger, 2021, p. 179; Pierson, Clark and Kelly, 2019; Damşa, et al., 2010). In figure 2, we can see my very simple start in green on the WB, and that Quincy has written his concept map differently. We can see his vocabulary, as well as his unusual connection with *sand* and *glass*, to which he is pointing; he told us that he had recently been to a fair where he had learned about glass-blowing. We would not have known that about him, nor would he have thought of writing it perhaps, had I presented everyone with more strict instructions and a photocopy of a pre-set blank concept

map to fill in, or "fill-in-the-map", as compared with my choice of the "construct-a-map" technique (Ruiz-Primo, et al., 2001, p. 7).



Farming figure 3 – Epistemic work: **Rich Point**. Ryu has written his sentence (in black) capturing his realization based on the discussion, on the small whiteboard, with spellings of words (in green) that he intends to write on his concept map. He has retitled his concept map as well, to include his realisation.

For Ryu, his epistemic work leads him to our first Rich Point: his work on the concept *nature* as seen in figure 3, on his whiteboard. He rewrites the title as *What we get from nature*, which can be seen on his paper, top left. I notice this verbally, and also signal it with the public act of taking this photo with the iPad, attempting to establish this act for him as a gesture of my responsiveness to his work. I thereby publicly respond to (Hickey, Chartrand and Andrews, 2020, p. 761; Van Zoest, et al., 2021, p. 4) this redefinition, authored by the student, which he developed through the discussion around Quincy's presentation. I discuss our use of concept maps and vocabulary building in the context of the developing student epistemic agency and authority, in the Outcomes section.

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Episode 2 – Anchor text: Epistemic Work, Meta-talk and Languaging

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *noticing* words as ideas in the anchor text ▪ *authoring words as ideas*, student-generated text	Rich Point: talk about and writing AL words, in first over-writing, by students, in: ▪ *authoring over-writing for AL*: figure 6 ▪ authoring study questions figure 4, figure 5	Specific Design Principles ▪ integrated language and literacy with representations ○ *text is an improvable object* ▪ emerging cultural practices: ○ *noticing as practice* ○ *AL as practice*
Meta-talk (MT) ▪ reading tasks are a context for *reasoning aloud*		
Languaging ▪ *over-writing the AL terms on the anchor text*		

The next Rich Point emerges in the text-based work using our anchor text. This work, as described in the intervention design, has the explicit purpose of imitating the use of a school textbook: starting by going through the content in order in a typical sequence of tasks with everyone working on it, at times collaboratively. The anchor text also has the role of the source of information and vocabulary, and models of print literacy features (e.g. Galloway, et al., 2020; Duke, et al., 2011); however, I almost immediately begin to adapt and modify both this text and the activities provided in it. These modifications, and the manner in which they are brought up in discussion and carried out by us, together form essential features of the EPs, as I will begin to describe using this episode.

We work with the chapter as a colour photocopy in A3 format (the school pays photocopy copyright fees as per Swiss legislation), in order to promote the annotations, note-taking and other semiotic work that would not be possible in the small A5 size original publication. Furthermore, the flat A3 format is simply more manipulable by the student and directly useful for various forms of annotation as we see in figure 4 and figure 5, and as will be shown throughout the study.

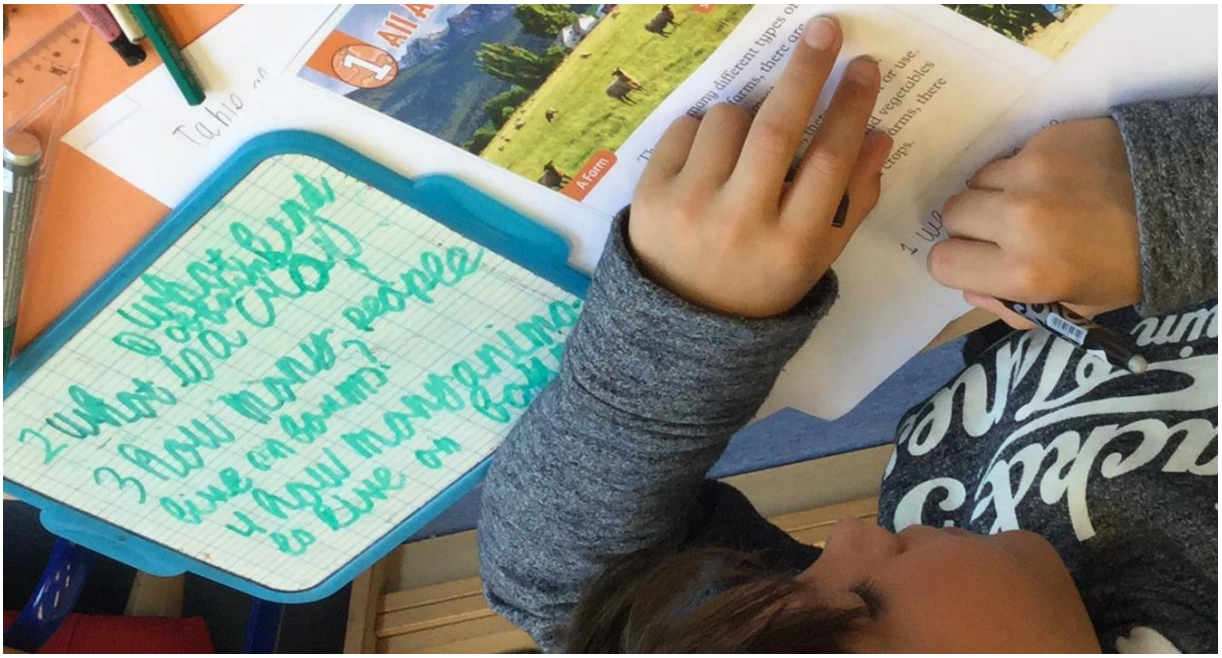


Farming figure 4 – Epistemic work. Students writing their own study questions from their individual whiteboards onto the A3 chapter page, for chapter 1 of the anchor text

Our initial work on this first chapter involves looking at the various features of the page, such as the title, the images and captions, and performing a read-aloud, followed by a discussion based on this text (e.g. Grabe and Stoller, 2020; Santoro, et al., 2016; Smolkin and Donovan, 2003). The students perform the read-aloud, taking turns; a practice which we maintain throughout the iterations and develops into our *reasoning aloud*, as shown in figures 4-2 and 4-3.

My relevant DP here is to immediately give a voice to each student, further to the idea of a community, so that they can hear themselves speaking the information and practicing the tone of the expository style in an authorial way. Concurrently, they have the opportunity to practice repeated reading for oral reading fluency (e.g. Stoller, et al., 2013; Duke and Cartwright, 2021; Powell and Gadke, 2018). This enactment of the expository text prosody is an essential component in laying the groundwork for our languaging and meta-talk about AL

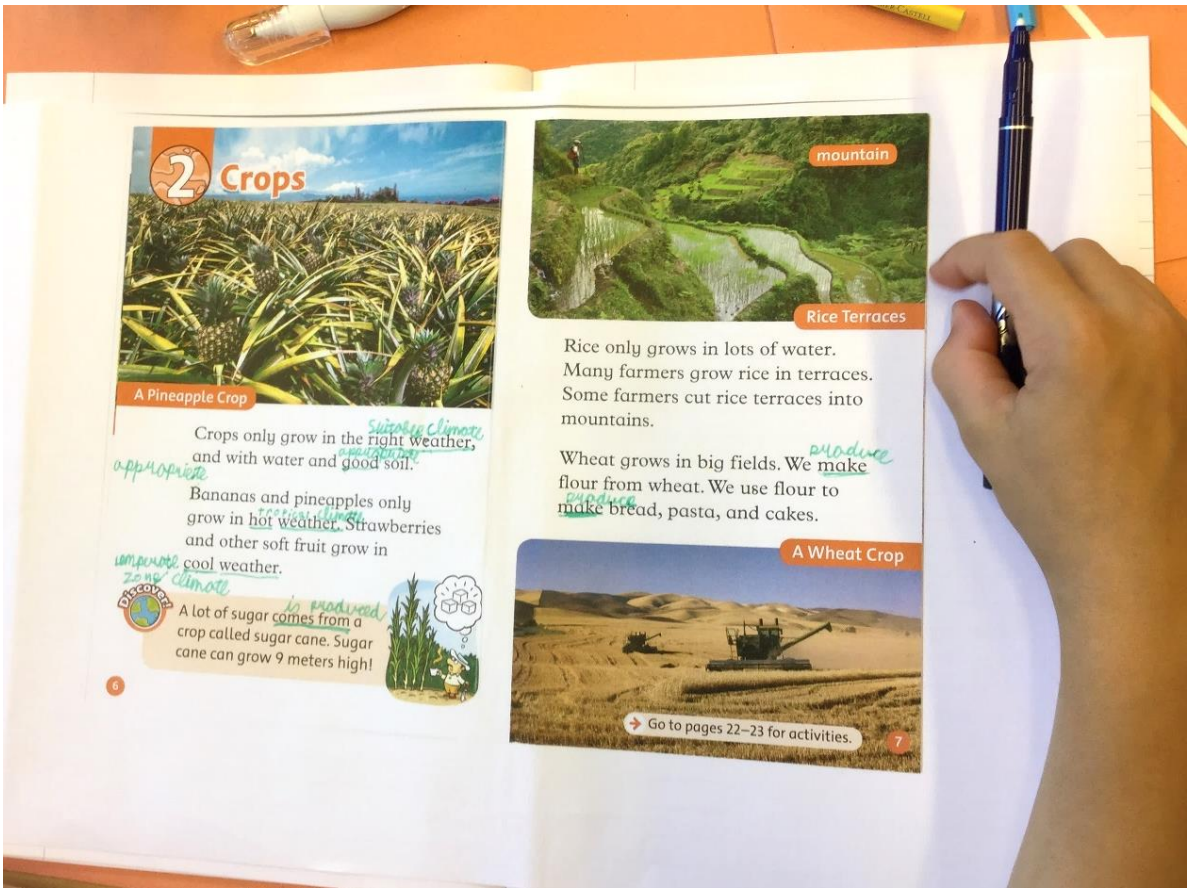
– practices which we initiate in this episode of text-based discussion and writing, and which constitute our next Rich Point.



Farming figure 5 – Epistemic work. Quincy is copying his own study questions for chapter 1 from his whiteboard to his paper copy of the chapter. The photo is rotated to better present the writing on the whiteboard.

Following the read-aloud, I ask the students to write study questions for the anchor text on their whiteboards, as seen in figures 4 and 5. I instruct them to focus on points that seem important to them. I explain that this is a study strategy, to imagine what could be on a test, for instance. I add that writing their own questions is in place of a grammar page about questions, and so in fact it is much "better". Again, I wish to give them authorial and interpretative importance, as discussed in the study DPs, by indicating that I prefer their questions (e.g. Scott, Mortimer and Aguiar, 2006). I tell them that I simply help with spelling, if needed, and then we share by presenting to each other by holding up the whiteboards, reading aloud our questions and discussing the interest in the questions. The space of their little whiteboard is confirmed as a visible thinking space (e.g. Hickey, Chartrand and Andrews, 2020), following our discussion and writing work in preparing the concept map (figure 3) as a model. I tell them that the writing on it serves as a rough copy, which is easy to rewrite and add things to, as well as to show and share. I underscore the importance of the locus of our thinking by taking more photos as they work on their whiteboard or using it, as in figures 3, 4 and 5. This act also confirms the public nature and thus the accountability of our epistemic work to each other, as we develop our understanding of our own practices

(Mondada, 2011). I take up this point in the Outcomes section, as part of the discussion on the EPs by which our local culture comes to be constructed and understood by the participants over time.



Farming figure 6 – Languaging through Meta-talk: **Rich Point**. Quincy with chapter 2, "Crops", and his *over-writing* of the everyday words such as "right weather" with AL, such as *suitable climate*, in green. At this point in the lesson, he has written in *is produced* over "comes from", and *produce* twice on the right hand page.

The next step in my design sequence involves adding academic terms through a process for which I use the term *over-writing* in the course of this study (see figure 6). This process requires preparation, as described in chapter 3, where I discuss my pilot project and my attempts in previous years to situate the lessons as expository text construction, i.e. our authoring practices. In this iteration, during our read-alouds, I explicitly begin to call attention to the expository text prosody during feedback to each student as he reads aloud, and by theatrically acting out phrases such as the one often heard on cable TV news, "this is CNN" (Stoller, et al., 2013, p. 7). In reading this chapter, I now compare this read-aloud with a short improvised retelling from a well-known fable, where I exaggerate the narrative tone.

Then I select the sentence in the chapter, "Farmers work every day" and ask them to focus on that, hearing themselves say it out loud. We discuss what the tone seems to be here, together with the idea of the fact page.

Working with the next chapter, titled "Crops", we again perform the read-aloud, but we now discuss the terms "right weather" and "hot weather" used in the chapter, as seen in figure 6. I attempt to draw on students' prior knowledge in a conversation about what I might consider hot weather, coming from Finland, and what someone from Greece or Spain might think hot, we agree that these are relative perceptions; similarly, for "right weather", as we may consider very sunny weather to be great for a day at the beach, but less so for exertion in a sporting activity. So I provide the terms *suitable* for right, and *tropical climate* for hot weather, as seen in figure 6. The students immediately exclaim that they have heard the term tropical climate, as well as suitable, before; they write these words on their page. I supply the term *temperate climate*, which they have not heard previously. This kind of discussion, concerning the choice of words through an exploration of the ideas represented in the anchor text, is our new Rich Point in our emerging culture: for this study, I term this kind of talk *meta-talk* (MT). I will present an excerpt exemplifying *meta-talk* from transcript 1 below, in Episode 3. This *meta-talk* is here concretized by the participants through the jointly agreed and concurrently performed act of *over-writing* of the AL term above the EL word in the anchor text, a semiotic act which I term *languaging*.

The next point of meta-talk in this episode involves the first process verb *produce*: I point to the page and the phrase "A lot of sugar comes from a crop called sugar cane" as seen in the orange text box, lower left, in figure 6. I will discuss my use of verbs with the students below, in the second half of the iteration in Episode 6, with the next level of our languaging work in constructing sentences. Here, I ask them what they think of this sentence, by having them say their own sentence using "come from". Immediately, they give examples such as "I come from Japan" and the like, so we now feel that we see an oddity in the sugar sentence. I tell them it should be *is produced from*, because "people are *doing* it", emphasizing the action. The students say they have also heard the term *produced* before, and we write in this word several times on the page as seen in figure 6, to replace the word *make*, repeating verbally that it indicates what people do.

With this episode, I have presented our early instantiations of the three main processes in our interaction around our artifacts, namely *meta-talk*, *languaging*, and *epistemic work*. The photos serve to situate the narrative description of our interaction, so as to convey the process by which the students are beginning to assemble meanings in our practices (Mondada, 2011), and so "form cultural models" (Gee and Green, 1998, p. 156).

I next present an episode showing our developing cultural practices through the first excerpt of our "classroom conversation" (e.g. Mercer, 1995; Kachur and Prendergast, 1997), and describe the Rich Point which emerges in our meta-talk, initiated by the students, where we have foregrounded the text as a "thinking device" (Lorman, 1988 cited in Kachur and Prendergast, 1997, p. 81).

Episode 3 – Anchor text : Epistemic Work, Meta-talk and Languaging

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ noticing as EW: reading and seeing words as ideas in the anchor text, for over-writing ▪ authoring: *reading comprehension tasks are now acts of knowledge construction*	Rich Point: "is there another word for water," by Ruslan ▪ discussion for AL: initiated by a student, Ruslan in figure 8	Specific Design Principles ▪ integrated language and literacy with text ○ *text is an improvable object* ○ *knowledge is inscribed as a resource*, ▪ identity building: ○ *epistemic authority: evaluating practices*
Meta-talk (MT) ▪ reading tasks are a context for reasoning aloud,		
Languaging ▪ over-writing the AL terms *on the activity page text*		

The first video data and dialogue are from the following lesson, where the students have, as a review, just taken turns reading aloud the anchor text chapter on crops (seen in figure 6), and have begun to carry out the written tasks on the activity page. I actually start the video recording only when I realize that something important is happening: the students have been carrying out the task of completing the activity page with the suggested word work and comprehension work, but I perceive that they have also started to *correct* the everyday language (EL) in the anchor text by doing their own over-writing, as in figures 7, 8 and 9, of *their own accord*.

I will explain my use of the term *correct* below, where I show it is derived by a student during our group discussion. This means of guiding joint attention (Wells, 1999, p 92) or establishing shared attention (Mortimer and Wertsch, 2003, p. 232) is our Rich Point defining this episode as well as clearly marking the next stage in our emerging cultural practices, to be developed across the iterations. The meta-talk containing the developing Rich Point is highlighted in yellow, here and in all excerpts.

I start the recording as I ask Ruslan to repeat a question that he had just asked me:

Farming Excerpt 1 – transcript 1

1	0:00.2 - 0:00.8	Tell me that again (T adjusting the iPad to begin recording)	Teacher
2	0:02.4 - 0:13.8	is, you know, another word for the "water" like in "cool" is *temperate* and the "hot" is *tropical*.	Ruslan
3	0:16.7 - 0:22.3	hmm, so you really feel that, the, it should be, it should be…	Teacher
4	0:22.4 - 0:28.8	something, there's another humanity word for the "water". figure 7	Ruslan
5	0:29.1 - 0:32.7	Mm hmm. How did you get that feeling?	Teacher
6	0:34.2 - 0:37.1	'cause hmm there is 'cause there is a (pointing to the page and the sentence with his pen) figure 8	Ruslan
7	0:41.1 - 0:42.6	the word, "good" (pointing to the anchor text)	Teacher
8	0:45.5 - 0:54.1	"Good", and um uh, from "hot" and "cold", I forget if I just there is like	Ruslan
9	0:54.5 - 0:55.3	so many words.	Teacher
10	0:55.5 - 0:59.5	Yeah, I think there's something for the "water".	Ruslan
11	1:01.6 - 1:03.9	There should be. There should be.	Teacher
12	1:04.5 - 1:05.2	But there's no.	Ruslan
13	1:05.5 - 1:48.2	Yes, there is. Yes, there is, absolutely, a great point. A great point. So now I'm just going to keep this here. (referring to the anchor text) I'm just going to keep this here for now good. I'm just going to keep this here for now, and we're going to look at this water. (referring to the activity page, see figure 7) We're going to learn the word what the farmer says for water. The water says, the farmer says. *Irrigation*. Did you ever hear that?	Teacher
14	1:48.8 - 1:49.1	Yeah,	Ryu
15	1:50.0 - 2:41.4	I think I did. Brilliant. So The water here here is a farmer (pointing to the illustration) he made he made this so that the plant can be properly you know the word properly, right, properly or appropriately. It's very close. Properly not "in lots of water", but *irrigate*. It sounds very complicated, but you could sense. OK, so. *Irrigation* can we write and *appropriate soil*	Teacher
16	2:43.1 - 2:44.2	a lot of words	Ryu
17	2:44.8 - 3:48.6	could. Yes. So can you write this word, (speaking to Ruslan, going to the word wall) In our little word wall over there, so ..... Let's read all the other important words. How about *suitable climate, suitable climate*	Teacher

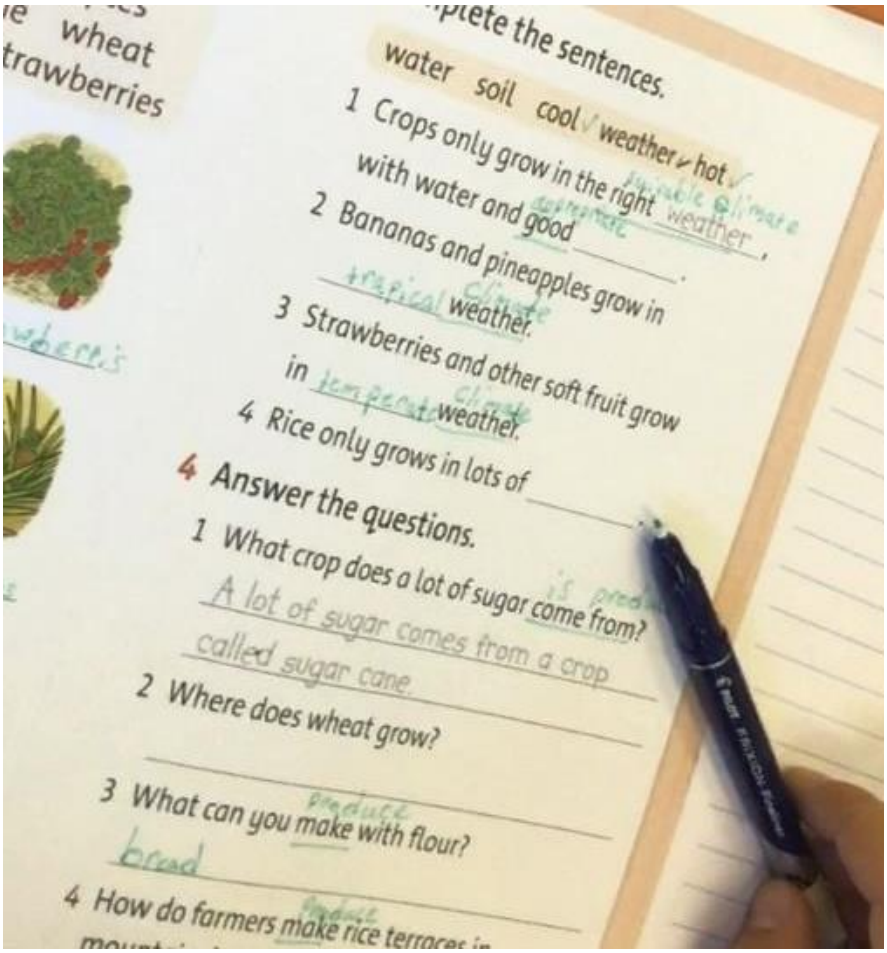
Ruslan is stating, in turn 2, "is, you know, another word for the water like in cool is *temperate* and the hot is *tropical*." Ruslan is explaining what he has noticed about the text in the activity page, where he has been writing in the over-writes or the AL from the work in the chapter 2 discussion reviewed above. Without prompting, he has been *languaging*: writing in the AL terms that we talked about during the read-aloud to replace the EL terms in the word box for the cloze activity as seen in the screenshot detail in figure 8. Now he pauses, with the pen pointing to the term *water* which is left in the word box in the task, exercise 3, item 4, seen in figure 7.



Farming figure 7 – Meta-talk: **Rich Point** Ch 2 crops, transcript 1. Ruslan is pointing to a word he now feels is not AL. He has already identified other such words and added the AL, based on the work in the chapter, which is next to him, on the left of the screenshot

I prompt Ruslan twice, in turns 3 and 5, to keep going with his idea, although his point in turn 2 is clearly stated with examples. In turn 12, he states, "but there's no." which I took to mean he knew we hadn't done meta-talk on a word for it (he is using a sentence construction from his language meaning "we haven't any"). So I reassure him finally by stating "yes, there is, absolutely a great point" in turn 13. I had put off giving an evaluative feedback as long as I could, in order to prolong the point and give it importance; I thought he might add something, as he was being very energetic. I then provided the term *irrigation*,

which I hadn't especially planned to talk about, at least yet. I immediately request that Ruslan write the new term on the word wall, so as to further signal the importance of his point, and the epistemic work of writing notes to add to our knowledge resources.



Farming figure 8 – detail from figure 7. Meta-talk and Languaging: **Rich Point**. Ruslan's languaging to over-write every AL term already discussed during the lesson, and pausing with the pen on the item he now wants to discuss through meta-talk, in exercise 3, item 4 of the page

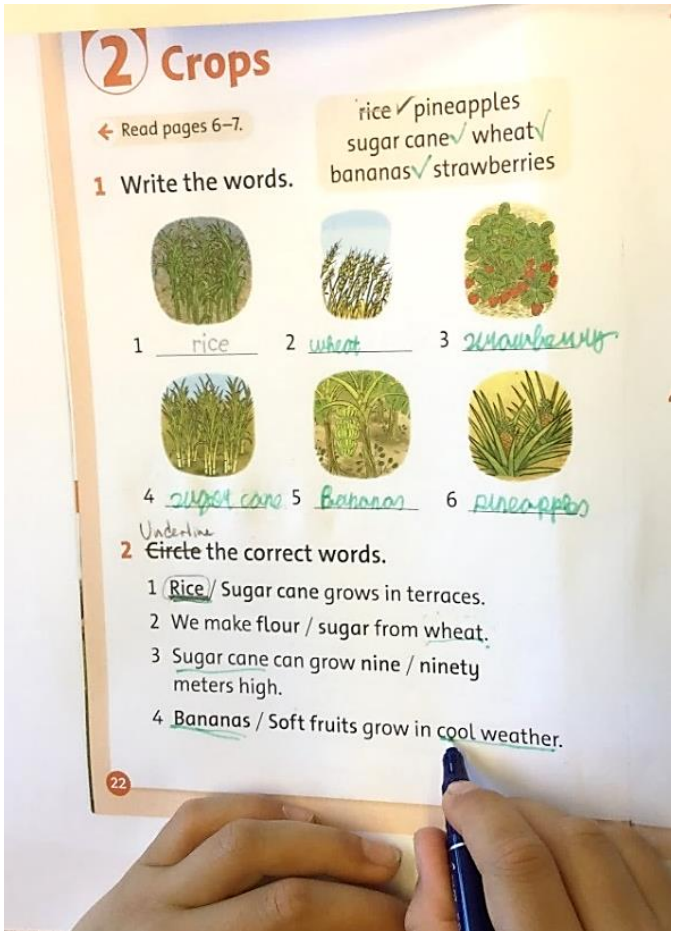
In that moment, I feel concern about providing an excessive amount of words and the whole activity of discussing words as such becoming onerous for the students; however, they are very engaged in this epistemic work, as shown by their unprompted talk and writing. I do prompt for more connection-making, by asking "Did you ever hear that" in turn 13. I try to explain it in terms of the farmer and what he would say, in order to draw attention to the terms of the farmer's craft, and by extension, the disciplinary terms. Ryu does interject in line 16 by stating "a lot of words": I perceive in the moment that he simply wants to be

involved, because he intervenes with a key point. In turn 38, he is repeating terms that I have just provided for over-writing:

Farming Excerpt 2 – transcript 1

38	6:50.3 - 6:50.8	*terraces irrigation*.	Ryu
39	6:52.8 - 7:12.9	Yes, terraces, and so *rice needs abundant irrigation*. Do you hear how that sounds like a textbook that sounds like a textbook, doesn't it?	Teacher
40	7:13.3 - 7:13.8	Yeah.	Ryu
41	7:15.3 - 7:36.8	*Abundant*. And the advantage is, children, it's the same word in French. Let me tell you then, *irrigation* (pronouncing in French)	Teacher
42	7:38.0 - 7:41.7	I hear a lot of time and then was going to French (the French lesson) I hear it a lot of times (speaking excitedly)	Ruslan
43	7:44.6 - 7:45.2	*abondante* (pronouncing in French)	Teacher
44	7:47.4 - 7:48.2	I heared those.	Ruslan
45	7:51.0 - 8:09.0	So this is the advantage, the book words are the same English and French most very, many times, very many times. Thank you. You are right, not 100 percent, but a lot.	Teacher
46	8:10.3 - 8:11.4	And I think there is *humanities book words*	Ryu
47	8:15.6 - 8:30.6	correct, correct. We'll get to that. We'll get to that, let's stick to this, because now we've learned that we've used a lot of words. Do you think you've learned them?	Teacher
48	8:30.9 - 8:31.5	Yes.	students
49	8:31.8 - 8:39.1	And what makes you think you have really learned them? How do you feel about how do you feel about? Yes, (indicating student)	Teacher
50	8:41.3 - 8:58.6	because how we know it is, it's kind of like lots of letters but the book word, because we underline the word that's not a book word and we, the book word, we put above it.	Quincy
51	8:59.6 - 9:00.0	Yeah. and also...	Ryu
52	9:00.1 - 9:06.0	And so you feel so you feel calm, you feel that you feel confident that you	Teacher
53	9:06.8 - 9:12.9	because I know that it means a lot of water, well, in a word.	Quincy
54	9:15.3 - 9:19.0	Is that, does that make sense to you? Do you agree with that? Do you agree with that?	Teacher
55	9:19.3 - 9:31.5	Yeah. And also, you know, just like, you know, just like it seems like a lot of times to remember, we're also writing and we're correcting it to remember more.	Ruslan

I have provided another key term, *abundant* for *lots,* and he is explicitly connecting the term *irrigation* with *terraces*, which we discussed during the chapter read-aloud, with its illustration of rice paddies. I am able to give encouraging feedback on that immediately, by stating "Yes, *terraces*, and so rice needs *abundant irrigation*. Do you hear how that sounds like a textbook, that sounds like a textbook, doesn't it" and he agrees. The episode has become a Rich Point, which clearly the students see themselves. With the writing and comments, Ruslan is showing his own noticing and carrying out his first meta-talk and languaging as evidence of his epistemic work. Furthermore, he is displaying agency and authority in this interaction. I discuss these emerging practices in the Outcomes section.



Farming figure 9 – Languaging: Quincy independently notices the same instance of EL as in the chapter word work, and underlines it here as in his work in the chapter, figure 6

Our talk about the *book words*, as Ryu calls them in turn 46, constitutes the interaction that I have labelled as meta-talk in transcript 1. He is of course echoing Ruslan's question in turn 4, but I consider this comment as part of his emerging practice, as will be seen very clearly in episode 5. During this kind of talk, we are not just discussing how to write a correct

sentence, or doing languaging in the sense of Swain and Lapkin's (Swain and Lapkin, 2001) focus on form, as discussed in chapter 2: in the group, we are all talking explicitly and consciously about *determining the word* that properly represents the *concept* in the *humanities book words*, namely our *disciplinary discourse*, and what it means to "participate appropriately" so as to construct the knowledge of our group (Heath, 1982, cited in Gee and Green, 1998, p. 126).

All participants (including the teacher), engage in this meta-talk, alternating at times with my prompts for connections, as in turns 13, 27, 37 and 41. In these turns, I prompt the students to remember a previous discussion in our lessons, or in another context, where the term was being used or discussed. For instance, in turn 41, I initiate a connection to the word in French for irrigation, and make much of my French pronunciation of it; Ruslan reacts very excitedly in turn 42, confirming his connection making. Encouraged by this, I add the French word *abondante*, and he continues with his animated responses. However, the students notice and make connections as well, and focus the discussion on their points. I elaborate on this idea of noticing in the Outcomes.

I also alternate the meta-talk with epistemic work, as in turns 1, 5, 11, 17, 23, 29, 31, and 33. This is to prompt the sort of talk I was trying to model in the first two weeks of lessons, where our work on the concept map served to make explicit the importance of words to show their ideas. In particular, I continue to work on noticing by using the word "notice" (turn 17, 23), as a synonym for "how did you get that feeling" (turn 5) or "did you hear" (turn 13, 37, 39), or "did you find" (also turn 17). These are followed by agreements, and by Quincy in turn 24, who asks the same type of question as Ruslan did in turn 2, "...I want a word for *a lot, a lot*", to which I ask him to elaborate, "*A lot*? Is that not humanities?" (turn 25) since I wish him to explain to us how he noticed this point.

Students also initiate meta-talk, as with Ruslan in turns 2 and 59, and Quincy in turn 24, who was following the example provided by the start of this episode. Ryu is not so active initially, but begins to respond to my prompts and to the interventions of Ruslan and Quincy by turn 32 and then more clearly in turn 38, where he connects the new word *abundant* with "*terraces, irrigation*". In turn 67, after I have just recapped our over-writing work, Ryu

reformulates an entire sentence without prompting, using the new terms and the verb *produced* so as to signal his understanding of and participation in our goal.

My repetitions of invitations and connections are designed to give time for the students to mentally formulate their ideas, and to get used to this sort of interaction where I try to orchestrate their epistemic work, and show that this work about AL and the concept of book words for humanities is more important than providing the actual word. My message, in the closing moments of the episode, is in turn 58, "…so you see our goal, I think you understand how we are working really really well, I'm really impressed…". Ruslan provides his own evaluation in turn 55, where he says "… just like it seems like a lot of times to remember, we're also writing and we're correcting it to remember more." He has in fact concretized more clearly than I did the idea of our local culture and its practices, by referring to our epistemic work here: he has identified the specific cultural practices in this context as writing and languaging actions that we carry out together, i.e. *correcting* the EL to better represent the epistemic work being discussed. By his use of "we", Ruslan has shown that the participants of this small community decide what is important, namely to have "a grasp of practice" as suggested by Ford and Forman (2006, p. 16), and "what counts as knowledge" (Wells, 1999, p. 121), and that it should be written down, as a goal. Thus, he has defined our identity and work as a group. I therefore now feel that I may refer to our group as a local culture, in this study (Kelly, 2023, p. 82).

After these initial narrative descriptions and notes on the participant interactions and mediating representations, written and oral, I have indicated evidence of student epistemic practices as expressed by their turns that I have labelled their *meta-talk.* I have also identified *epistemic work*. In the second part of this iteration, the episodes will have more such instances, as well as focus more on our third type of cultural practice, namely *languaging*.

Part 2 Farming weeks 4 – 6 "So you can maybe draw a picture to say."

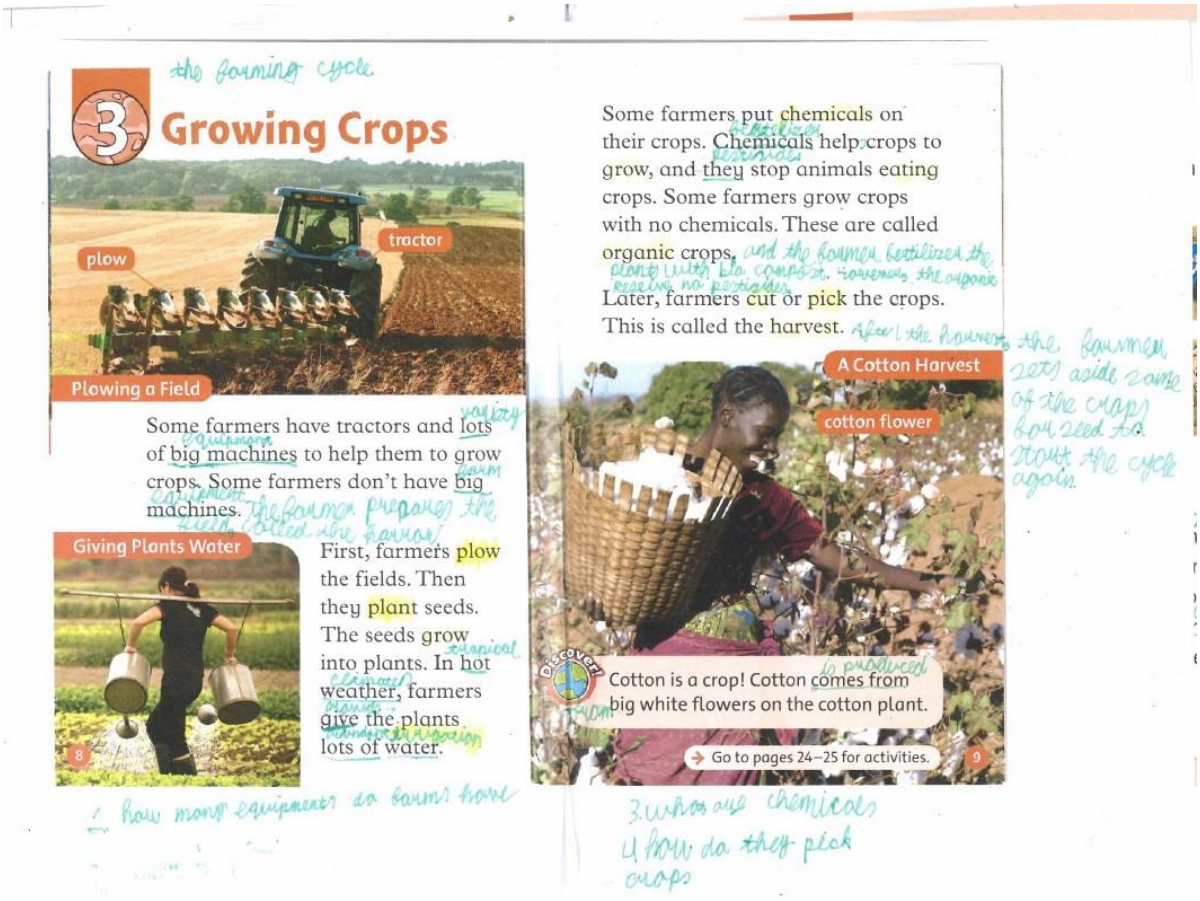
Episode 4 – Anchor text and representations: Epistemic work and Languaging

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ noticing as EW ▪ *modalities* ▪ *representations:* ○ *drawing tables : digital* ○ *drawing diagrams: paper* ○ *devising colour codes and symbols as ideas*	Rich Point: representation construction, by Ryu ▪ note-taking: epistemic work ○ *drawing diagrams as idea elaboration*, figure 14 ○ *drawing tables* figure 12 ○ *drawing diagrams as note-taking* figure 13	Specific Design Principles ▪ *improvable objects*: elaboration *anchored in Ss constructions and edits of their representations* ▪ *identity building:* selecting , constructing semiotic signs ▪ *authoring text in AL as knowledge resource*
Languaging (L) ▪ text and representation over-writing with the AL terms ▪ first re-writing EL to AL sentence		

In this episode, I present our first Rich Point with representation work as a step in a learning progression for model-based reasoning (e.g. Tytler, et al., 2020) as part of our developing AL as disciplinary literacy.

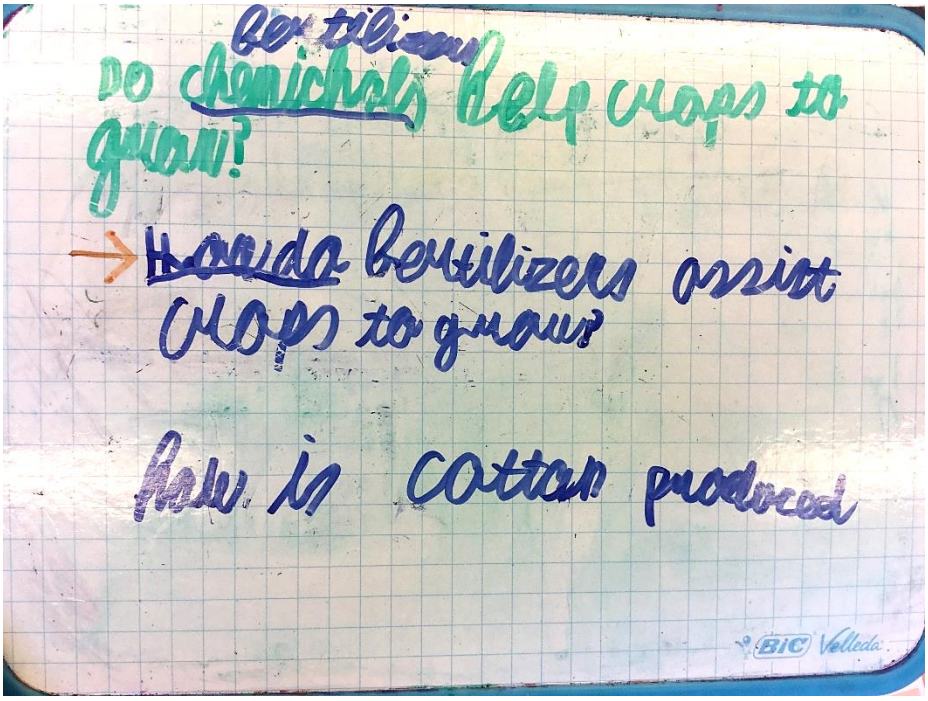
The next interaction in my design sequence consists in carrying out epistemic work in other forms of note-taking, namely constructing diagrams and tables, in addition to more forms of writing work at the sentence level. I now describe the process by which we enact our first level of representation or semiotic work, through these forms of note-taking, mediated by the anchor text, the meta-talk, and the work on the students' whiteboards. I also introduce the Book Creator for Chrome (Tools for Schools, 2023) as a digital note-taking tool, due to its capabilities for drawing and other work with images, thus providing more resources (Engle and Conant, 2002) to foster the students' engagement.

Our work with the anchor text continues with chapter 3, Growing crops, as seen in figure 10. We conduct our read-alouds and over-writing as before, as well as writing study questions. The students add the terms used in chapter 2, such as *tropical climate* or *abundant irrigation*, but sentences are added also as we elaborate on the farming process, especially regarding the types of chemicals and defining organic crops. Hence, the page begins to look very busy with our various edits including the chapter title, which we now call *the farming cycle*.



Farming figure 10 – Languaging. Quincy's notebook page with his shared over-writing to add the disciplinary AL terms, and highlighting in yellow to prepare for diagram work. During discussion within the read-aloud activity, the chapter title has been over-written, and sentences have been written in with information for points that were brought up.

In this context, I have the opportunity to suggest to the students that our book words could be used during the process of writing study questions. In figure 11, Quincy shows his new process on his whiteboard: first, he has written "Do chemicals help crops to grow?" using EL from the anchor text, focusing on a point that he found interesting in it. Then, using a different colour marker at my request, he has over-written "chemicals " with *fertilizers*, which we had over-written in the anchor text during the read-aloud. Finally, he obtains, *How do fertilizers assist crops to grow*, marked by the orange arrow, again using a new process verb from the chapter work. His second question is written without edits, as he derived it from his over-writing in the chapter, as seen in figure 10, in the lower right text box.

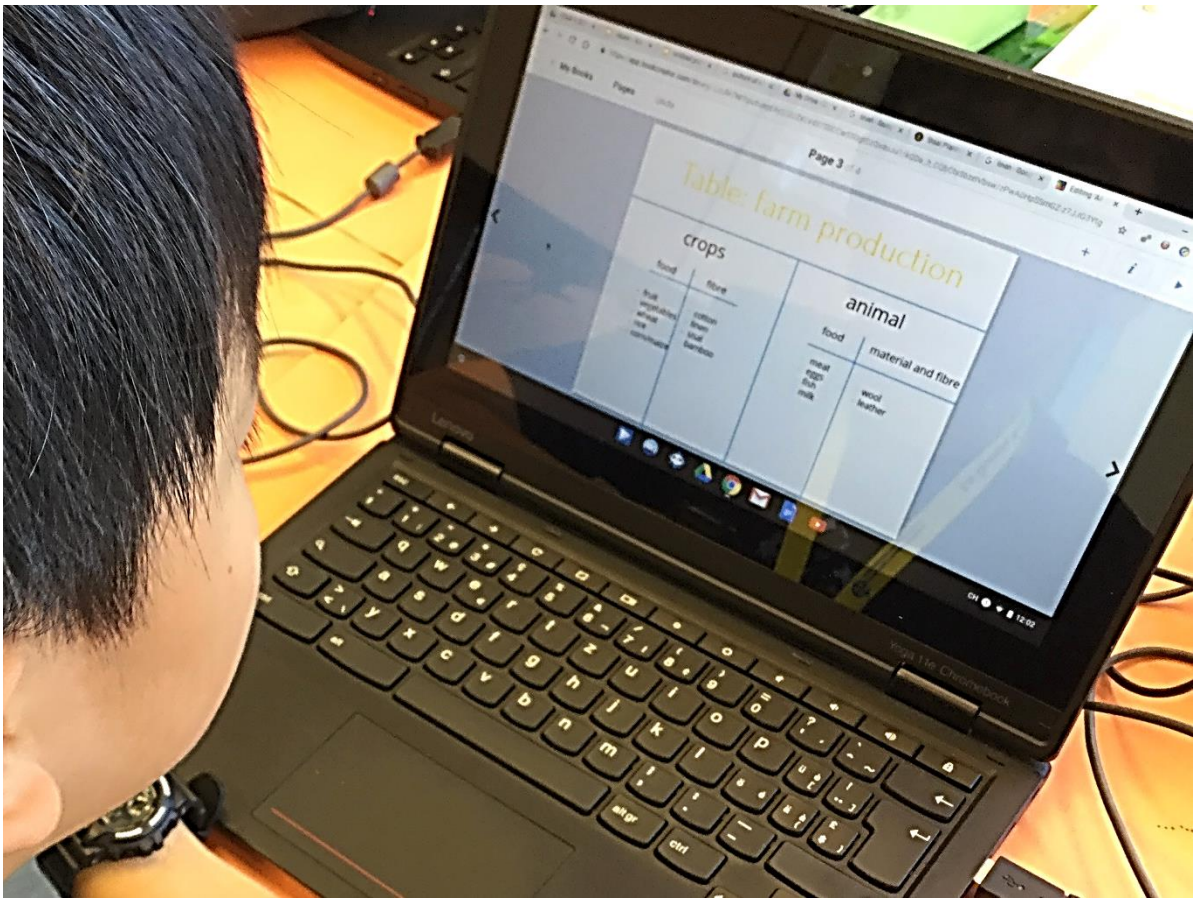


Farming figure 11 – Languaging: Quincy's whiteboard with his study questions for chapter 3 "growing crops" where he independently over-writes his original question which is in green, and then rewrites it, using a process verb. There is also a question using the passive construction.

This sentence work prepares the ground for chapter 4: this whiteboard work is Quincy's first languaging work at the sentence level, and he will produce a Rich Point in episode 6 on that chapter which I believe in retrospect was an outcome of this first effort.

As stated, I also wish to enact new work with representations: I introduce this to the students as a form of note-taking. Figure 12 shows Ryu working on his Book Creator

notebook, constructing a table to collect vocabulary that we derived during the chapter read-aloud, including food and fibre categories, and the title *Farm production*.



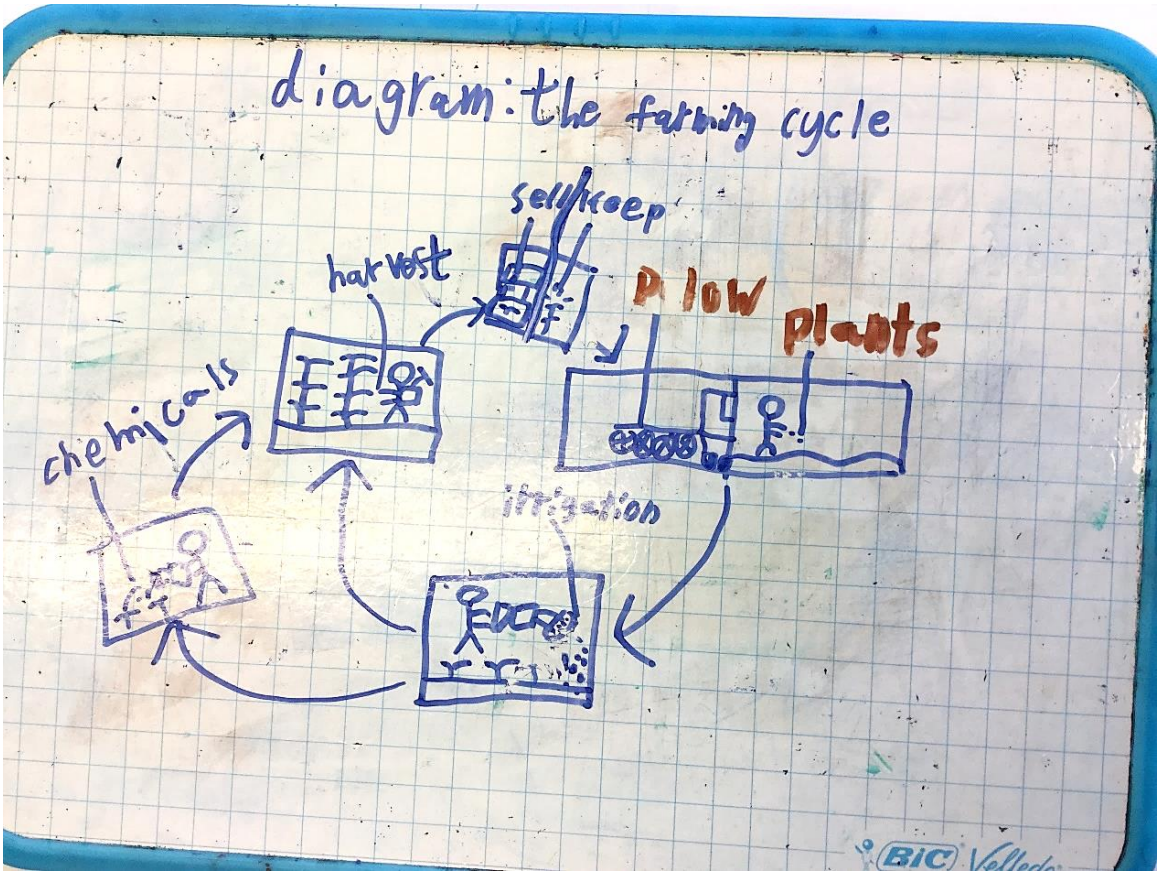
Farming figure 12 – Epistemic work: Note-taking in the digital notebook. Ryu constructs a table that, in discussion, we have entitled *Farm production*. He adds vocabulary and ideas not in the anchor text but agreed on in discussion, such as food and fibre categories with their items.

For each unfamiliar word, it is easy to add a page and insert images through an online search as examples, using the functionalities of the Book Creator software. This kind of digital note-taking will be used extensively as part of our work throughout the study, by means of other, unexplored software and in other, unplanned and highly surprising learning contexts as well, seen in Iteration IV.

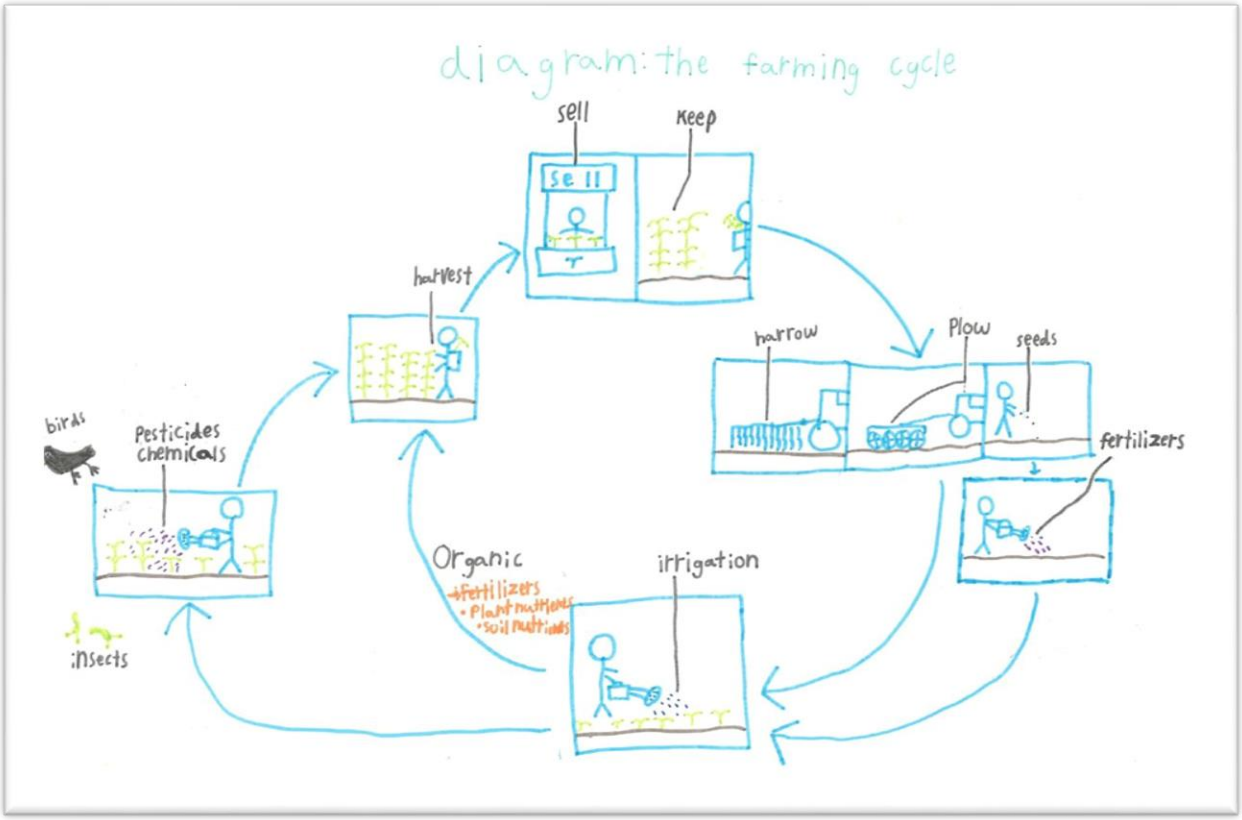
However, with this chapter, we also undertake our first epistemic work with a text-based diagram: a Rich Point emerges. This work again involves discussion and using the student whiteboard, an essential tool in our practices. I prepare this by first having the students colour the farming cycle words in yellow pencil, as seen in figure 10. Then I ask them to

carry over these highlights to their whiteboard and to make a cycle, since we have over-written the chapter title as *the farming cycle*. The work on the whiteboard allows for easy changes, and holding up to show others. The crucial process work involved in constructing the representation is more evident: I am always suggesting colour pens being used and that colour should be used to signal meaning in a thoughtful way.

In figure 13, Ryu's use of stylized images appears to show an understanding of the use of symbolic drawings, which I attributed to his previous schooling in Japan. Figure 14 shows how he has elaborated on these symbols, and added colour use very strategically.



Farming figure 13 – Epistemic work: The farming cycle diagram. Ryu's whiteboard notes on using the highlighted farming verbs; he has added the words in brown during further discussion and re-reading of the anchor text.



Farming figure 14 – Epistemic work: **Rich Point**. Ryu's completed diagram of the farming cycle, including the new farming terms and verbs, as well as the concept of two paths for organic crops or with pesticides which were derived through discussion about the meaning of the term chemicals

After a while, I suggest that we now attempt the diagram construction work on an A3 blank paper, changing modalities so as to reinterpret the sign-making work, as suggested by Gilbert (2013), Knain, et al., (2017) and Kress, et al. (2001). Using the set of erasable colour pens that we have had from the start, he and the others proceed to draw as shown in figure 14, which is Ryu's "finished" version. This epistemic work becomes a Rich Point for us: it will be seen in the subsequent episodes and iterations throughout the study, that we spontaneously refer back to this representation on different occasions, showing how it became a knowledge resource for us (Scardamalia and Bereiter, 2014). This drawing activity is also designed to alternate activity structures and semiotic work; similarly, the digital notebook also serves to alternate modalities and explore possibilities of representation, fostering student agency.

Episode 5 – Anchor text : Languaging through Meta-talk

Enactment process	Evidence	Design Principle
Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need to be resolved ▪ ***opportunities*** *taken by Ss to lead in reasoning process* Languaging ▪ re-writing the AL terms and *applying at sentence level*	Rich Point: ED grammar point, by Ryu ▪ authoring text turn 93 figure 20, figure 21 re-writing for AL figure 18, figure 19	Specific Design Principles ▪ *improvable objects*: elaboration anchored in Ss constructions and edits of their text ▪ epistemic agency and authority: ○ *constructing semiotic signs* ○ *authoring text in AL* ○ *redirecting activity* ○ *evaluating practices*

On completing our representation work in the context of chapter 3 of the anchor text, we return to sentence writing on the chapter 4 page, which will involve the next Rich Point, concerning languaging and translanguaging. The episode is shown in transcripts 2 and 3. As noted, references to the screenshots from the video are also embedded in the transcripts here and throughout the study, while the screenshots are formatted to include the timing, shown on the bottom of the image, to also facilitate cross-referencing with the transcript.

Although the episode is situated within the read-aloud and discussion practices that we have clearly established, I focus this description on our interaction from turn 40, transcript 2, so as to present the episode as interaction about our new languaging work. This work involves developing a step-wise process of converting sentences in the active voice into the passive voice, which I based on Thomson and Martinet (1980, p. 254), so as to achieve a characteristic feature of academic writing, as discussed in chapter 2 of this study. As detailed in chapter 3, I developed the following procedure during my pilot work as a way to do a grammar lesson on the passive voice in a more meaningful way, by combining it with feedback on students' writing during lessons using this same anchor text. In this study, I

have applied my DPs so as to situate this interaction in our emerging culture of academic language and disciplinary practices.



Farming figure 15 – Languaging through Meta-talk. Ch 4 overwriting and rewriting steps at 11min16, transcript 2: The teacher is standing, Quincy to the left, Ryu with back to the camera, Dai to the right, and Ruslan hidden from view by Ryu. The teacher is using Quincy's over-writing and re-writing on the whiteboard, shown in figure 11, as an exemplar of the languaging.

Following the chapter 4 read-aloud and over-writing, I suggest to the students that they continue to identify yet more words that they think should be changed to AL, by referring to them as "silly words", perhaps unfairly. I am connecting to the same over-writing practice that they have already been carrying out spontaneously with this anchor text (as in chapters 2 and 3). I include the start of this interaction as an excerpt here, to show our rapid exchanges in meta-talk, with a focus on Ryu's active work, as he responds to my prompt for words to be underlined and then to be over-written.

Farming Excerpt 3 – transcript 2

41	8:30.8 - 8:31.0	"machines" (should be underlined as everyday)	Ryu
42	8:31.0 - 8:33.6	First of all, "machines", (indicating student) go ahead, go ahead. Yeah.	Teacher
43	8:33.6 - 8:33.8	*equipment* (suggesting over-writing)	Ryu
44	8:33.8 - 9:57.2	Good, say, ... Ready. What other words, do we need to change to get closer to the social studies textbook? aah (noticing student glancing at the word wall) And one person is looking at the word wall , you are looking at the word wall. Huh. Hmm…. What is it supposed to be? "Machines",	Teacher
45	9:57.7 - 9:57.9	*equipment*	students
46	9:58.1 - 10:03.3	*equipment* OK. OK. Anything else	Teacher
47	10:04.7 - 10:05.5	I think I have one ideas	Ryu
48	10:05.8 - 10:06.4	What is it?	Teacher
49	10:07.1 - 10:11.0	So you can maybe draw a picture to say.	Ryu
50	10:12.4 - 10:17.0	We could add more, add more illustrations, we could add more illustrations.	Teacher
51	10:17.8 - 10:18.1	I wrote it,	Ryu
52	10:18.1 - 10:34.2	Good, good, good, good. But first, yes, don't tell me that (about drawing). Don't tell me about, tell me instead, please, what *word* (emphasizing) we should use. What other word you wrote. One more word, instead of "make". Every time you see the word, "make", it's...	Teacher
53	10:34.6 - 10:34.8	*produce*	students

Ryu immediately suggests "machines" (turn 41) and then when I encourage him by echoing his word, he provides the term *equipment*, which we used in chapter 2, so he is connecting to a word he has used himself. Ryu then suggests drawing a picture, certainly referring to his own very successful "picture" of the farming cycle in the previous lesson. In the moment, I recognize that he is making an enormous cognitive leap in epistemic work, which is the purpose of my use of echoing, or re-voicing, to highlight the participation (O'Connor and Michaels, 1993). I elaborate on this point in discussing framing for transfer, together with epistemic agency and authority (Greeno and Gresalfi, 2008, p. 193), in the Outcomes section.



Farming figure 16 –. Languaging through Meta-talk: transcript 3 at omin13: The teacher is pointing to the languaging of step 2: the text word "machine" is replaced with *equipment*.



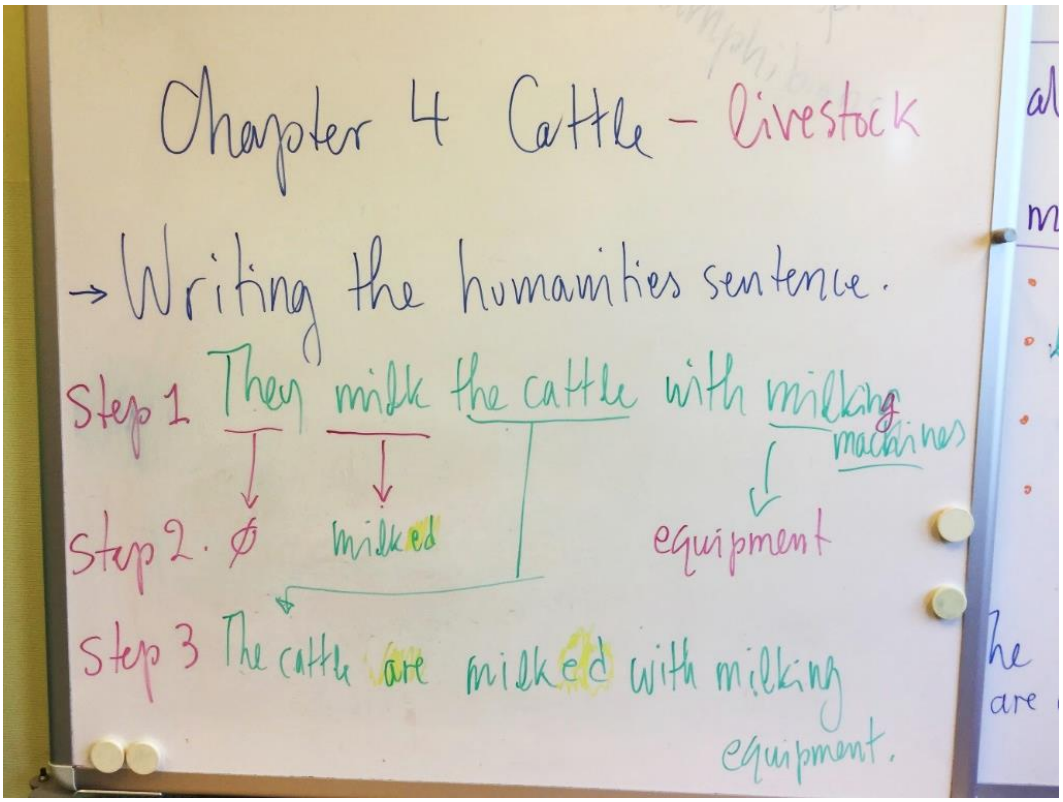
Farming figure 17 - – Languaging through Meta-talk: transcript 3 at omin20. The teacher is pointing to the null symbol, representing the deletion of the active sentence subject of step 1

This excerpt also serves to illustrate how I am constructing the students' agency in these early stages of the first iteration, and how Ryu is already taking opportunities to exert his agency and epistemic authority in the lesson: he is suggesting that we engage in a task that had been a focal point of extensive epistemic work in episode 4, and thus giving evidence of his framing of himself as an epistemic agent and able to build across contexts and time (Engle, 2006). I will reiterate this point below and in Episode 6. The screenshots showing our shared writing work are from interaction in transcript 3, from the last 5 minutes of this episode. Through discussion and this process of shared writing, we do several examples with words like ice cream and butter, as suggested by the students. In this transcript, my turn 1 contains the screenshots shown in figures 16, 17 and 18, as the camera is now positioned to view the board.



Farming figure 18 – Languaging through Meta-talk: transcript 3 at omin54. The teacher is writing out the AL sentence in step 3. The passive construction is highlighted in yellow. The new sentence subject is moved to the front with an arrow, and writing in the AL term that had been suggested by Ryu in transcript 2, turn 43

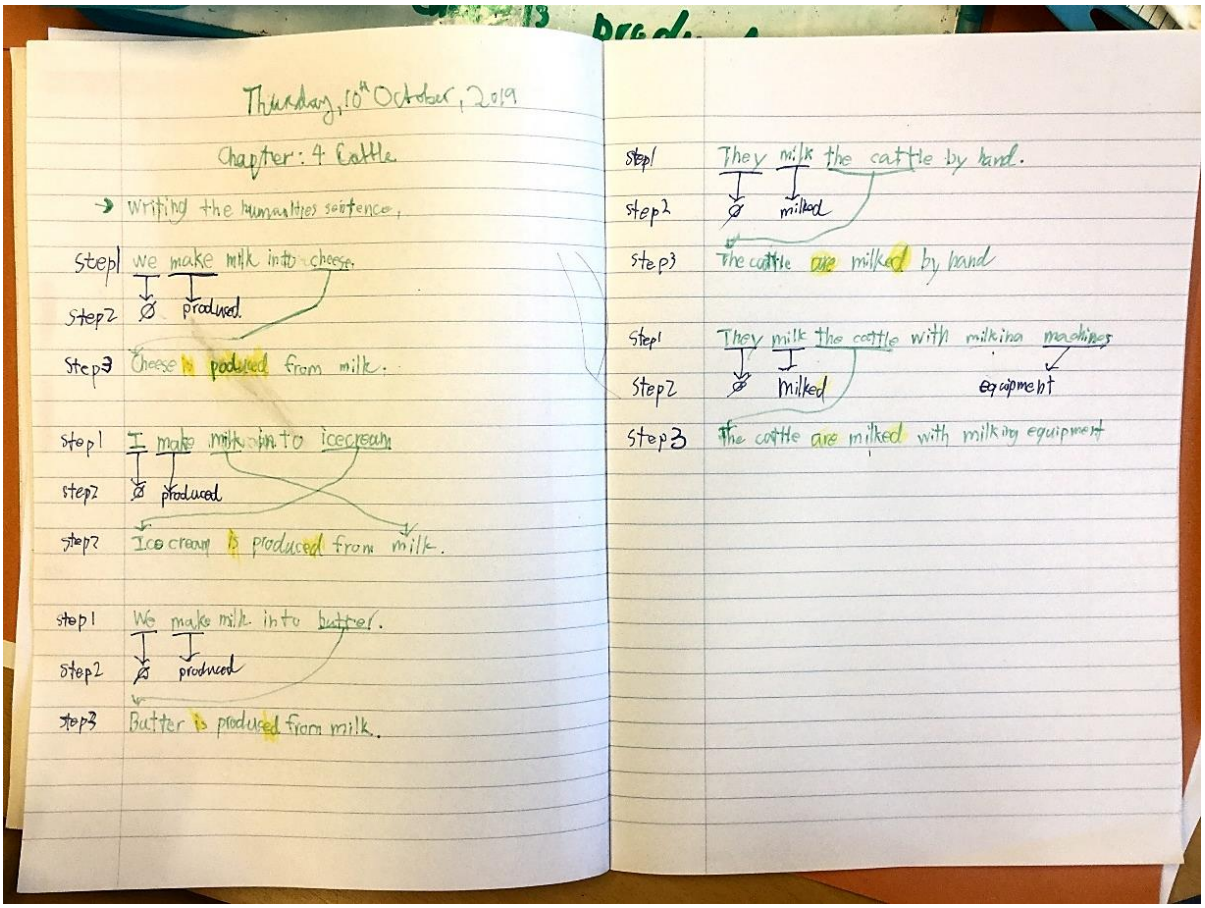
In the lesson segment, I next refer to the first over-writing we did in chapter 1 of the anchor text, with the verb *make*, and the students immediately supply the verb *produce*. Next in turn 56, I use Quincy's over-writing on his whiteboard from the previous lesson, shown in figure 11, and which I had set aside on purpose, as shown in the screenshot in figure 15. I try to make the connection to their previous epistemic work with Quincy's work as our exemplar. I prompt them with "can you please fix the sentence" so that it can be in the same manner. I draw their attention to *we* and the *farmer* not being used in the exemplar.



Farming figure 19 – Languaging: **Rich Point**. Ryu: "it's an -ED which is past " turn 93 Here, the teacher's final shared writing on the whiteboard (transcript 3 and figure 17), showing the use of colour pens, the arrows, and the yellow highlight to indicate the passive construction referred to as -ED during the lessons.

Quincy is thinking of writing it as a question, in turn 59, but I then explain that "we don't see the word *farmer* anymore. We don't want it…we know it was the farmer, we don't need to add that." I now refer to the notebook, in turn 62, and ask them to find a sentence there about sugar cane, "remember the sugar cane example?" Ryu remembers the chapter and the page, and Quincy reads it out loud and expresses that he remembers it now. After helping the students make these connections, I announce that "we are going to learn the strategy", and "we are going to write, *Writing the humanities sentence*" (turn 70). I write this title on the board, as seen in figure 19 (transcript 3, turn 1).

In the subsequent turns, I begin to write on the board, with a running commentary on using the colour pens, first to write the words "step 1, step 2, step 3" and then the first EL sentence from the anchor text to be worked on, "we make milk into cheese", as seen in figure 20, in Dai's notebook. As before in this episode, Ryu is constantly contributing to the dialogue, as in turns 77, 79 and 82, and concurrently writing neatly in his notebook, as seen in figure 21. In writing my notes for the day, I retrospectively ascribe his visible participation here to his feeling of expertise gained during the preceding farming cycle work. In turn 75, I introduce the null symbol, which I had successfully used in previous years to help visibly clarify how the subject in the active sentence is not needed for the passive sentence. This can be seen in figure 17, where I am pointing to this symbol on the board during the shared writing for the last sentence writing in the episode (transcript 3, turn 1).

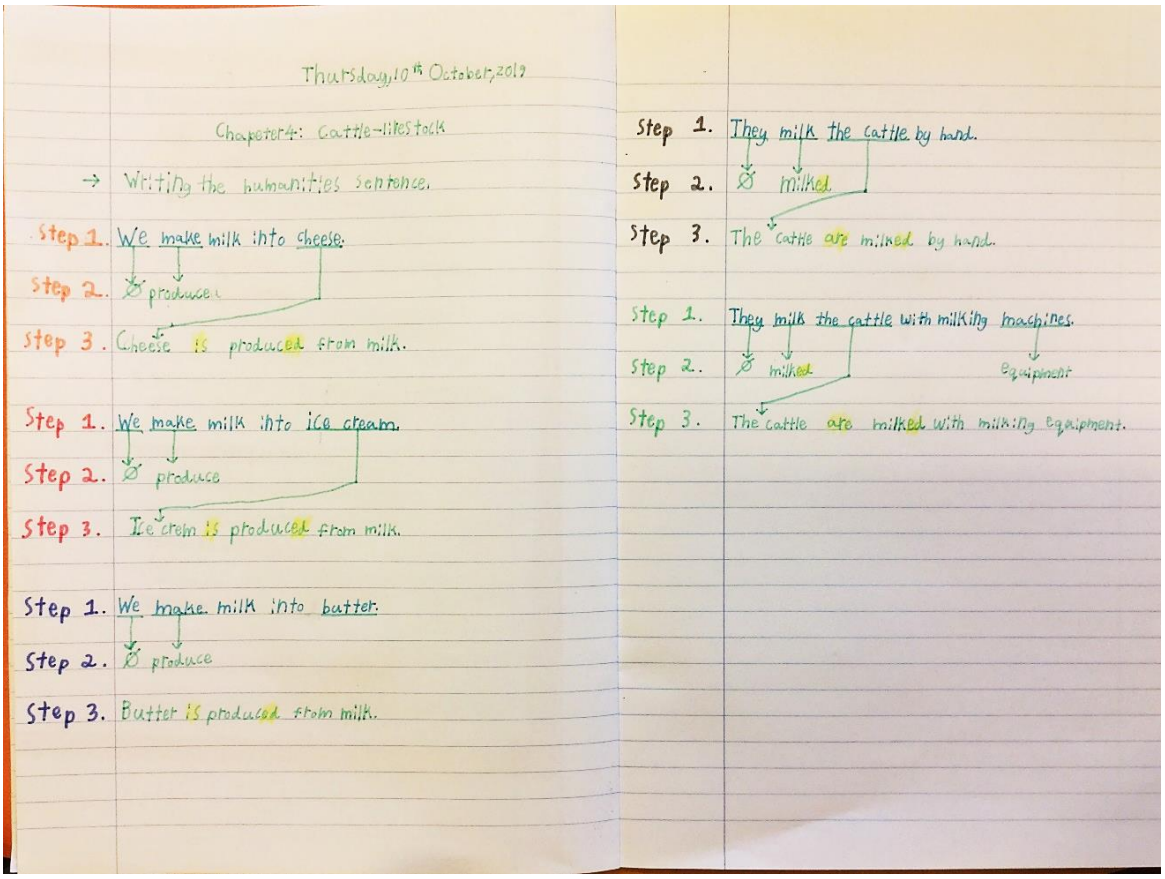


Farming figure 20 - Languaging: Dai's notebook with his writing steps and yellow highlights of the past participle -ED with is or are, written during the interaction in transcripts 2 and 3

In turn 108, I ask them to rehearse the steps aloud: "step 1 is the regular sentence", "step 2 is the important word", and "step 3 is the rearranging to make it a humanities sentence." (turn 110). Ryu

seems very comfortable with this work, and is regularly contributing to my prompts or suggesting, as in turn 93, "it's an ED which is past" and then announcing that he has put yellow to highlight, so I compliment him on noticing in turn 96. This act on my part serves to explicitly point out how noticing is part of our languaging practices, although I do not use the latter term with the students. I wish to publicly recognize Ryu's emerging practice just as I did with Ruslan in figure 7, which is of course in turn an act of noticing. This level of discussion and writing presented at some length throughout the episode by Ryu clearly indicates his progression in his continuum (Gibbons, 2003, p. 259) of engaging in our EL and AL cultural practices. This interaction thus constitutes a Rich Point in our emerging practices. In Episode 6, the following day, Ryu continues this trend of his own accord, in his interaction and work.

Dai is new to our group, having joined the week before. He is not very talkative but writes as suggested, as shown in figure 20. I have seated him facing the board, as seen in figure 15, so that he may view the word wall and the other writing on the board constantly, as his language background involves using a script not based on the Roman alphabet. This initial sequence of languaging work and interactions develops further in the next set of short interactions taking place in Episode 6, the following day. I will also come to the Rich Point on translanguaging by Quincy, as mentioned earlier, and show how it emerges from the situated practices that we are developing. Hence, this episode includes evidence of the students' increasingly self-directed work, within our cultural practices that we are constructing in an increasingly self-aware manner.



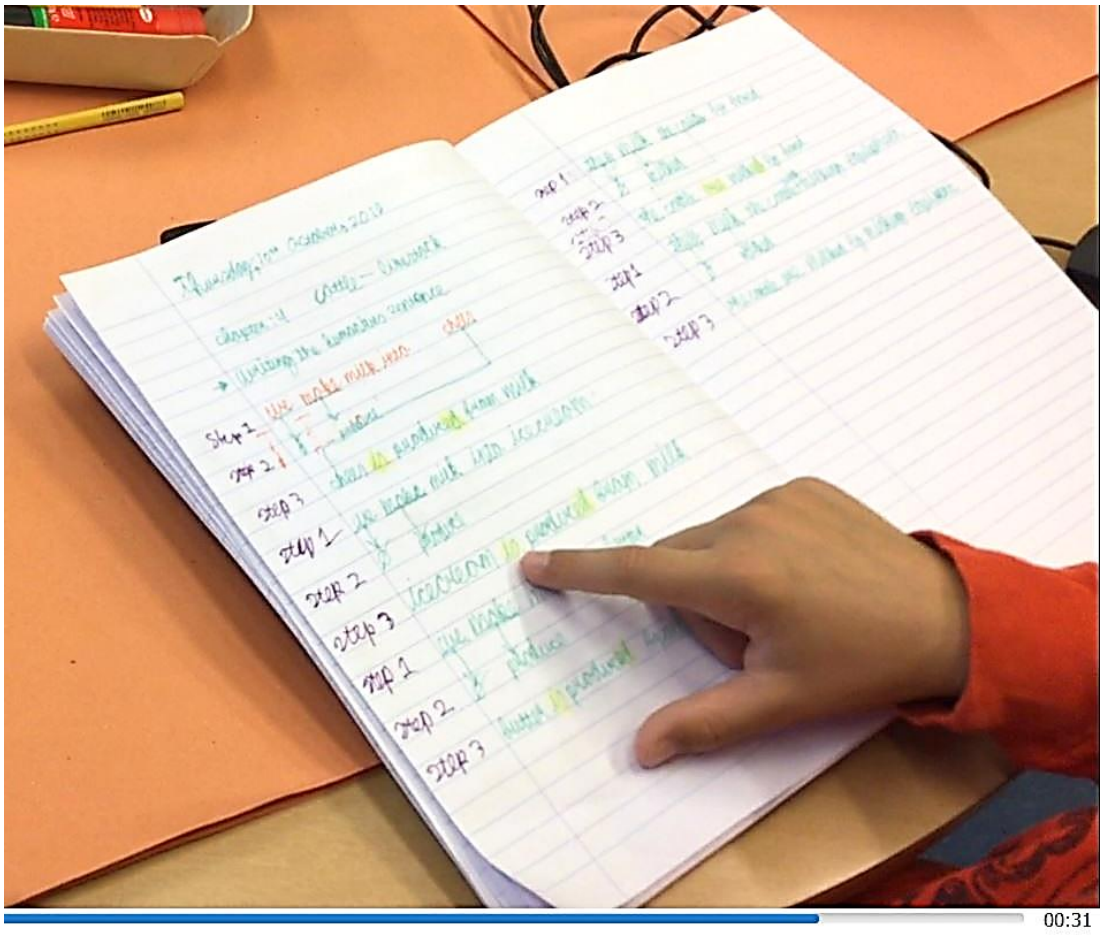
Farming figure 21 Languaging: Ryu's notebook with his precise note-taking and codified use of colour, also written during the interaction in transcripts 2 and 3.

Episode 6 – Anchor text : Languaging and translanguaging through Meta-talk

Enactment process	Evidence	Design Principle
Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need ▪ exhibiting framing and transfer : *student inner speech reconstructed in social plane*	Rich Point: translanguaging, finding 3 steps for AL in Dutch, through Meta-talk, by Quincy ▪ *authoring text through languaging and meta-talk re-writing practices* ○ translanguaging for AL figure 23 ○ re-writing for AL figure 29	Specific Design Principles ▪ *improvable objects*: elaboration *anchored in Ss constructions and edits of their text* ▪ *identity building:* ○ selecting semiotic signs ○ constructing semiotic signs ○ authoring text in AL through cultural practices ▪ epistemic agency and authority: ○ *evaluating practices*
Languaging (L) ▪ text and representation over-writing with the AL terms		
Translanguaging ▪ student makes connections to own language		

This episode follows up directly from the work in episode 5. I begin the lesson with interactions with the students reviewing the sentence writing of the previous lesson. During most of the following interactions, the screenshots and photos are taken as I am holding the iPad and discussing with the student or observing his work, rather than only placing the iPad on a stand. I do not predetermine how the photos and videos should be taken, in part due to my degree of comfort with the technology, but essentially as part of my tools for establishing joint attention for meta-talk in our epistemic work, as noted above.

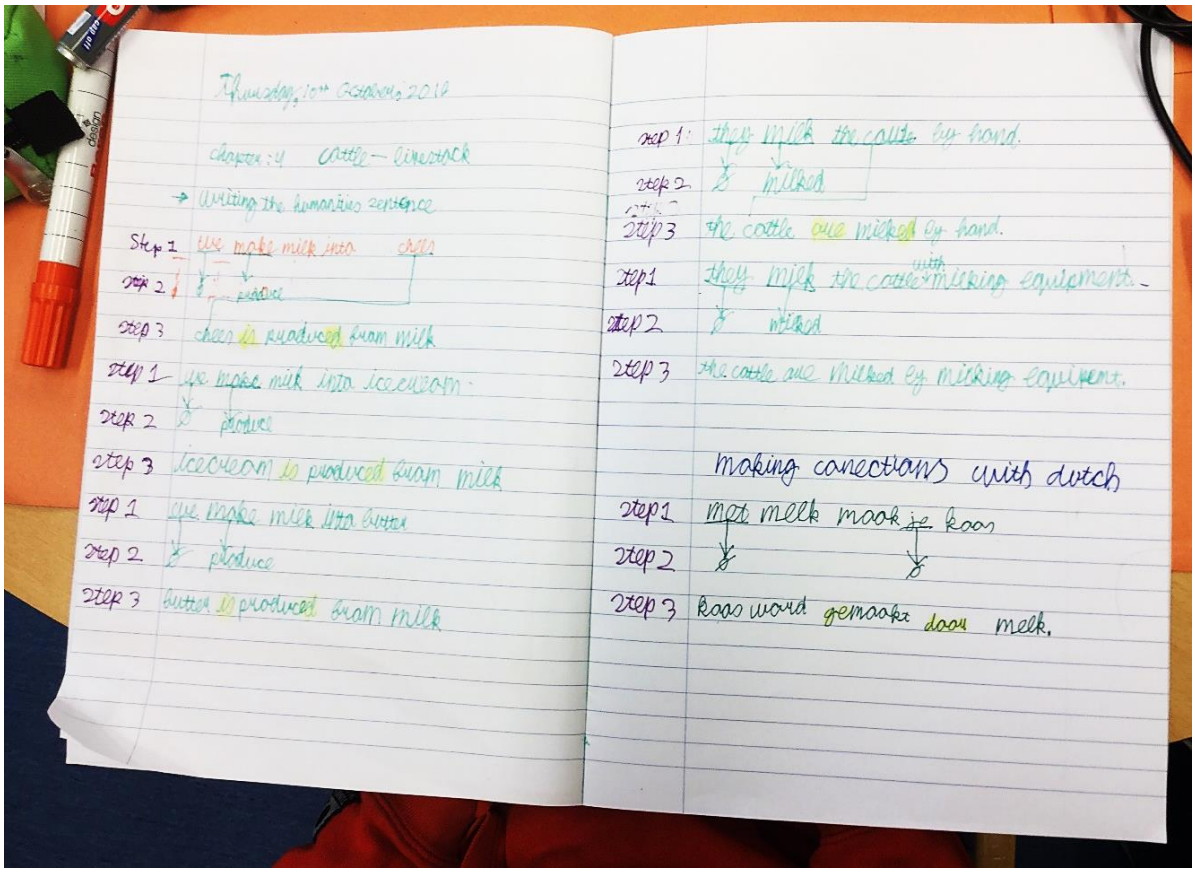
Particularly at this point in my design of the meta-talk and languaging work, I also wish to document the locus of this work more clearly for this study. In the moment of interacting and directing the activity, I feel I should direct the iPad camera more specifically at the artifacts that are mediating our talk and thinking, so that the *direction* of our gaze may be shown more clearly, and therefore the *space* is located for the viewer. In particular, I now wish to focus more on the coordination of the various tools and materials during the activity, to try to reveal better how the participants *reason with* them, as well as *produce* them.



Farming figure 22 – Meta-talk: Quincy "...what we did is "we make milk into ice cream" (pointing to the sentence), then we put like a mark that says that the "we" should be erased (pointing to the null symbol), and the "make" turns out to be *produced* (pointing to each word in turn), and then the sentence became *Ice cream is produced from milk* " (finger resting on the highlighted yellow word indicating the passive).

Hence, in figure 22, the screenshot shows Quincy reviewing, at my request, "what we did yesterday". The screenshot is taken to capture him pointing to the various steps of the process and explaining them. This clip is only thirty seconds long, so I have placed the transcribed speech in the caption with annotations to explain gestures in parentheses, and so created a multimodal transcription (Bezemer and Mavers, 2011), which to my mind conveys the situatedness of our interaction clearly.

I had reviewed these steps with the students the previous day as a think-aloud in the form of our Meta-talk, as shown in transcript 2, turns 108-114, during which Ryu participated by interjecting relevant points. With this question, I now wished to give Quincy a chance to connect with that work, and voice his thinking on it. As seen in the caption, figure 22, he does so, readily and smoothly, pointing to the steps and words as he speaks.



Farming figure 23 – Languaging: **Rich Point**. Quincy has transferred the EL to AL writing steps to sentence work in Dutch, prompted by a discussion on the cognates of milk and cheese, and the importance of dairy production in his country. This work is in the lower left in the notebook, with the title "making connections with dutch". The example with cheese in English is the first one, top left, in orange.

As we review and make connections with the languaging and writing of the previous day, I now make a different attempt to promote connections, this time with more translanguaging, which I have been attempting from time to time in our lessons (e.g. transcript 1 turn 41). It occurs to me now, as Quincy is talking to me about the languaging steps, and I am looking at his notebook (shown by the point of view of the iPad) that the example above it with *cheese* contains words that must have obvious cognates in Dutch, which I judge from my knowledge of German. I do not have the recording of this exchange, although I took photos (figure 23); however, it consists in having Quincy tell me orally what the example sentence "we make milk into cheese" would be in Dutch, through a discussion of dairy production in his country, which is of well-known prominence. He relates at length how he learned about dairy farms in school in his country, explaining to us about different types of cheese being produced. At my suggestion, he readily carries out the writing steps in the same way in Dutch, while

explaining each word, and produces the work as seen in figure 23 with ease. Independently, he adds the null symbol, the arrows and the highlighting on the passive, which he points out to me and explains.

I am quite elated by the length of this interaction, and the depth of Quincy's engagement in the languaging and translanguaging. I feel, on the one hand, a wish to continue finding other cognates and doing other examples of AL in Dutch, but I must allow Ryu to feel his languaging is important as well, although he has just seen me show interest in Quincy's ideas and language. Nevertheless, this is a Rich Point for us in many ways, which I discuss further in the Outcomes section.

Next, I return to the meta-talk and languaging work in which Ryu had been engaging very actively the day before. I request that the students take their own whiteboards and colour markers to carry out more sentence work in another of our forms of shared writing using the space of the WB, with which they are at ease. We have selected the sentence from the chapter, "Farmers keep cattle for meat and for milk". Ryu has written it on his whiteboard and underlined the words meat and milk, as in our previous work (e.g. figures 19 and 21): he then points to these words in turn and states, " So this can be *beef* and this can be *dairy*" (figure 24). He has drawn arrows under each toward the space for step 2 on his board. Ryu then inquires about the word "keep", an exchange which is not in the video. I now include the transcribed ensuing short languaging interaction below of less than two minutes, which accompanies the work in figures 24 and 25.

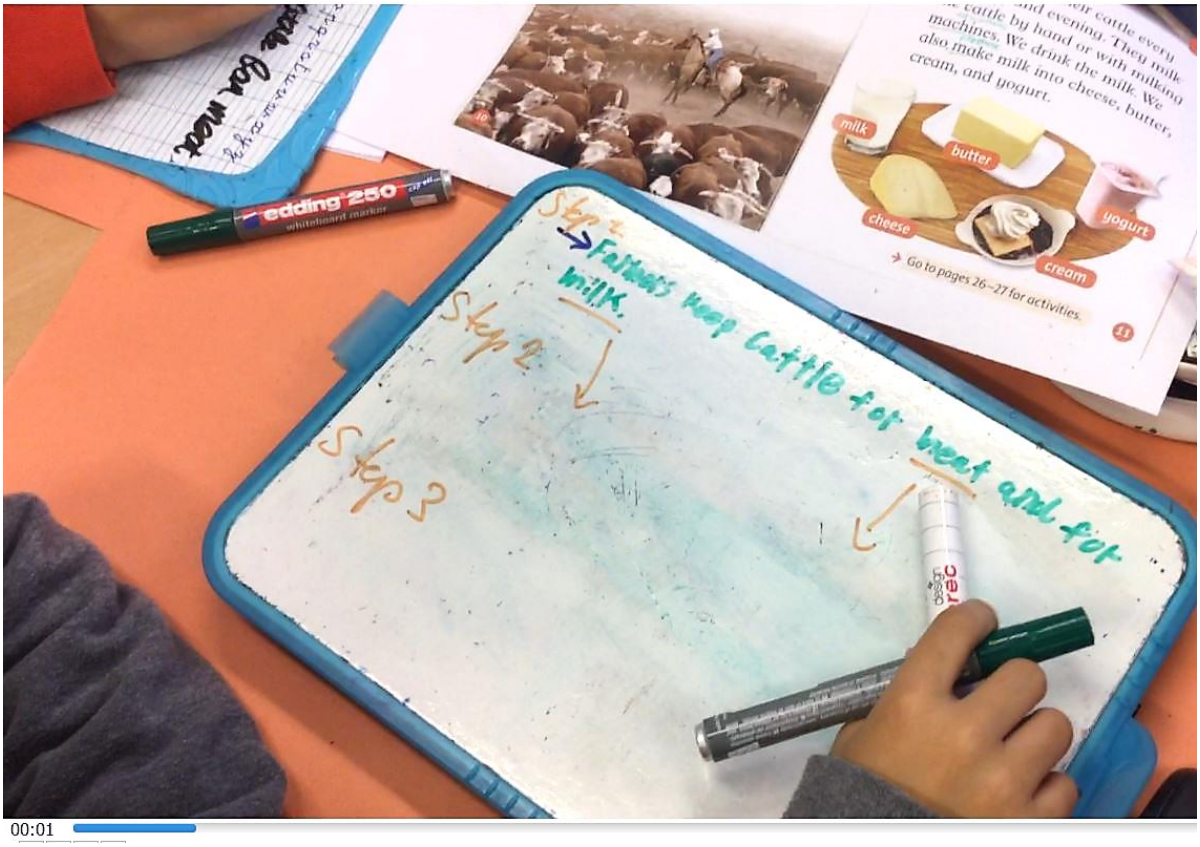
Farming Excerpt 4 – short interaction segment filmed during episode 6

1	0:01.4 - 0:08.2	Yes, there is another word. What can it be? What should we do	Teacher
2	0:09.2 - 0:13.2	so we can underline "keep" and find a book humanities word.	Ryu
3	0:13.7 - 0:33.2	We have to think of what is the humanities word. So there is the, there is the step one. Underline the everyday words. Underline the everyday words.	Teacher
4	0:35.0 - 0:35.3	so	Ryu
5	0:00.2 - 0:00.5	..(recording has restarted) .. is "for" an everyday word?	Quincy
6	0:02.2 - 0:07.6	a little bit, a little bit, so "for" and "keep" are everyday words.	Teacher

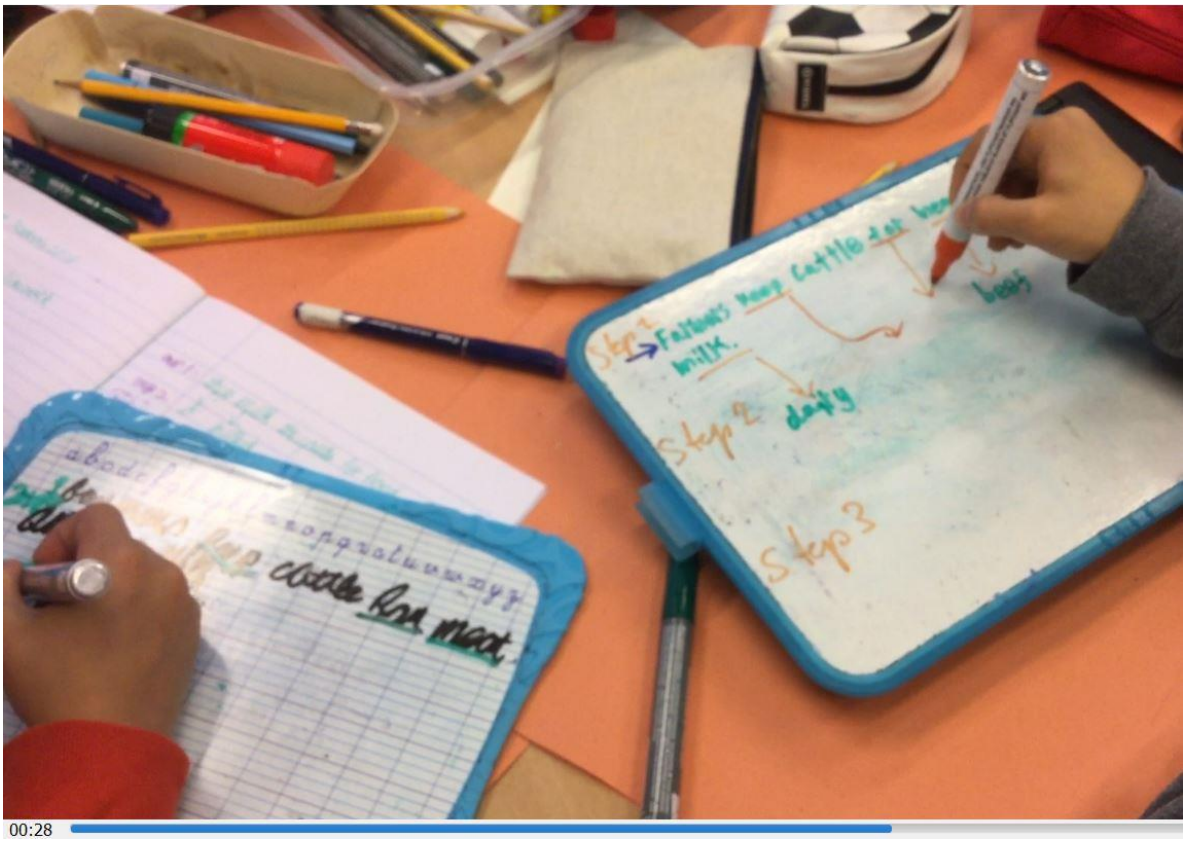
7	0:09.3 - 0:11.4	So you got three every day words, figure 25	Quincy
7	0:11.5 - 0:11.6	no, four (emphasising) everyday words.	Ryu
9	0:13.0 - 0:16.0	What about that one? (pointing to the word "meat" on Quincy's whiteboard) Remember that one?	Teacher
10	0:16.3 - 0:16.8	Oh yeah.	Quincy
11	0:17.1 - 0:18.2	What's that supposed to be?	Teacher
12	0:19.5 - 0:19.6	uh	Quincy
13	0:19.6 - 0:39.6	So now you write your step two write your step two, see what he did (speaking to Quincy and pointing to Ryu's whiteboard). See what he did. so now I'm going to tell you what the word is for "keep" it turns out we say the word *raise*. Farmers *raise* cattle	Teacher
14	0:39.8 - 0:40.2	R A I (beginning to spell it out)	Ryu
15	0:40.2 - 0:43.3	R A I s e	Teacher
16	0:43.8 - 0:45.2	can I write on the word wall?	Ryu

During this interaction, Ryu is calmly initiating points in the languaging work with his questions about the words and with his writing on his whiteboard, thereby showing agency and authority in the same manner as Ruslan did in Episode 2. I feel here, as noted in my daily notes, that Ryu is riding on a sense of success from the day before, seen in Episode 5. He has applied the use of colour, the arrows and the underlining work from before without prompting. He is also showing his noticing of the EL words by pointing them out and underlining them methodically: following his question about "keep", and my question in turn 1 above, Ryu immediately states that "we can underline "keep" and find a book humanities word" and proceeds to do underlining.

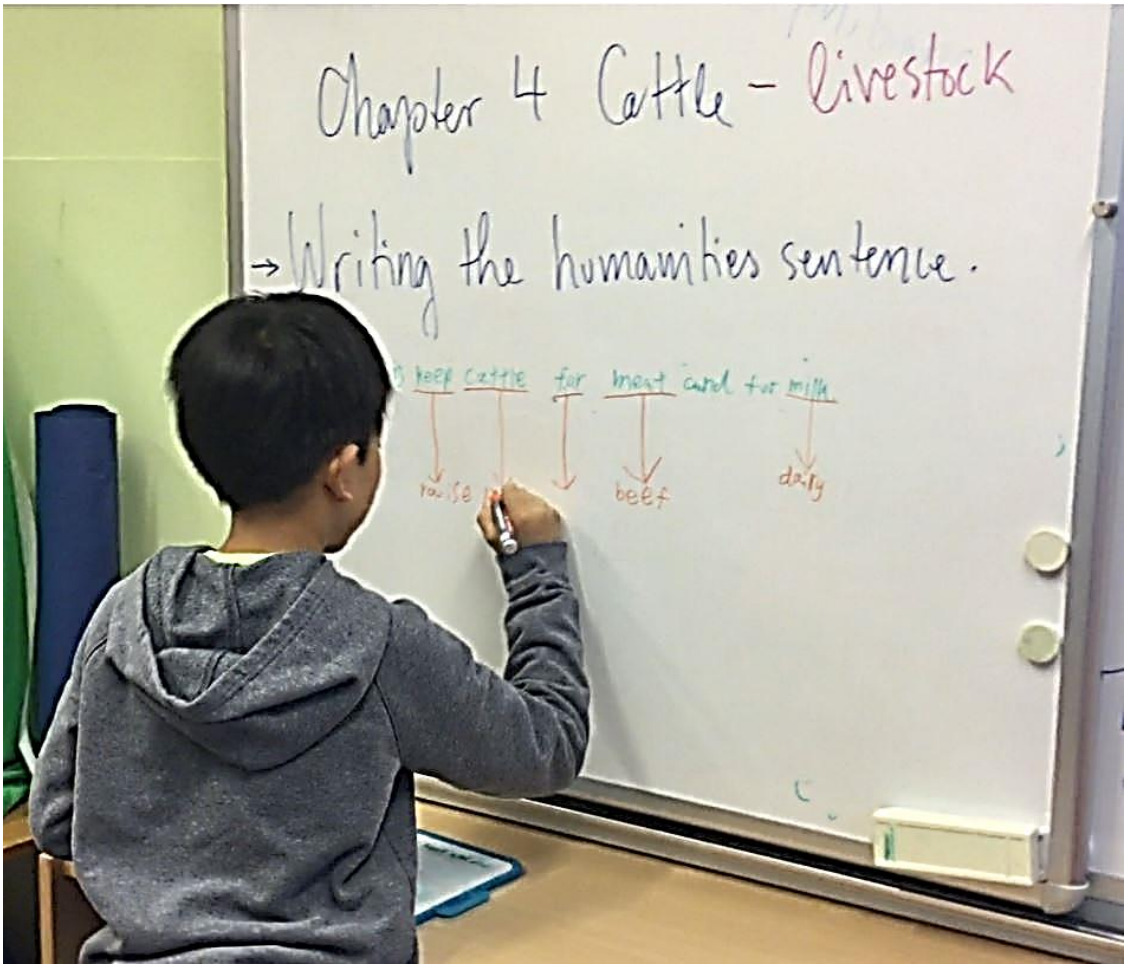
He then prompts me in turn 4 with "so", clearly because I have not answered with the AL word for "keep". In figure 24, he is busily writing in the arrow from "for", because he heard me say that it was another EL word, which Quincy had noticed.



Farming figure 24 – Languaging through MT: Ryu " So this can be *beef* and this can be *dairy* (pointing at each word with his marker)" Teacher "and that is my step 2"

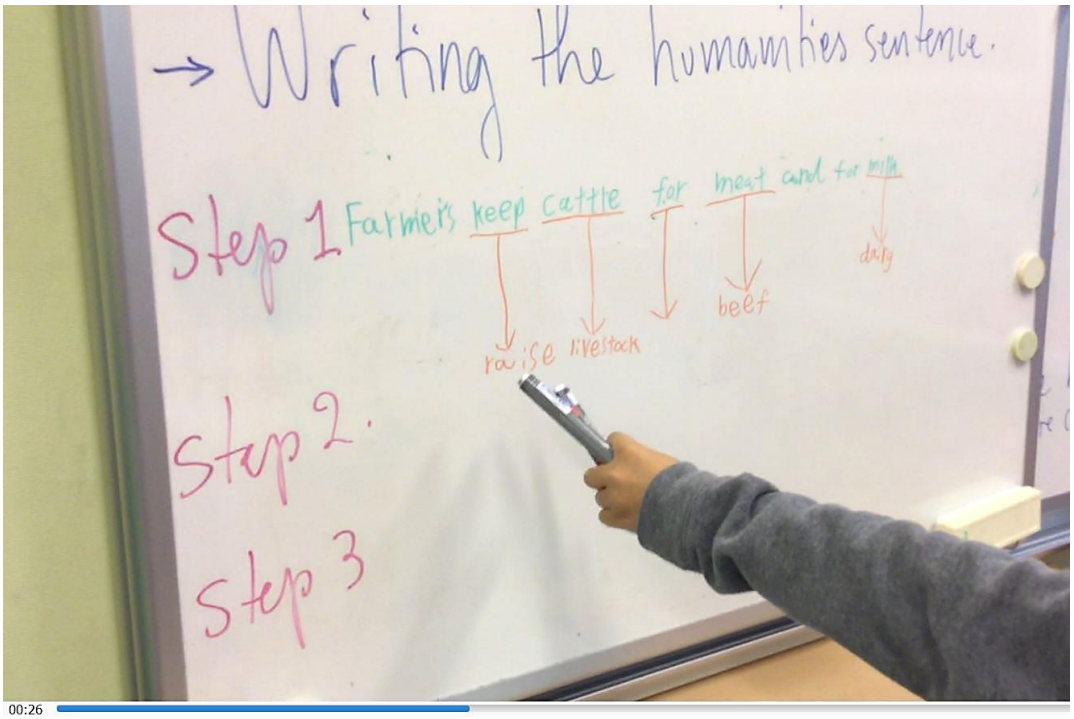


Farming figure 25 – Languaging through MT: Teacher "...so *for* and *keep* are everyday words." Quincy "so you got three everyday words" Ryu "no, four everyday words".

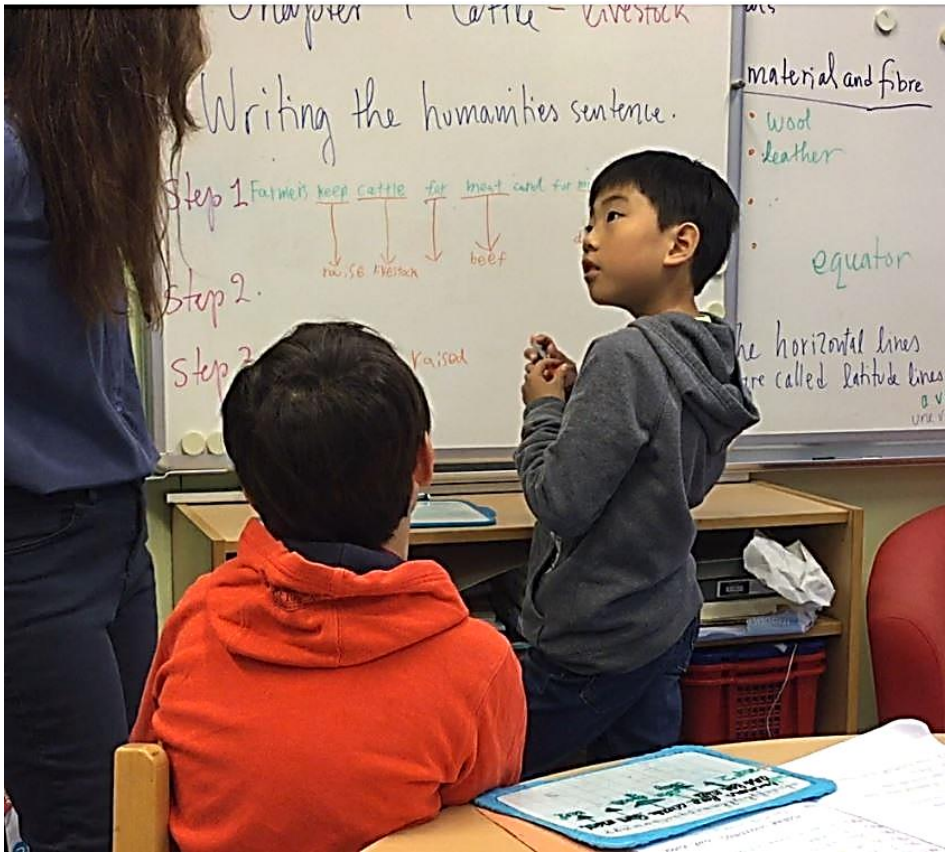


Farming figure 26 – Languaging through MT: While Ryu is languaging at the WB, Teacher " "Cattle". What about "cattle"? What was the humanities word again?" Quincy "*livestock*. The whole sentence is wrong"

I must keep the momentum of Ryu's thinking going, as well as get to step three to see who will do the rewriting to find the AL sentence. I try to encourage Quincy by prompting him to write his step 2 on his board. I proceed to supply the word *raise*, and Ryu is ready to try to spell it. He then asks to write it in the word wall, in turn 16, which he then does (seen in figure 30, top right). I now decide to switch modalities again, and suggest that we do the writing on the WB, and Ryu gets up to do so, as seen in figure 26. He erases the previous day's sentence and writes out what he has on his whiteboard, seen in front of him in figure 26. Quincy supplies the term *livestock*, when Ryu hesitates: "*livestock*. The whole sentence is wrong". I see from this decisive, independent evaluation that Quincy has been thinking about the languaging all along. My effort to promote the meta- talk is aided by our constant reading aloud of our work on the WB the day before through my prompt with *noticing* and *feeling.*



Farming figure 28 – Languaging through MT: Teacher "we don't have *produced*... where is the verb here" Ryu "*raise*?" Teacher "so now you're going to write the word..." Ryu "*raised*."

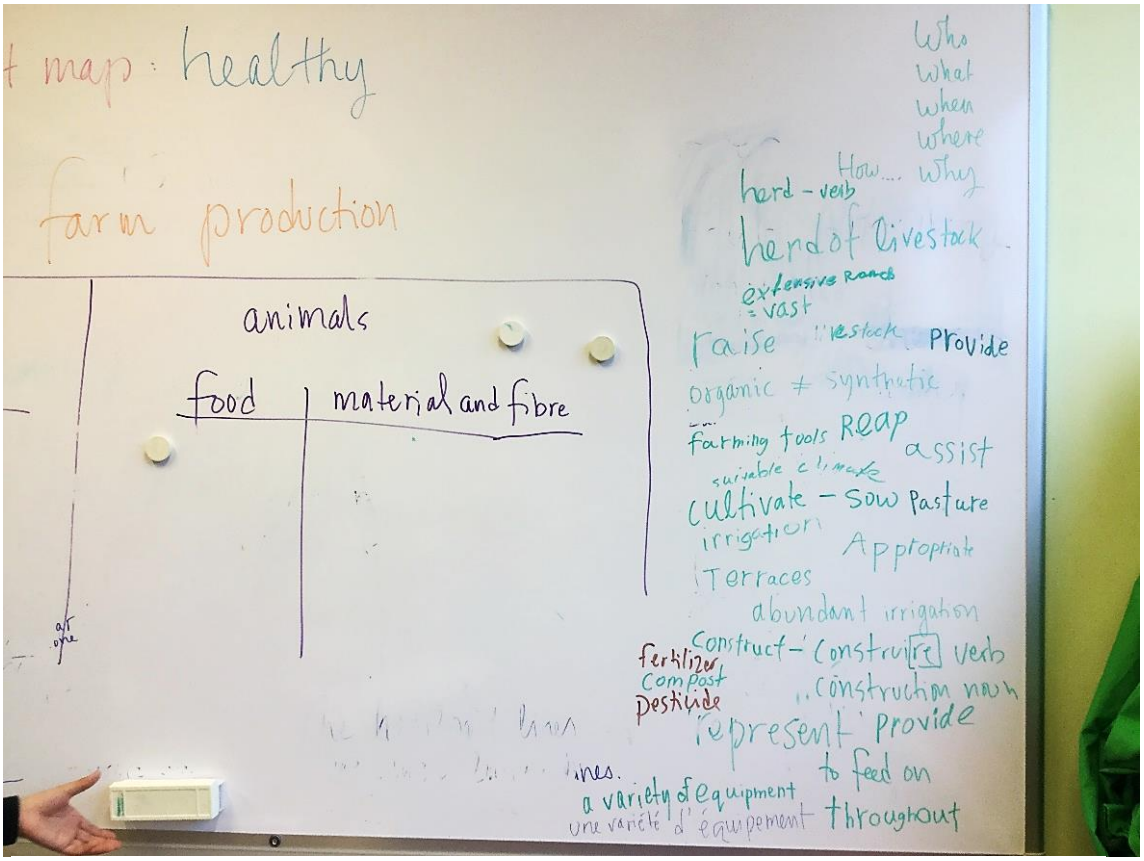


Farming figure 27 - Languaging through MT: Teacher "we have this as our verb, *are raised*, what is going to go first?" Ryu "*livestock*?"

Now to do the step three, I ask Ryu to find the verb because that is key to constructing the passive: I refer to *produced* in the previous examples now written neatly in the notebook, and state that it is not here on the board. Ryu points to *raise* in figure 27, then he states "*raised*" and writes it in the step three space as seen in figure 28. I then ask what word has to go first. Ryu knows that we have to put the "last words in front" from our work with the arrows yesterday, so he quickly states "*beef and dairy?*" to which I point out that it has to go with the verb "*are raised*". He then answers "*livestock*", in figure 28. He then goes on to write the entire step 3 sentence, as seen in the background in figure 29. I suggest to the students that they now sit and copy this work into their notebooks, and they do so, as seen in figure 29.



Farming figure 29 – Languaging: Ryu and Quincy are copying out the languaging work from the WB into their notebooks, using the erasable colour pens. The completed writing steps, written by Ryu in figures 26-28 as shared writing, can be seen in the background. The verb *raise*, which Ryu wanted to write in (turn 16) is visible on the word wall, top right, see also figure 30.



Farming figure 30 – Epistemic work: farming word wall at the end of the unit.

The lesson then continues with more instances of this kind of shared writing, but I conclude the episode here. I have presented these last two episodes in detail, so as to show the interactions around artifacts and writing that foster the emergence of our languaging and translanguaging practices for epistemic work in our developing local culture. These changes are noted in bold in figure 4-3, and discussed in the Intermediate Outcomes for this iteration.

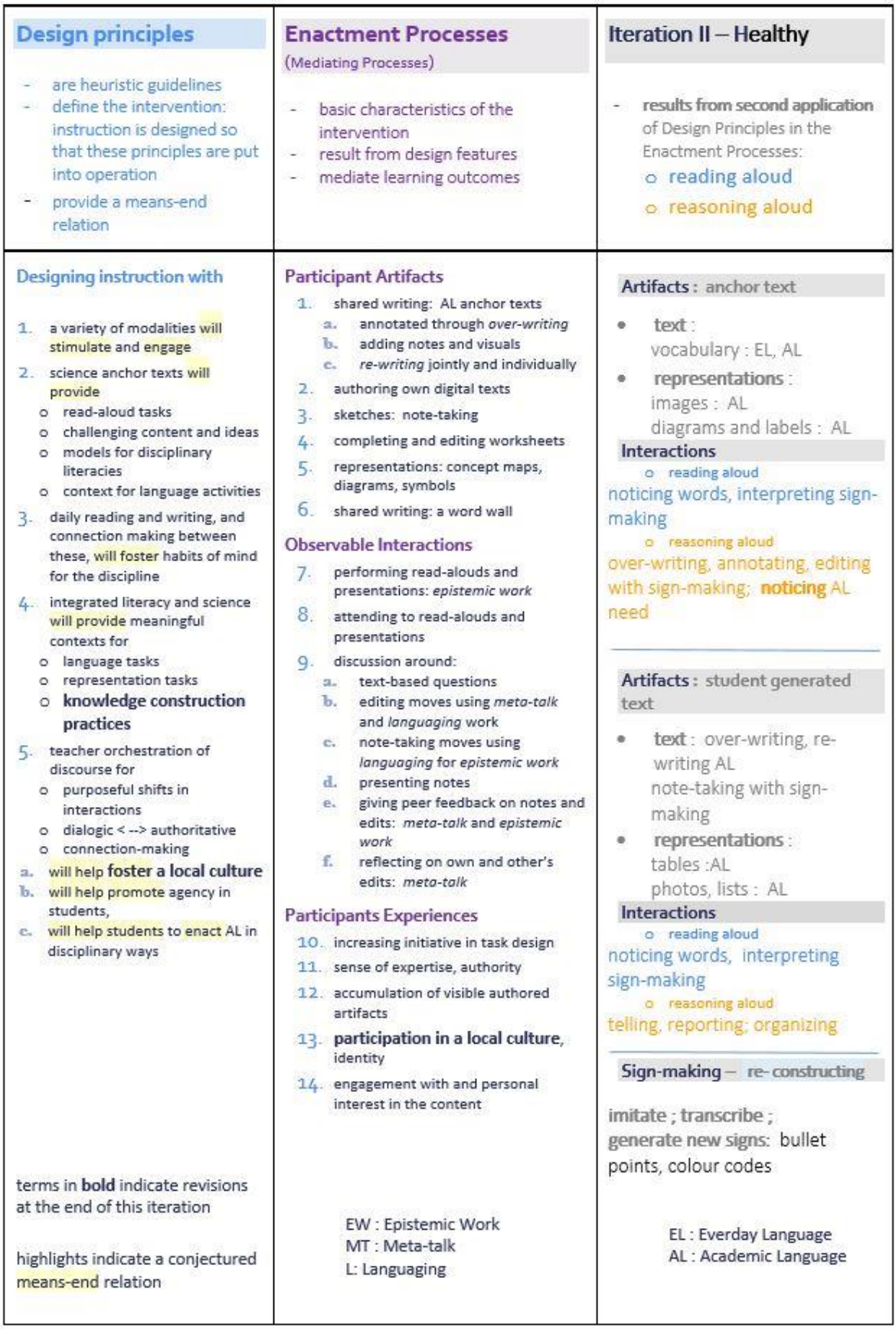
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4.3 Iteration II – Healthy

In this unit, I continue to design instruction with the DPs shown in figure 4-4, carried on from figure 4-3 for *Farming*. The basic characteristics of the intervention are maintained, as shown in column 2. However, the participants (students and teacher) now begin another cycle of activity with a shared history of enacting this design in a self-aware manner. This awareness emerged in the Rich Points, as I showed in Iteration I Outcomes (section 4.2.1): the students stated their views on our practices, using the expression "we are" and referring clearly to the *improvable objects*. I argued that these episodes provided clear evidence of emerging intersubjectivity on the tools and conceptual resources (e.g. Säljö, 1998, p. 59) used by the participants, and that these shared practices therefore constitute the beginnings of our local culture (e.g. Green, et al., 2020; Kelly, 2023).

In this iteration, my intervention involves testing the validity of the DPs and verifying the intermediate outcomes of Iteration I, namely the cultural knowledge of the participants as shown in figure 4-3, by applying the design in a new topic. Figure 4-4, column 3, summarizes the Outcomes of *Healthy*. It shows the further development of our EPs through reading aloud and reasoning aloud practices, shown in blue and orange respectively: moving on from "learning to" to "interpreting", and from "annotating" to "editing with sign-making", and so on. I discuss the evidence for these points in detail in the next section, through a comparison of similar knowledge construction tasks across the two iterations: each episode here is discussed and compared with the similar event in the corresponding episode of Iteration I, and the series of Rich Points is accounted for by referring to the Process Conjectures. The cited meta-talk containing the developing Rich Point is highlighted in yellow.

Figure 4-4 Map of Design Principles and Enactment Processes applied to findings for Iteration II



4.3.1 Iteration II Healthy – Analysis and Outcomes

Introduction

In this second iteration, *Healthy*, I designed new applications for the semiotic tools and interactions developed in Iteration I, with a view to achieving new epistemic goals and new levels of identity and agency for the students. They continue using and further developing tools and practices for sign-making, now building on their shared cultural history. Our stated goal for the unit is preparing a class project on nutrition; hence, the new aim is constructing knowledge resources to be shared in the wider community of the mainstream classroom. My Design Conjectures on multimodal tools, read-alouds, and authoring artifacts are enacted in our established EPs, enabling a growing sense of expertise and autonomy as the students carry out both familiar and new tasks.

Healthy weeks 1 – 3 : episodes 1-4

In episode 1, the familiar task involves the interaction around constructing a new concept map. In *Farming*, this task involved initiating the students to authoring and using the text as a tool for reflection: the Rich Point showed where this took place, in Ryu's re-writing the title. In *Healthy*, students are now conscious of sign-making and are enacting new kinds of authoring, mediated by our interaction and revising their sign-making in successive versions. The sign-making itself is an object of discussion, situated in the conventions in geography as a discipline, thus making connections with "other writers". The implicit connection with a community of experts lends a sense of authority to the students, as they adapt the colour codes in their respective ways, during the interaction, as can be seen in the different ways they each prepared a key (figures 1, 2 and 3). We considered aesthetic criteria, which added to the depth of the students' engagement, as can be seen from the care and detail evident in the drawings. The Rich Point here consists in the collective reasoning and individual application of a design, a colour code and key, which turns out to be a critical signpost in our agency in epistemic work and in our process of developing intersubjectivity through semiotic means.

In Episode 2, the familiar task involves our *read alouds*, introduced in *Farming* episode 2 as reading with a certain prosody and making annotations through over-writing for AL. Here, more authoring practices are applied, with note-taking for editing the text for features such as labels and bullet point lists with headings, seen in Ryu's annotations, figure 5. The Rich Point here involves this *shared writing* for authoring with new sign-making tools, to be employed individually later in the iteration. In this study, I have been using the term *shared writing* as referring to our epistemic work through interaction around a *text* including diagrams and other representations. This is to represent the individual work of writing with sign-making by the student, taking place by means of the oral interaction in the group and the public writing being concurrently inscribed by the teacher on the WB. The concurrent aspect of these *shared writing* and *read-aloud* acts, together with the various kinds of sign-making – i.e. here referring to colour code, bullet points and layout – are designed to promote noticing through sign forms to develop intersubjectivity among the participants. Hence, the Rich Point constitutes a resource for the students about our cultural practices, which we are about to apply in a longer piece of work.

In Episode 3, we continue with read-alouds for over-writing. In *Farming*, the over-writing for AL emerged in a Rich Point through relating the EL terms to personal lifeworld experience in terms of weather, temperature and water. Here, the over-writing for AL takes place through more connections with prior knowledge, but which lead to student argumentation about the term nutrition, and why it should be studied. The Rich Point emerges in annotation of this kind of argumentation point, as another level of authoring to edit the anchor text, seen in figure 6. These conceptual edits, using over-writing and editing for AL, become more frequent in the following iterations.

In Episode 4, we attempt new forms of representation construction, using multimodal functions, author information using the semiotic means that we have been developing, as well as digital tools. In *Farming*, we highlighted key points in the anchor text, and constructed the farming cycle diagram, editing and revising it to add more information and detail with AL through discussion. Here, we are annotating the anchor text on some of the human body organs: reading to highlight key terms, over-writing with new key AL process verbs such as *transport* and *provide*, and using the information to author a personal book in

the Book Creator. The Rich Point can be seen in the students authoring through re-writing the anchor text in their notebook, with the added AL terms and verbs seen in figure 16. This authoring as re-writing is further developed in the next episode.

Healthy week 4 : episode 5

In Episode 5, we perform *read-alouds* with the intention of languaging through meta-talk and carrying out *shared writing*. In *Farming* episodes 5 and 6, students newly practiced the steps of over-writing and re-writing in order to incorporate AL while "writing the humanities sentence". The Rich Points emerged through the students explicitly reasoning and translanguaging both the purpose and the steps of the re-writing. Here, in *Healthy*, the group is able to draw on this previous work as a knowledge resource, and the practice as a cultural practice. It is now about a topic in science, but the transfer to the context is seamless, as performing the read alouds and shared writing practices in the preceding episodes have contextualized and framed this epistemic work as involving these same cultural practices. The evidence is in the meta-talk manner of the students, and their noticing points, which are about AL, e.g. Excerpt 2; the effortless writing of the re-writing steps in the notebook using the colour codes and annotations, seen in figure 19; the persistence in writing several examples of "science sentences" with neatness and care; most remarkably, the evaluative comments by the students on the result and the practice, this time in science. Quincy states "I think it's good. It's a real science sentence." and so this is a fitting title for the section of the iteration.

Outcomes – Iteration II Healthy

This second iteration extends the validity of the Process Conjectures as engendering the suggested outcomes, as the students continued to produce artifacts in the form of text and representations applying new semiotic signs and multimodal tools through the interaction that was established in the first iteration. I conjectured that these tools would enable the students to feel engagement and a sense of carrying out authoring practices, as personal choices as well as seeing the practices as epistemic work. The interaction moves of meta-talk with the languaging and other epistemic work were in constant use by students to express their sense of AL and representation in science, thus expressing their agency and authority in the lessons.

Hence, the EPs mediating these outcomes continued to provide the means for the students to develop new aspects of their semiotic sign-making and new AL through extending the practices that were initiated in *Farming*. The DFs that I determined for the study continue to permit new levels of problematizing the EL – AL continuum through providing opportunities for exploring and engaging with text and information in a science topic.

Through these two iterations, the participants in the group have established a local culture with its clearly defined practices of interaction and using semiotic tools (e.g. Prain and Tytler, 2012, p. 2754; Wertsch and Kazak, 2005, p. 3; Wells, 1999, p. 136) for jointly defined epistemic work. There is now also a history of the local culture (Barab and Duffy, 2012, p. 36). The knowledge resources as artifacts are now features of the local culture as history; furthermore, the manner in which those artifacts were produced is also part of the cultural history, of which the participants are aware through the continuous meta-talk. Hence, knowledge of this shared history promotes the participants' growing sense of intersubjectivity, which is increasingly evident in the meta-talk i.e. our *reasoning aloud* around the *improvable objects,* as seen in figure 4-4. In chapter 5, I discuss these ideas further, as I overview the learning progression through the four iterations.

4.3.2 Iteration II Healthy – Design Narrative

This section sets out the ethnographic Design Narrative for the data selection in Iteration II *Healthy*, presenting the participants' emic perspective through a narrative style which conveys their in-the-moment responsiveness and decisions. This narrative style includes references to gestures and expressions of the participants, in addition to statements about my perceptions or feelings in the context of the interaction, as these impact my decision making for responsiveness to students' ideas (Berland, et al., 2020; Thompson, et al., 2016).

This iteration is only about 4 weeks in duration. However, it is nevertheless presented in two parts: Part 1 shows the participants' (students and teacher) development of the wider context of the human body topic and attendant knowledge construction activities, while Part 2 delineates the students' application of their new ideas and developing representation skills to the nutrition topic work, as preparation for their class projects.

In all references and excerpts of transcripts, the meta-talk containing the developing Rich Point is highlighted in yellow.

Part 1 Healthy weeks 1 – 2 : "because "food" is everyday"

Episode 1 – Concept maps: Epistemic Work

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ disciplinary conventions compared and constructed ▪ idea generation at symbolic level as a discourse practice ▪ publicly *devising symbolic and aesthetic criteria with colour keys and layout*	Rich Point: constructing concept maps using symbolic and aesthetic criteria, by students ▪ Ruslan presents unusual points figure 2 ▪ Ryu writes colour key with adding math symbols figure 1 ▪ Quincy writes colour key with own terms figure 3	Specific Design Principles ▪ *noticing as thinking mediated by semiotic signs* ▪ *new tools for authoring* representations, which are ▪ *objects of discussion as text*

As with the Farming unit, the new unit begins with an activity involving constructing a concept map and creating opportunities for wide-ranging talking points by the participants. The first Rich Point of this iteration takes place during this work, in the students devising new semiotic signs to represent the points arising through the discussion. This construction and discussion activity is carried out over several lessons, alternating with the first read-alouds and annotations of the new anchor text, *How to Stay Healthy* (Penn, 2011). The students' concept map work presented here in figures 1, 2 and 3 (scanned after the lessons) are shown to discuss the students' sign-making, which also permits a comparison with the Farming figures 1 and 2 for the same students, as discussed in the Outcomes section and in chapter 5 in the context of representations as *text* and AL.

As noted in *Farming* (see farming figure 13), we have been using erasable felt pens that I provided, transposing the flexibility of the whiteboard work to the paper, but in a more appealing way than colour pencils which are not cleanly erasable. This is part of my design

for fostering fluidity of ideas transformed in the representation construction process through a variety of tools and modalities for sign-making. In this activity, I have explicitly worked on uses of colour as a code for this representation work, building on what we have already been doing in the notebook writing and on the whiteboards, and leading to our first Rich Point of the iteration.



healthy figure 1 – Epistemic work. **Rich Point** Ryu's concept map "Staying Healthy", after intermittent work during several lessons, showing his elaborate colour key design: new semiotic work with sign-making

Activities in this iteration therefore aim to foster our progression in representational competence, here beginning with expanding on our previous concept map work shown in Farming, Episode 1. Near the start of this activity, I ask the students to each look at a school Atlas, and we note the uses of colour in the physical map of Europe, where it is used to indicate elevation on land or ocean depth. We discuss how colour can therefore show ideas, summarized in a key. The students then proceed to construct a colour code and a key as part of our discussion on the topic, as can be seen in the bottom right-hand corner of each example. I state that using the key also helps when we want to add ideas as we go along, and it is not practical to rewrite everything to be more neat, as with the addition of the item

DNA, which Ruslan provides, from his prior knowledge. In figure 1, he writes *DNA* at the far end to the right, but struggles to connect the term with a line.

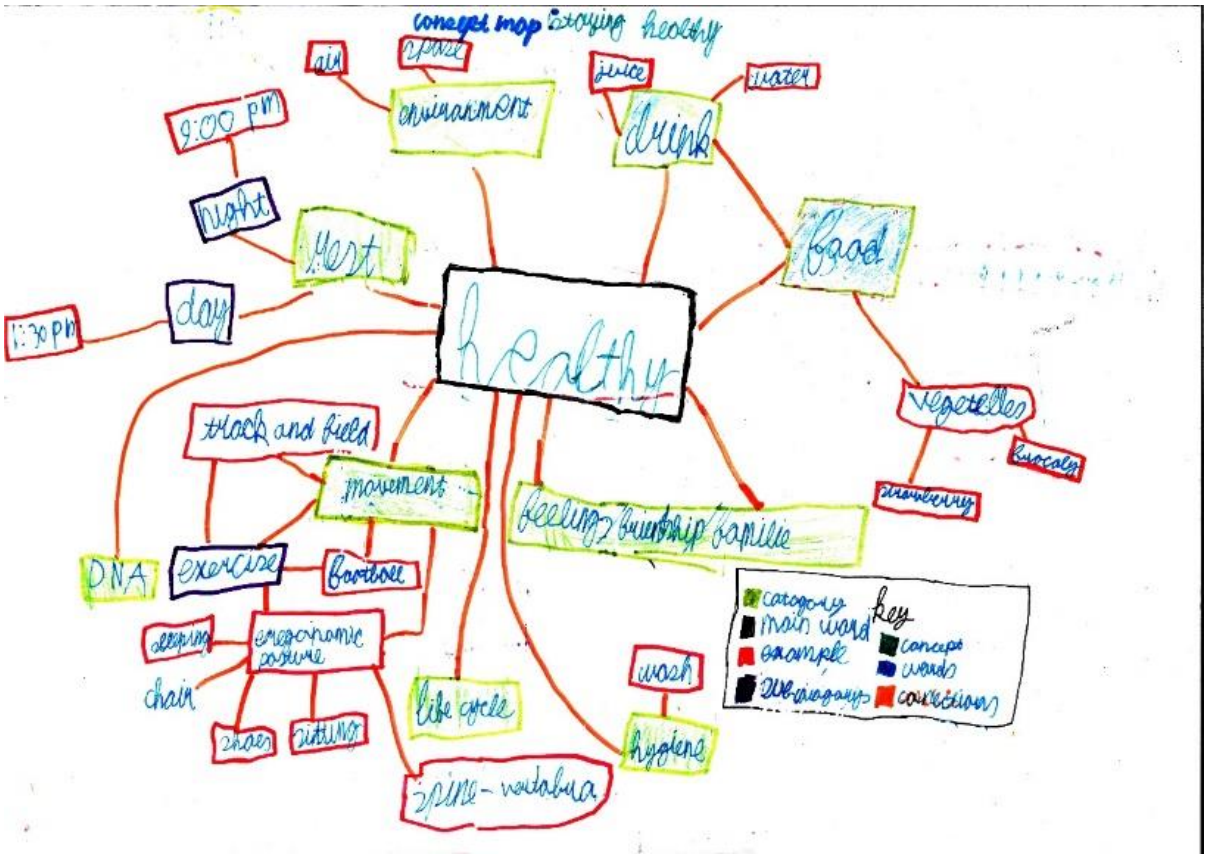
I suggest that to further help structure the ideas visually, the students should shade in the main category as well. They have each borrowed terms from the others, as well as prepared similar colour keys; however, individual choices are still very evident in the details and the layout.



healthy figure 2 – Epistemic work. **Rich Point**. Ruslan's concept map "Staying Healthy", after intermittent work during several lessons, showing his elaborate colour coding: new semiotic work with sign-making

This sequence of work turns into a Rich Point for us, as we explicitly connect the representation work with disciplinary practices such as the mapping conventions in our school Atlas. The explicit discussion on colour work becomes a means for each student to focus on and to *notice* their ideas as manipulable objects, and so concretely "feel authoring", as it seems to me as I view them working, applying their own semiotic signs and explaining to each other. The concept map evolves from a jumble of loosely connected words to a

complex knowledge representation constructed with aesthetic as well as symbolic criteria. Developing these and other authoring practices for representation construction as *text* in a larger sense, constitutes my essential aim in this iteration, as we continue to build our local culture in increasingly conscious ways. I refer to these points in the Outcomes discussion.



healthy figure 3 – Epistemic work. **Rich Point** Quincy's concept map titled "Staying Healthy", after intermittent work during several lessons: new semiotic work with sign-making

My second instructional design purpose in working with colour in this activity involves making the explicit connection for students about colour and layout design in the Book Creator digital notebook work as well as in the paper notebook. Thus, the time that I take here is necessary as it provides us with our models and knowledge resources (Scardamalia, 2002) for our subsequent work in this iteration, as part of building our cultural practices according to my DFs (figure 3-5). Our Rich Points are signposts in our learning progression, where key semiotic mechanisms emerged: I discuss the significance of this Rich Point in the Outcomes section, with respect to the *Farming* iteration, and also as an essential signpost to further work in iterations III and IV.

Episode 2 – Anchor text: Epistemic Work, Meta-talk and translanguaging

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *noticing as EW: seeing images as ideas in the anchor text* ▪ *authoring: writing idea elaborations*	Rich Point: note-taking for idea elaboration, with categories and bullet points, by students ▪ writing: authoring text figure 5 ○ note-taking ○ labelling for ideas: applying own new semiotic signs	Specific Design Principles ▪ integrated language and literacy with representations ○ *text is an improvable object*
Meta-talk (MT) ▪ *reading tasks* are a context for reasoning aloud,		
Translanguaging ▪ student makes connections to own language with the AL terms		

I now turn to our work with our new anchor text for this iteration, *How to Stay Healthy* (Penn, 2011), to present an episode with a Rich Point on our *shared writing* practices: jointly constructed note-taking for idea elaboration. In Transcript 1 we are reading aloud from the anchor text, as shown in figure 4 and practicing annotation through meta-talk. The discussion in the episode relates to the Introduction to this anchor text, shown in figure 5.

In transcript 1, the episode starts with us looking at the introduction to the anchor text, seen in figure 5, which I am holding up in the screenshot in figure 4. In turns 19 through 31, I prompt the students for captions for the images illustrating food and physical activities, starting with "Please write little captions. Every picture should have something. And here, because it's about what, is this about exercise? So what can we write here?" (turn 19) where I connect with their concept maps and the term *exercise* on each of them, and each time I echo the students' suggestions, except when there is a nuance as in turn 25.

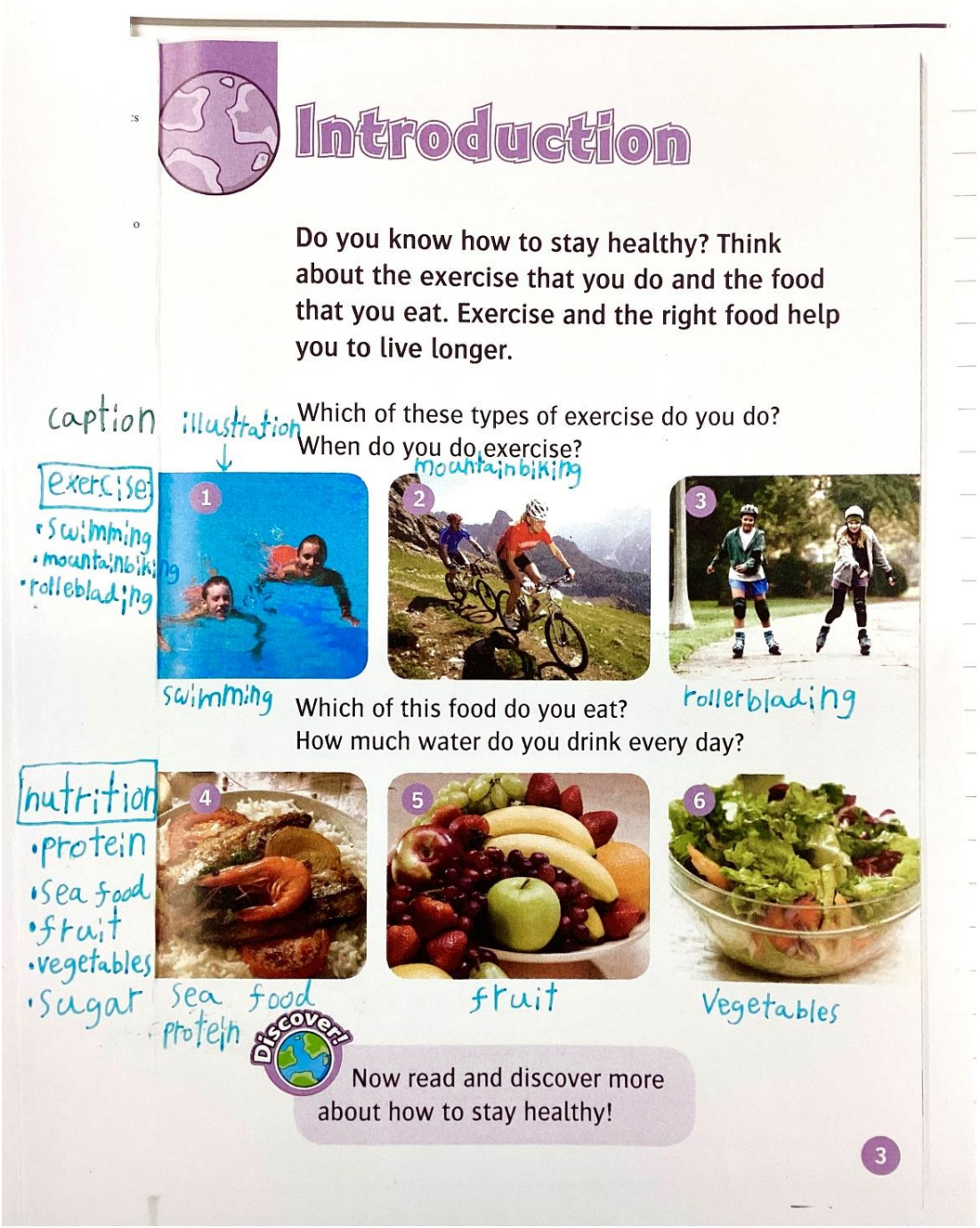
I go to the board in turn 25, and write the word *nutrition* in the word wall, which they have not written in their concept maps. In turn 28, Ryu wants to suggest *energy*: he is consistently making suggestions about words, and I usually aim to take up his point , as part of our sharing of time and agency (Scott, Mortimer and Aguiar, 2006) as we develop our practices. Here, I am staying focused on the epistemic work of identifying the ideas in the images and representing these ideas through captioning. In turn 31, I do meta-talk on what we are doing as we conclude the caption writing, and ask the students to repeat the terms *illustration* and *caption*.

The design in this part of the episode is concerned with continuing the epistemic work of representations and labelling through our text-based discussion practices. By focusing explicitly on how illustrations and captions are used to construct a science text, I am developing the terms for working in the discipline, and continuing to build on the concept map work with categories and colour. Ryu's work, shown here in figure 5, exemplifies our Rich Point in this episode: his note-taking neatly follows my instructions on headings and



healthy figure 4 – Epistemic work through MT. Text based discussion and writing with the new anchor text Introduction page, at 08min50 in the lesson (Healthy transcript 1, turn 1)

bullet points. He and the other students are continuing our visible authoring and our cultural practices for epistemic work.



healthy figure 5 – Epistemic work. **Rich Point**. Ryu's annotations on the Introduction to the anchor text, showing categories and bullet points to extend the representation work on concept maps, to be applied in the digital notebook, figures 11, 12

Hence, we also expanding our ways to annotate text (Lapp, Fisher and Grant, 2008), and to have our models of this work as knowledge resources, ready to carry over across modalities into the digital notebooks, by building on our work in the digital notebook in *Farming*. I have designed further application of practices across modalities into the sequence of activities for this iteration, including continued use of the word wall as a modality. These note-taking practices are representations as *text*, through the application of these semiotic signs. The students are constructing with signs as a new epistemic task in the social plane: they will take this further in episode 4 in collaboration for a common or "collective enterprise" (Alzen, et al., 2023).

At this point in the episode we switch to meta-talk on translanguaging in a spontaneous way, as we discuss what we are doing and how the terms are used in the discipline, and so language becomes the object of discussion. In turn 40, Quincy wishes to add the word *illustration* on the word wall, and there ensues a discussion about spelling and *book words*. Quincy is showing his continued interest in this public act of writing, and I elaborate during this writing point, as an implicit validation of his intervention. I refer to our theme of book words and reiterate the point from the farming unit, that our book words are often the same across many languages. I refer to French, in turn 45 "…all these book words you will find in French" and we pronounce the word *illustration* in French. The episode therefore concludes with translanguaging, as I find a connection with Ruslan's evident interest in the French language, enthusiastically expressed on several occasions in the farming unit. I also attempt to situate us in the wider context of the bilingual character of the school and the francophone society in which the school is located, as communities in which our local culture is a member as well.

Episode 3 – Anchor text : Epistemic Work through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ noticing as EW: *ideas in the anchor text, to be corrected through argumentation* ▪ authoring: *own work is now anchor text* ▪ argumentation	Rich Point: note-taking on argumentation using AL, by students ▪ *note-taking on the argumentation,* figure 6 ▪ *over-writing for argumentation,* turn 103	Specific Design Principles ▪ integrated language and literacy with text o *text is an "improvable object"* o *knowledge is inscribed as a resource,* o *sedimentation of practices: resources shared and used across time*
Meta-talk (MT) ▪ reading tasks are a context for reasoning aloud, rehearsing new AL		

The next episode contains a Rich Point in the form of epistemic work by students during our *read-aloud*, which involves not only performing a reading aloud of the anchor text, but also meta-talk about over-writing and other forms of annotation, as established in the *Farming* iteration. The recording (Transcript 2) begins as we are carrying out this text-based discussion regarding chapter 1 of the anchor text with two students, seen in figure 7. This episode initially involves over-writing, through discussion of academic language terms, but develops into another unexpected Rich Point, this time on student explanations and argumentation through work with the anchor text.

Continuing with my DP of forms of annotation while reading, at the start of the lesson, I am repeatedly asking the two students to suggest finding and highlighting AL terms on the topic that are already in the text, before we add more through over-writing. So, in turn 1, Dai has just suggested *exercise* should be highlighted, and I am prompting for more.



healthy figure 6 – Epistemic work. **Rich Point**. Ryu's notebook page with annotations, including over-writing and highlighting as shared writing derived during discussion.

This work can be seen here in figure 6. I have stated my reasoning to them, ". What's another important book word that we should know. Tell me another one" to establish the goal of these study strategies and habits of mind. Further to that, I refer to the word wall and the concept map as study resources that we can use, in turn 8, as can be seen in figure 7. However, in this second iteration, I am constructing the idea of a sedimentation of our practices (Pierson and Clark, 2019) with the students, since "shared classroom practices influence individual students' practices," (p. 897). In the Outcomes section, I discuss the idea of sedimentation

as part of building identity and a history of our culture through our constructed cognitive artifacts as tools (Wells, 1999, p. 315; Kelly, 2023).



healthy figure 7 – Meta-talk. Discussion on finding AL words in the anchor text, consulting the concept map (in the teacher's hand) and the word wall (transcript 2, turn 8)

At that moment, Ryu, Quincy and Ruslan arrive, and the interaction changes markedly. After an interruption while they settle in, I continue to make suggestions and invite comments, with immediate responses from these students, as shown in this excerpt from Transcript 2. They are engaging in our meta-talk practices, while Dai and Lina write notes.

Healthy Excerpt 1 – from transcript 2

28	7:49.6 - 8:10.1	... OK. And what about *equipment*? (an AL word in the anchor text) We didn't put it in our concept map, but you see that if we had space in our concept map, which is too full now, we would put *equipment* someplace, right?	Teacher
29	8:12.5 - 8:12.6	yeah	Ryu
30	8:12.6 - 8:30.5	And then we would put *disabilities* someplace right? But our concept map is too full now. So what's another one? Do I need to do I need to highlight "supermarket"?	Teacher
31	8:31.6 - 8:31.9	No,	Ryu
32	8:32.2 - 8:35.9	no, no, no. That's an everyday word. That's an everyday word, right?	Teacher
33	8:36.8 - 8:36.9	yeah.	Ruslan

34	8:36.9 - 8:53.6	Right. And do I need to highlight the "right food"? Do you know now I was waiting for someone to tell me the "right food"? Is that science?	Teacher
35	8:54.5 - 8:54.8	No.	Ruslan
36	8:57.9 - 8:58.8	Why is it not science?	Teacher
37	9:00.8 - 9:02.1	Because "food" is everyday.	Ruslan
38	9:02.6 - 9:12.7	The "food" is an everyday word. What about if I say "the right"? "You need the right food" Does that sound, Lina, like a science thing to say? (trying to invite Lina to speak)	Teacher
39	9:14.1 - 9:21.5	Yes. No, right, is he in his right, it seems right, but "food" is not, is everyday.	Ruslan
40	9:24.6 - 9:26.2	What's the science word for "food"?	Teacher
41	9:34.2 - 9:35.4	*nutrition*.	all
42	9:40.6 - 9:40.9	so *nutrition*.	Ruslan

As I take up the discussion again in turn 28, Excerpt 1, I suggest adding the term which is also on the word wall, *equipment*, from the text to the concept map, as well as the term *disabilities* which are both now highlighted on the text page (turn 28). However, in turn 30, I suggest a non-example (Beck, McKeown and Kucan, 2013, p. 84), "supermarket", but the students immediately identify this as an "everyday word". I invite reasoning about the phrase "the right food", trying to connect to the main ideas in the students' concept map work. First I ask "is that science", and Ruslan answers in his decisive tone, "No", which I ask him to justify: he states " Because "food" is everyday" without hesitating. I am also waiting for someone to supply the word *nutrition*, which we have already on the word wall, but I have to prompt for it in turn 40, and then they all state it.

There ensues a lengthy 10 minute discussion, during which several student interventions take place, which constitutes our Rich Point, as we realize the need for AL, or *book words*, to properly explore the concept of *appropriate nutrition for the life cycle*, instead of "you need the right food". For this Rich Point, the annotations on our shared writing through meta-talk are inscribed in the chapter, as shown by Ryu's page in figure 5.

To encourage students to contribute prior knowledge and help them notice their sense of language for epistemic work, I connect with Quincy's point from an earlier lesson about his mother being a vegetarian, and he repeated it with the explanation "she said that she didn't need

to grow that much " (turn 46). I try to show reasoning about that, by saying "…do you see at the different times and different people needed different things. So then the "right food" is too vague," (turn 49). Ruslan comes up with a talking point starting in turn 52 about a centenarian's lifestyle, using the term vegetarian, and "…we can read what she was doing" (turn 54). I seize on this contribution to present the term *investigate*, and to identify Ruslan's point with the behaviour of a science person who investigates (turn 61). This explicit emphasis and discussion on the mindset and practices of the discipline is taken up regularly in my interactions with the students, and culminates in episode 8 of the final iteration.

In turn 82, Ryu contributes with an argumentation point, to connect with my term *life cycle*. "…Because like when you're vegetarian, when you're a child it's it's no good because you just have a healthy food and you're not going to grow. So until 20, about 20 to 24 year olds. You eat the normal food There's a protein in it. And then you can do things going right". I support this turn with further compliments and examples until turn 109, where I close this sequence with a reference to a school science textbook that I hold up, opened to a page about nutrition, stating "…it does not say "the right food". It says *Nutrition* and it says science words". I finally supply the term *appropriate* in turn 109, and request that we write it in the notebook page as shown in figure 6. I conclude the episode by requesting that we write the term *life cycle* in the notebook page (seen in figure 6) and on the concept map (turn 130).

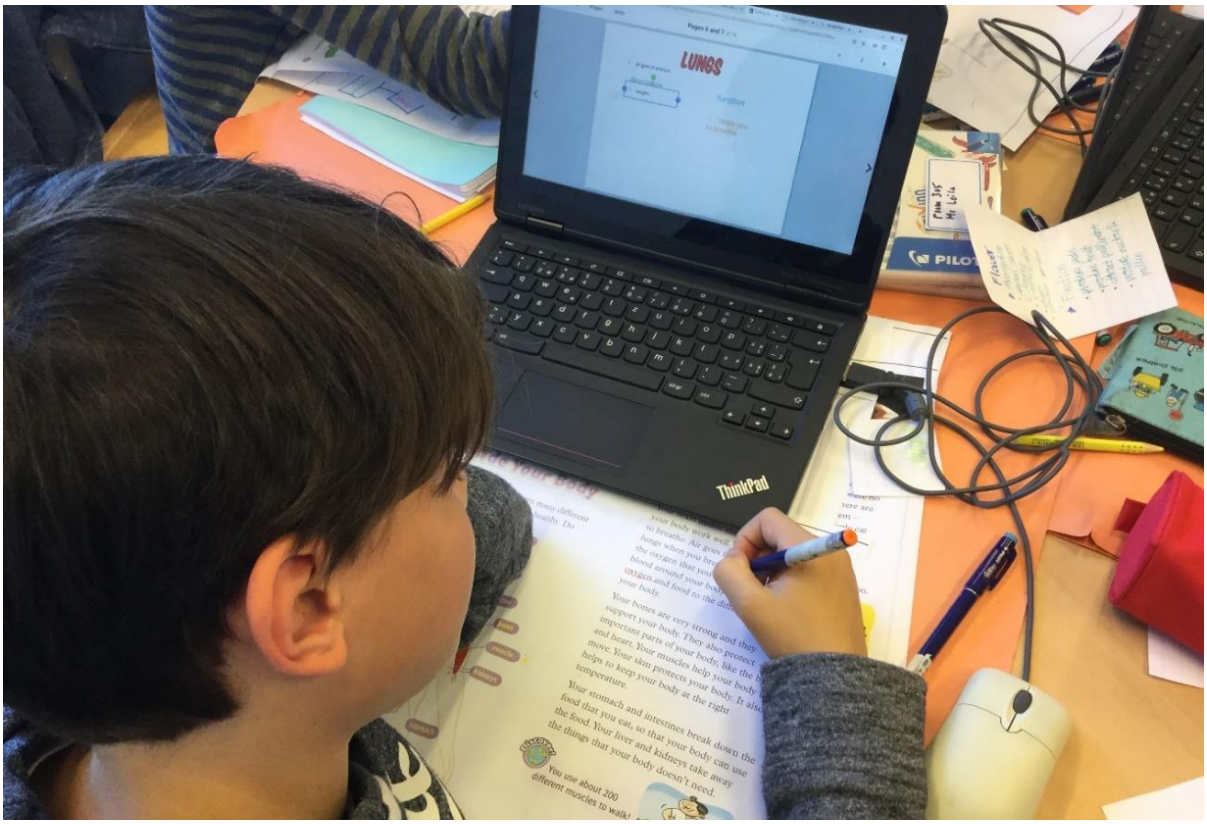
The term *appropriate* was used in the farming unit, and had been on the word wall; however, we erased much of the farming word wall during the new word work on the Introduction page above, and so could not now refer to those words easily without searching through the notebook. On reviewing this video material after the lesson, I resolved to find ways to modify my approach with the word wall in this study, as shown below in figure 14.

Episode 4 – Anchor text and representations: Epistemic work, Languaging

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *connections between diagrams and words as ideas* ▪ *determining choices in semiotic signs* Languaging ▪ text and representation over-writing with the AL terms	Rich Point: authoring through over-writing, re-writing and representation through modalities, by students ▪ authoring text figure 16 ○ over-writing for AL figure 10 figure 11 ○ writing elaborated text figure 14, figure 16 ○ selecting colour, text, layout, symbols figure 11, figure 14, figure 16	Specific Design Principles ▪ improvable objects: elaboration *anchored in Ss constructions and edits of their representations* ▪ *identity building: selecting , constructing semiotic signs* ▪ *authoring text in AL as knowledge resource*

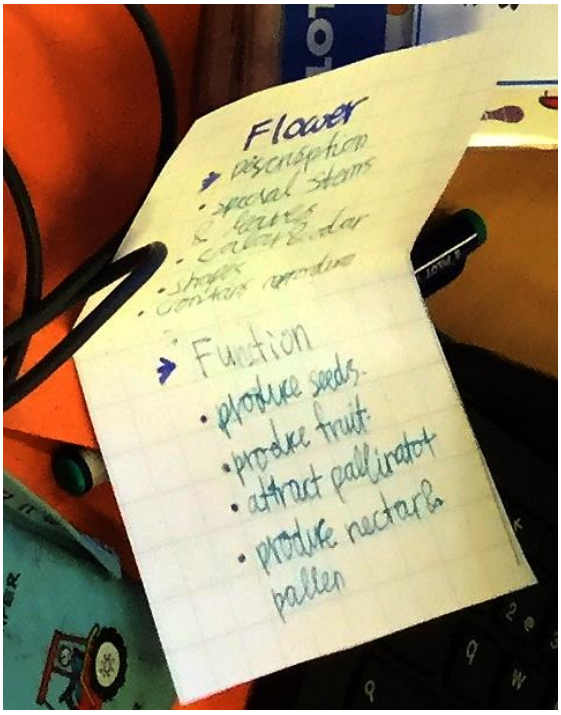
The next episode for this part of the iteration contains the Rich Point involving students doing and organizing knowledge in the discipline, combining our various resources to construct their own individual science book in their respective Book Creator notebooks, again through discussion and collaboration. The second part concerns nutrition and the students' research for the mainstream class project, taking our languaging to a new level of authoring, situated in the context of that epistemic work for a collaborative public goal.

This Rich Point emerges as a through a sequence of activities taking place over several days; I am still referring to this as an episode, as it is organized as a set of our developing cultural activities, which are being brought to bear on a new collective goal of epistemic work. The episode thus involves students collaborating, working in different modalities, carrying out text-based discussion and note-taking, and producing their own individual research based texts on paper, drawing on their work using the Book Creator functionalities on the Chromebook platform.

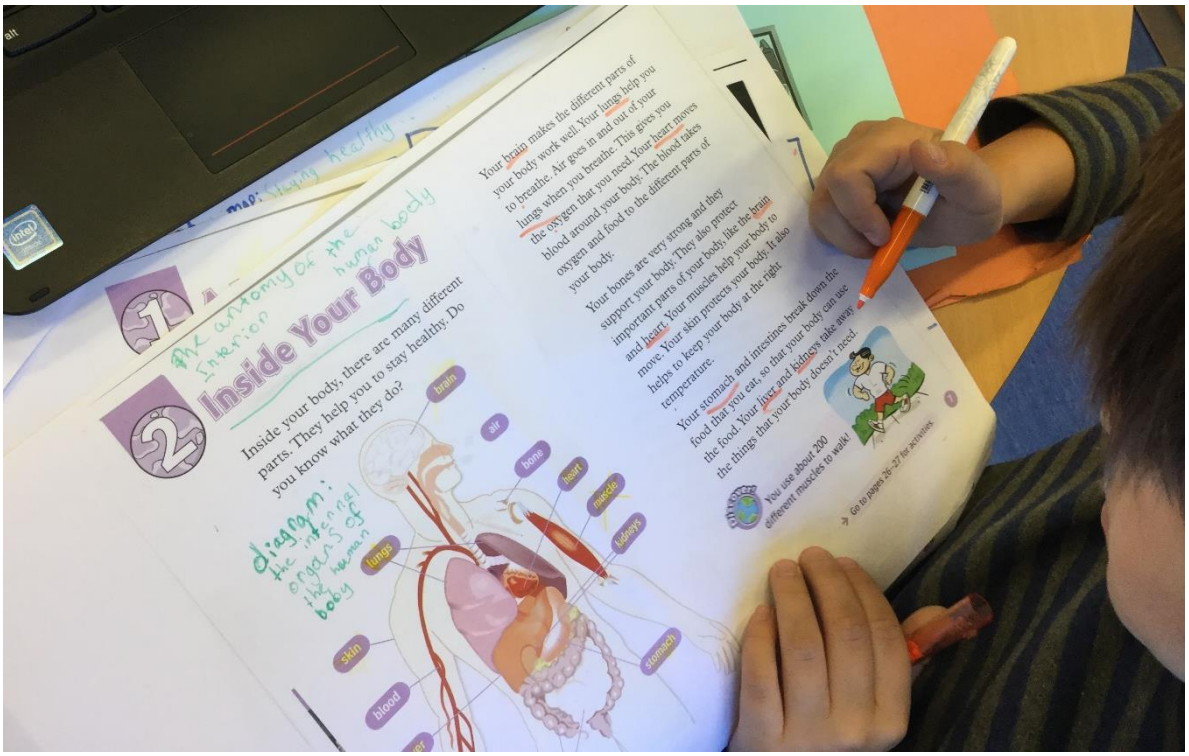


healthy figure 8 – Epistemic work. Quincy is underlining notes in the anchor text chapter 2 on the human body organs, with the Book Creator notebook open in front of him, where he is copying the relevant information that he has selected.

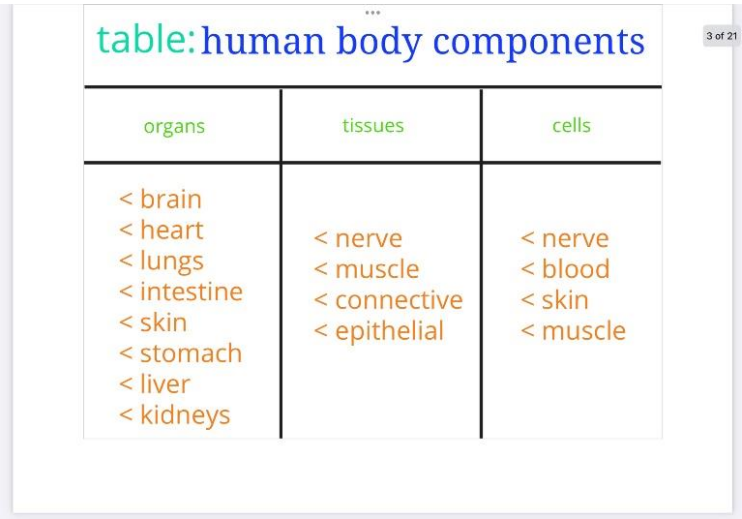
For this sequence, I inform the students that our goal is to make our own book about our own investigation of the human body organs so as to learn more about ourselves, as I had mentioned in transcript 2 (turn 59). At the same time, we discuss that we have more time to practice research and note-taking skills for the nutrition research project taking place in the mainstream class.



healthy figure 9 – Epistemic work. Detail from figure 8, top right, showing the note-taking exemplar using phrases about a plant structure, made by my students in another group.



healthy figure 10 – Epistemic work. Ruslan is reading for note-taking, and underlining the organ names which are the same as on the diagram on the left. On this diagram, we have first highlighted the organ names in yellow through discussion, to apply meaning through a colour code, as there are other types of body components mixed in.



healthy figure 11 – Epistemic work. Ryu's Book Creator notebook page 3 with his chart based on information that he found in the anchor text and certain reference books, using his practice note-taking that he developed in figure 5 for the introduction page.

The sequence uses the anchor text with our practices of read-alouds, discussion and annotation. The chapter 2 of this text is titled "Inside your body", which we over-write in our usual way as shown in figure 10, where Ruslan has over-written the chapter title in green as *The interior anatomy of the human body*. Reading the diagram on the page, we discussed that it had no title, so we agreed on one, *the internal organs of the human body*, to elaborate on the words *interior* and *internal*.

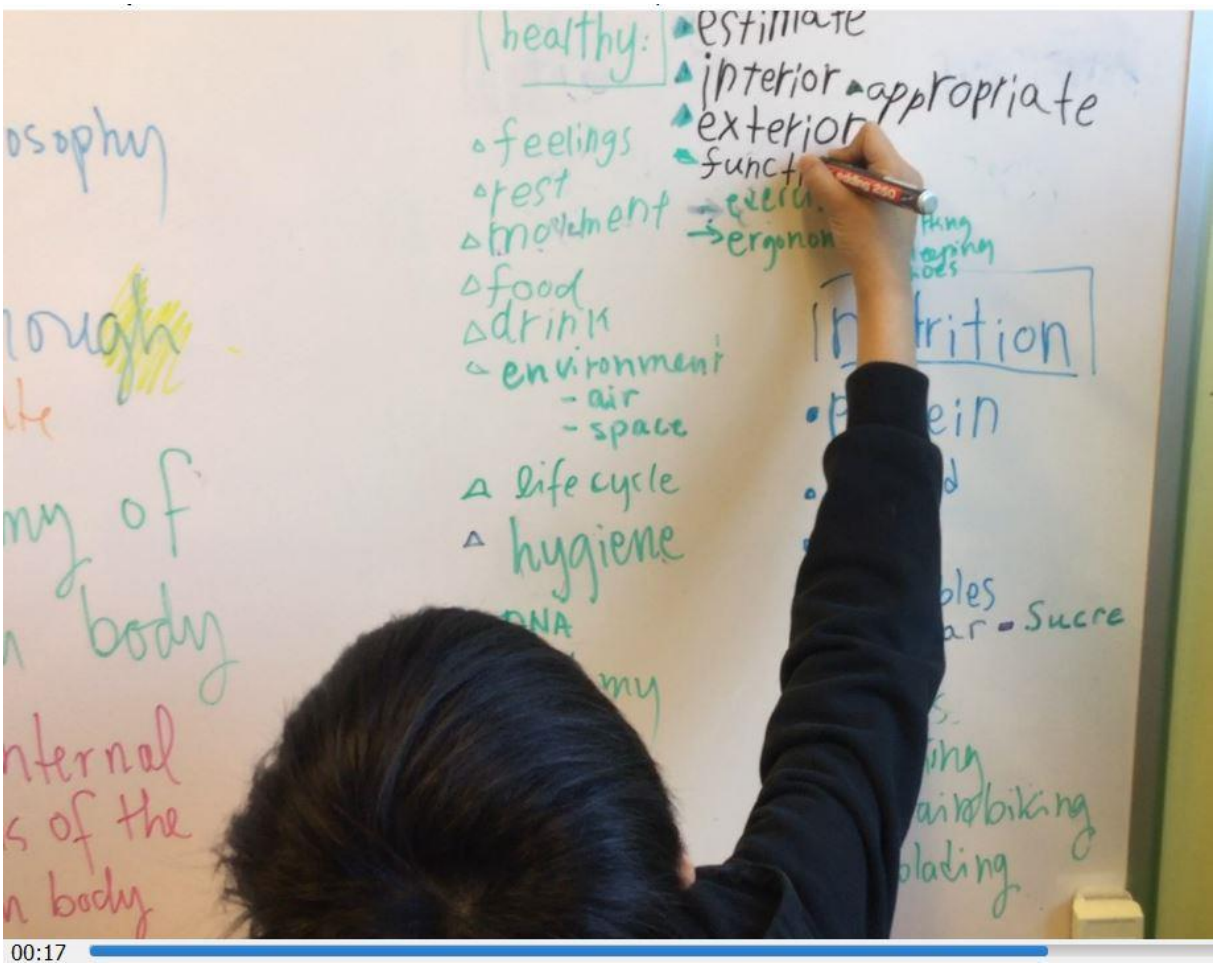
Furthermore, I pointed out that the diagram is disorganized due to lumping all the types of components (various organs, tissues and cells) together using the same colour. We then discussed the types of components in the human body, by comparing with some reference books (seen on the table in figure 13, top right corner) and also the medical model with the removable organs. With those resources, I asked the students to prepare a chart in their Book Creator notebook (figure 11) to organize the human body components better, prior to working on the organs research. This digital note-taking drew on our work on the farming chart on types of crops, (see farming figure 12), as well as our note-taking earlier in this iteration, seen in figure 5.



healthy figure 13 – Epistemic work. View of Ryu's Book Creator notebook page 5 with his photos inserted (see fig. 13) and his notes from the anchor text seen in figure 15, using new AL terms from the over-writing work.



healthy figure 12 – Epistemic work. Ryu and Quincy taking a photo of the lung model with the Chromebook camera using the Book Creator functionality for photo insertion. Reference books for students can be seen on the table, top right

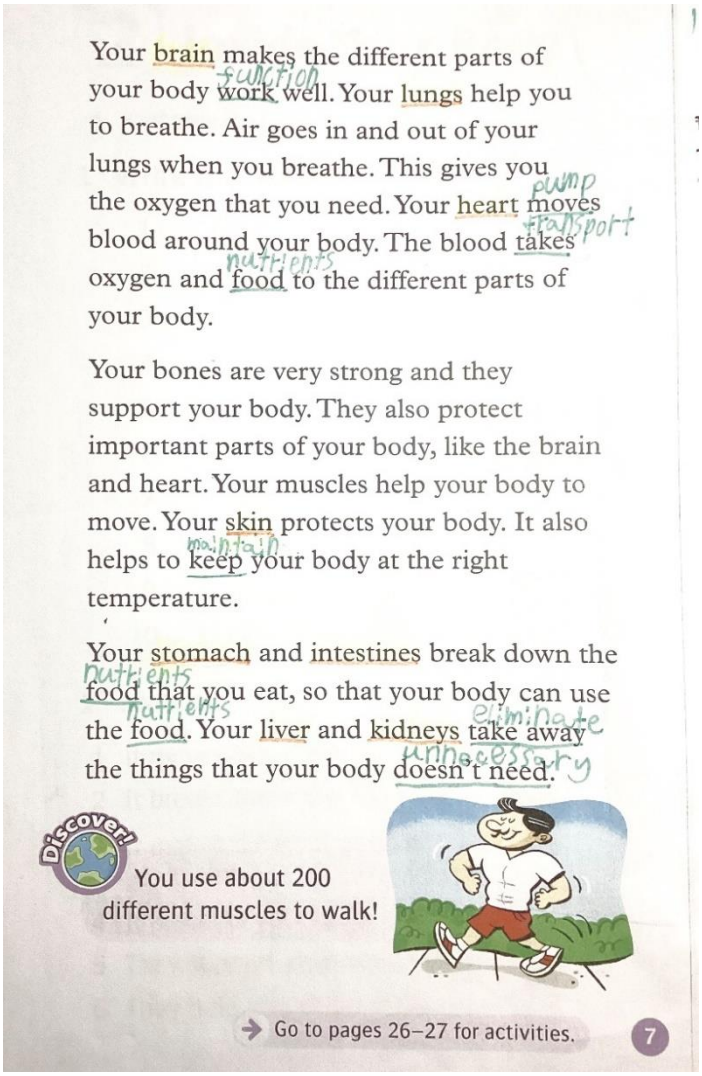


healthy figure 14 – Epistemic work. Ryu writing in *function* on the word wall. Colour codes, bullet points and headings are now being used; different handwritings indicate different students; the teacher wrote *hygiene* and the sport words bottom right. Ruslan wrote *sucre* in French, next to the word *sugar.*

Then we disassembled the medical model of the torso as a type of hands-on investigation, reassembling it again every day in this sequence. The students identified the 3D model of each organ through discussion, referring to the anchor text diagram. We followed this with taking photos as shown in figure 13, so as to prepare our own reference book, adding the information that we found in the anchor text, as shown in figure 12. This information had already been read aloud and discussed, with over-writing, as can be seen in figure 15: Ryu has written in the AL words which he then proceeded to use in his own digital notebook pages on the organs.

The exemplar for this kind of writing was discussed using material that I had prepared with my students in a different teaching group, as seen in figure 9. This exemplar again showed the students how to title the bullet point list, and to make their own creative bullet points,

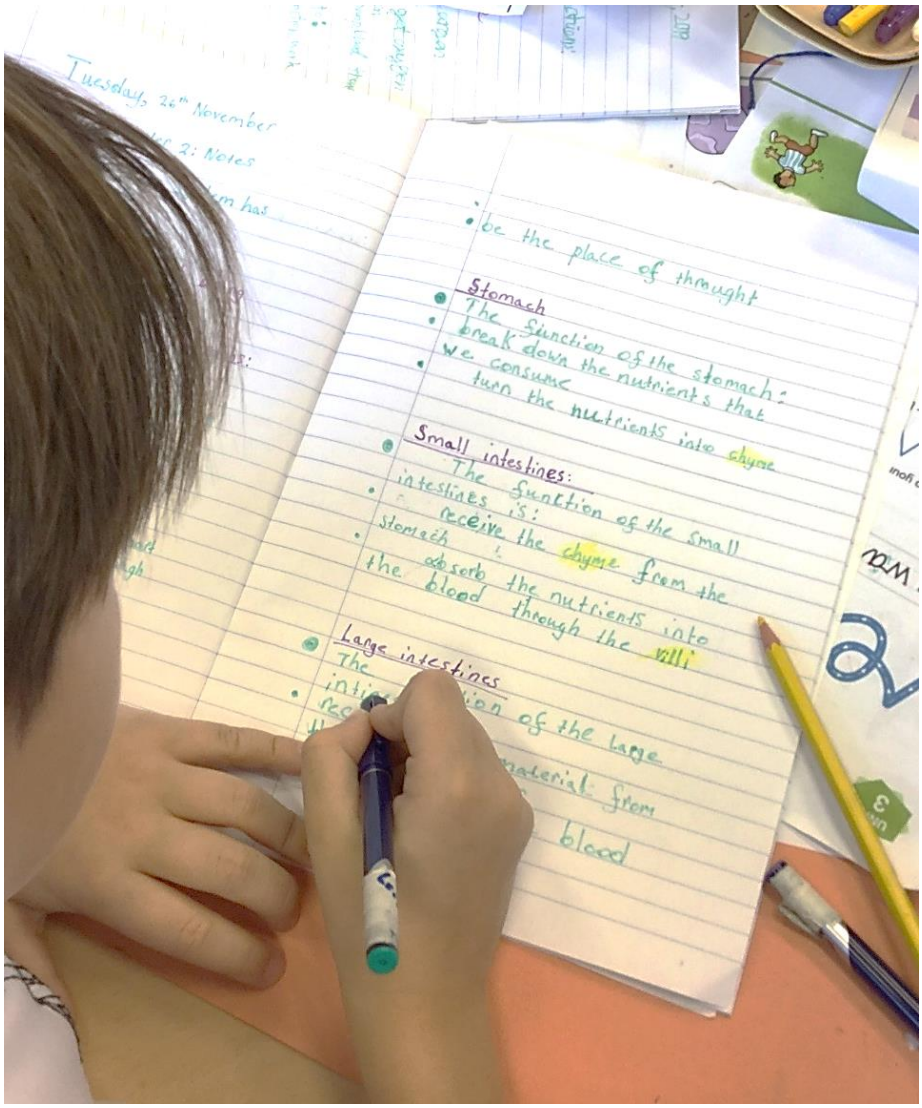
which we had worked on in figure 5. However, this exemplar also showed notes using *phrases*: there are AL verbs for each item, which the students are familiar with, such as *produce*. Hence, our over-writing seen in figures 10 and 15 included process verbs such as *carry out* and *provide*, which Ryu has typed in his digital notebook, figure 12.



healthy figure 15 – Epistemic work with Languaging. Ryu's anchor text chapter 2 with over-writes with the AL words, prepared through our discussion, prior work in the notebook and on the word wall; this page is also seen in figure 8 and 10

This digital notebook work therefore drew on our work in the farming unit, but had the novel element of this multi-modal note-taking, as we as taking our own photos as a form of investigation. This is a term I use in transcript 2 (turn 59) to compliment the students, as I refer to them as "scientists". I refer to "scientists" and "what scientists do", regularly during

the successive iterations, according to my DPs of developing identity and mindset for the discipline.



healthy figure 16 – Epistemic work. **Rich Point**. Ruslan is re-writing the chapter 2 text into his notebook, drawing on our over-writing work as seen in figure 15, our hands-on activity with digital notebook work, and our research from reference books. He is applying the titles, colour codes, bullet points and highlighting note-taking strategies from these activities.

This creative research and over-writing in the anchor text was then carried over to re-writing by hand in the notebook, as seen in figure 16, which summarizes our Rich Point. The students author: they re-write the anchor text, drawing on our sequence of work, to change the narrative style of chapter 2 by using the AL terms; furthermore, they author through the "hands-on" investigation and the information derived as described above.

Using the exemplar "flower functions" card (figure 9) and the digital notebook work on note-taking in figure 12, we modelled the disciplinary style of these sentences using what

students are calling the “science word” (transcript 3 turn 2), by means of our established discussion based process of shared writing,. In figure 16, Ruslan is writing out headings, bullet points and phrases, modelled on *The function of the small intestine is,* followed by bullet points with the process verbs and the key terms for the topic highlighted in yellow.

Part 2 Healthy weeks 3 – 4 : "I think it's good. It's a real science sentence"

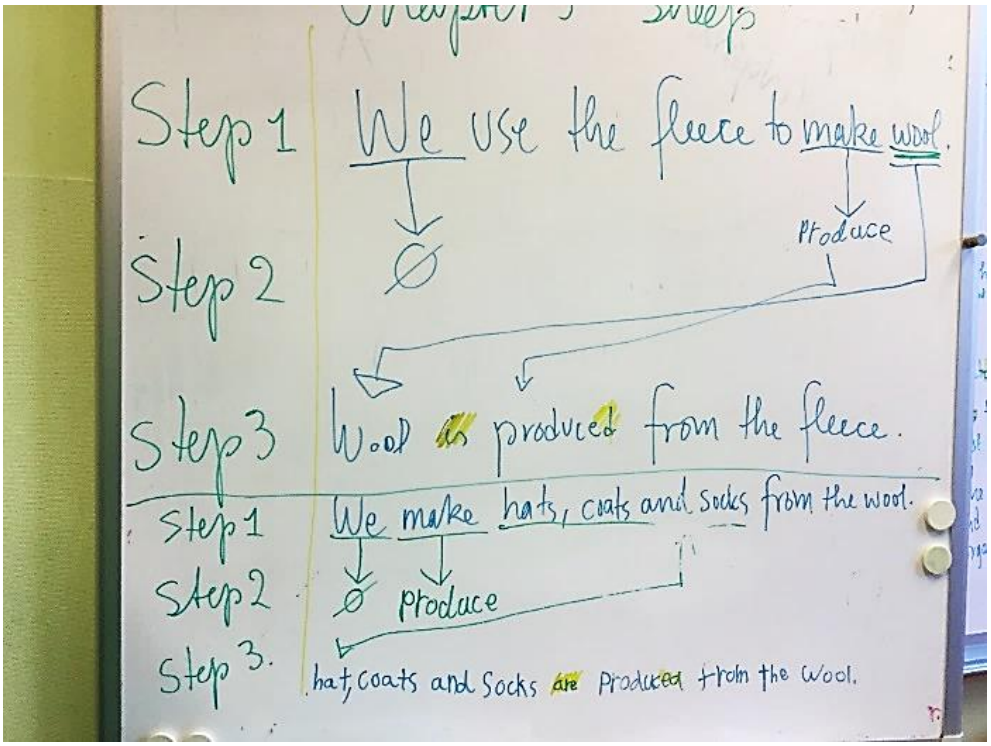
Episode 5 – Anchor text : Languaging through Meta-talk

Enactment process	Evidence	Design Principle
Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need Languaging ▪ text and representation over-writing with the AL terms	Rich Point: Languaging, shared re-writing and evaluating, by students ▪ writing: *authoring text through languaging and meta-talk re-writing practices:* ○ as object of reasoning and discussion figure 17 ○ as elaborating, extending ideas figure 19 ○ selecting, re-writing for AL figure 20	Specific Design Principles ▪ improvable objects: elaboration *anchored in Ss constructions and edits of their text* ▪ *identity building: authoring text in AL through cultural practices*

The Rich Point in this section emerges in the discussion around the students' re-writing of their notes on nutrition using our languaging through meta-talk practices established in *Farming*. We discuss AL words and re-writing steps, while concurrently doing research about some foods and their nutrients for the class projects. We are therefore able to continue to a new level in the development of our cultural practices: epistemic work using new forms of language and other semiotic signs through our meta-talk, situated in carrying out the term project in the mainstream class as a personally relevant context with a public goal (Hickey, Chartrand and Andrews, 2020).

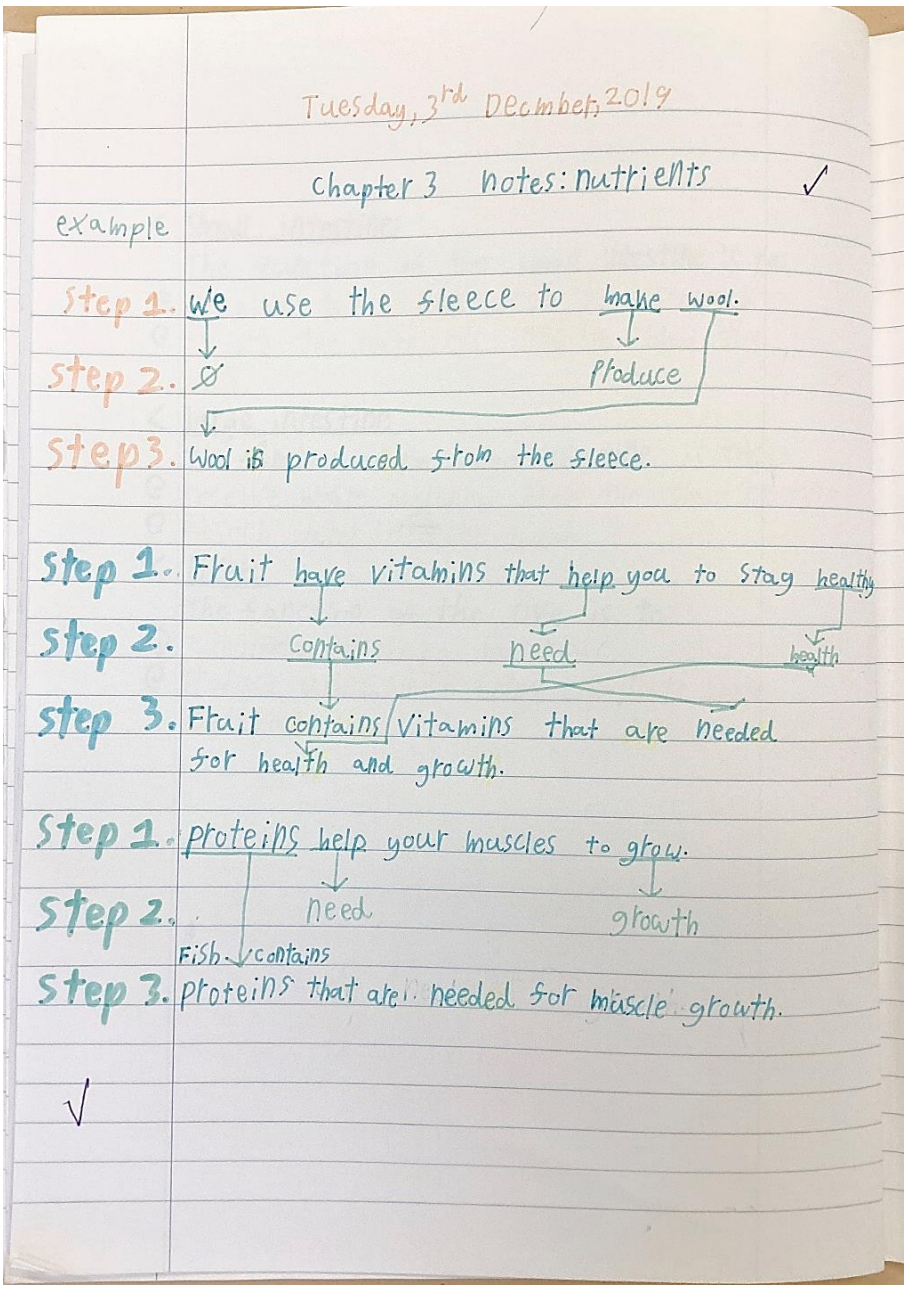


healthy figure 17 – Languaging work through MT. Prior to starting new writing work for the new chapter, Quincy, Ryu and Dai are re-constructing one of the writing steps re-writing work constructed during the farming unit (fig. 18) as knowledge resource, seen on the laptop screen as a photo of the WB work, at omin 00 (transcript 3)



healthy figure 18 – Languaging work through MT. Making use of our own knowledge resources, in new languaging and writing. Re-writing work from the end of the Farming unit, showing my shared writing in the first example, written through discussion; Ryu's step 2 and 3 re-writing in the second example; he has also written *produce* in both examples.

In transcript 3 , excerpt 2, shown below, we are already in chapter 3 of our anchor text, titled "The Right Food", which can be seen in the middle of the table in figure 17. The transcript shows the second half of the lesson, following our familiar read-alouds and over-writing of the anchor text through discussion. We are using this chapter to provide us with information for the term projects as well as to continue with our languaging and writing steps through our familiar process.



healthy figure 19 – **Rich Point.** Languaging: Ryu's notebook page with the writing completed during this lesson (see figure 20), my check marks in purple. Ryu's step 3 with *proteins* shows that he has erased and written in *Fish contains* and *that* during his languaging work, turn 50

Hence, the research notes for the projects can be written in the same discourse: for example, the students have re-written the title for the chapter in the notebook as *nutrients*, as seen in figure 19.

In turn 1, I am encouraging the students to refer to their previous notes on the re-writing steps, and have just asked them to recopy our exemplars seen in figure 18, which we had constructed together during the *Farming* work. Figure 17 is a screenshot from the start of the episode, showing the students writing, and with the photo of the exemplar on my laptop screen for ease of access rather than having them flip back and forth in the same notebook. In my dialogue I am going through the steps again in our languaging through meta-talk manner, and in turn 2, Ryu completes my prompt about the "the book word is the …" by adding "science word". The discussion through to turn 19 refers to the middle task in Ryu's notebook page, shown in figure 19.

Having reviewed by constructing our knowledge resource from our previous work together, we begin to language through meta-talk about the new science sentences using our established practices. This review was also necessary for Dai's benefit, as he had not been present for this discussion and writing process during the Farming iteration, although now familiar with over-writing for AL. Hence, as I stated in turn 3, I make the explicit connection for the students, "we need to first remember or realize that the science word needs to go in instead of the everyday word, right? And then we're going to go with our example of today " with my meta-talk, and I copy the new sentence for discussion on the WB. In turn 5, I begin the meta-talk with prompting for the re-writing process, by pointing out the verb "have", and the students respond to indicate that they see what the task is about. I ask "have", what what are we going to change with "have"? "Have" is going to be what" (turn 7) and Dai responds immediately with "*contain*" (turn 8) demonstrating his comprehension of our over-writing for AL.

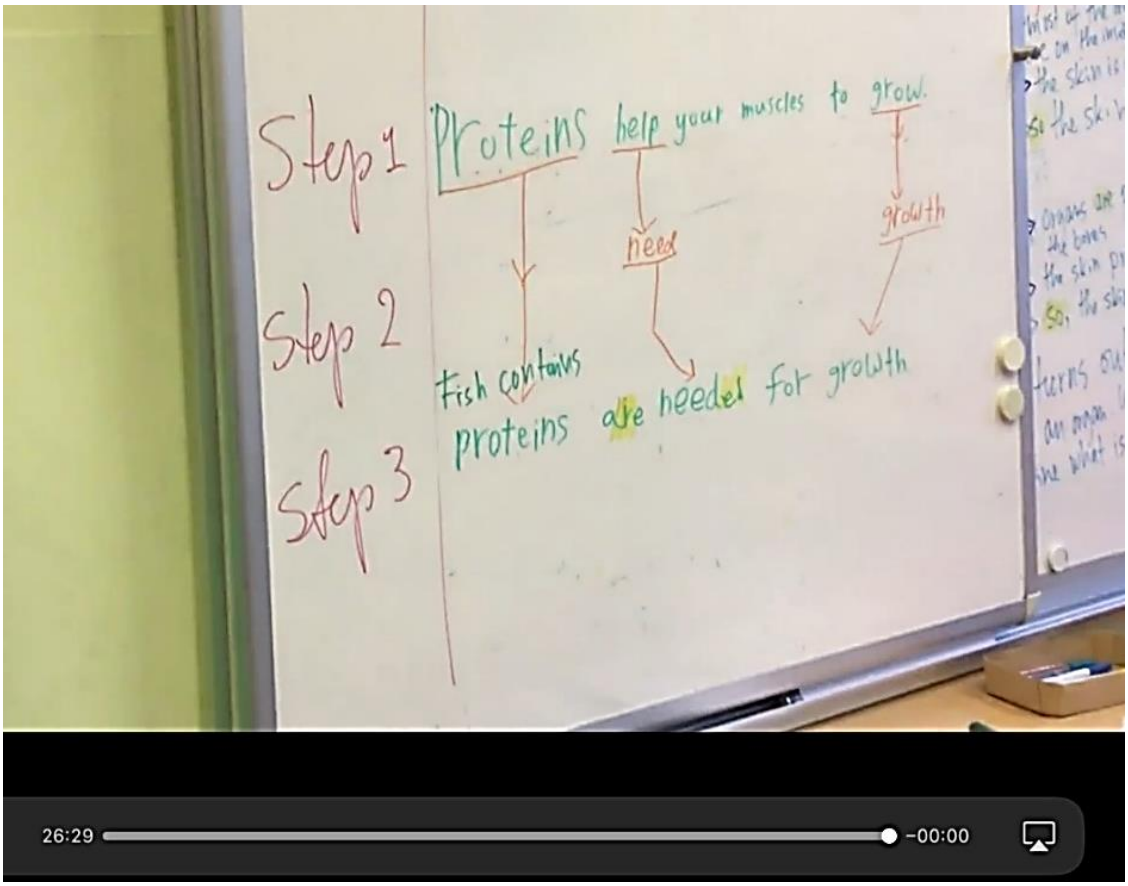
I continue with my writing of the languaging steps on the WB, stating the words to be changed and that these must be underlined, while prompting the students with our note-taking colour codes. In turn 12, Quincy meta-talks on the verb "help": he looks up as he is writing in his notebook carrying out the work for example 2, as seen in Ryu's page in figure 19. I show this interaction here in excerpt 2:

Healthy Excerpt 2 – from transcript 3

12	6:18.9 - 6:20.8	Wait, "help" is wrong, right?	Quincy
13	6:21.2 - 6:44.4	That's right. "healthy", instead of "healthy" we're going to write *health*, just the noun. (T writing at the WB) Remember, we're going to start taking away the verbs and adjectives, and we turn everything into nouns, ideas, because science is ideas and facts. OK, so *fruit*.	Teacher
14	6:49.3 - 6:51.3	Instead of "helping to" something, *need*.	Quincy
15	6:57.9 - 8:17.9	Right. So now we had so we had . How was my colour code before, my colour code was like this, so *fruit contains vitamins that are needed*. let's write *health* and *growth*. *Health* and *Growth* in.	Teacher
16	8:19.6 - 8:26.3	I don't I don't think I wrote the *continues growth*.	Quincy
17	8:28.4 - 9:05.2	So are you OK dear? OK And then I put the yellow. …. (pause while students write in silence)	Teacher
18	9:54.2 - 10:20.6	Good. Good. So let's look at it. One person is still copying out. Well done. How do you feel about this sentence now? Let's read it out loud. *Fruit contains vitamins that are needed for health and growth.*	Teacher
19	10:21.6 - 10:26.4	I think it's good. It's a real science sentence.	Quincy
20	10:28.3 - 10:29.4	How do you feel that?	Teacher
21	10:30.7 - 10:44.3	Well, because fruit, because it doesn't have, have the word "have", and "help", it, it has science words inside	Quincy

In turn 13, I remind the students of the features of the science writing that we have been working on since the *Farming* unit, "Remember, we're going to start taking away the verbs and adjectives, and we turn everything into nouns, ideas, because science is ideas and facts", and in turn 15, I write and say "let's write *health* and *growth*". In turn 18, I ask the students to evaluate our work as I have written the annotations on the board and the students have copied in their notebooks, "Good. Good. So let's look at it. One person is still copying out. Well done. How do you feel about this sentence now? Let's read it out loud. *Fruit contains vitamins that are needed for health and growth*". Quincy responds firmly with "I think it's good. It's a real science sentence" in turn 19. He explains by saying "because it doesn't have, have the word "have", and "help", it, it has science words inside" (turn 21). I believe he is connecting with Ryu's statement in turn 2 a few minutes earlier, "science words". He has been initiating meta-talk, in turns 12 and 14, leading up to this emphatic evaluation. This exchange in the interaction on our re-writing in this episode constitutes our

concluding Rich Point for the iteration, as it summarizes the students' increasing sense of epistemic authority, as exhibited by their initiated meta-talk and evaluations throughout this transcript.



healthy figure 20 – **Rich Point**. Languaging work through MT. The WB at the end of the lesson showing the shared writing: the three steps re-writing work by Ryu, also written out in the notebook as seen in figure 19.

Each student is in fact seizing opportunities to intervene in this episode, as seen in the work on the next example. After a few turns of observing the students' work and complimenting, I ask the students to try another re-write, which is discussed in turns 28 through 51. The purpose is to ask a student to go to the board, and Ryu goes to the board at my request in turn 33. I wish to see him build on his work in Farming Episode 6, e.g. figure 26. His work here is seen in figure 20.

I continue with my process of meta-talk for languaging, and provide colour pens, as he works. As in the preceding re-writing task, I prompt him with "what are we going to do instead of to "grow"?" (turn 36). At first, he thinks of the past tense, grew, but I prompt him with "what's the noun, Remember, *healthy* and *health*" (turn 38), and he responds with "*grow* and *growth*" (turn

39). We continue with our meta-talk for languaging and I ask "what are we going to say instead of "help"" (turn 40) and Dai contributes again with "*contain*" but Ryu contradicts and says "oh that's *have*" (turn 41), to which I give compliments. I prompt again with "what did we say" and Dai remembers and says "*need*".

With this episode, I conclude Iterations I and II; the cumulative Outcomes are discussed in section 4.3.1, where I delineate the progression in our practices thus far, and summarized in figure 4-4, where I indicate revisions to the design, due to the findings shown in this narrative section.

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4 ***PART B**: Iterations III and IV*

4.4 Iteration III – Kelp Forest

My design for Iteration III *Kelp Forest* involves assisting students with their preparations for a class presentation regarding an aspect of ecology, while continuing to enact our discourse moves for AL around *improvable objects* for knowledge construction*;* that is, e*pistemic Work* (EW), m*eta-talk* (MT) and *languaging* (L) practices enacted around a new anchor text and new student generated text and representations.

In this unit, I follow on the successful application of DPs in Iteration II *Healthy*, in obtaining individual and collaborative knowledge construction outcomes involving new forms of sign-making for note-taking purposes as well as for editing. I continue to design instruction with the DPs shown in figure 4-5, carried on from figure 4-4 for *Healthy*, with one important revision, shown in blue highlight, DP 5a fostering a local culture. The basic characteristics of the intervention are maintained for Artifacts and Interactions; for Experiences, items 11 and 13 are revised to show the emergence of agency and cultural practices. Column 3 indicates new interactions: the participants now begin to build on the more individual note-taking and representation work of *Farming* and *Healthy*, to carry out collective knowledge construction (Scardamalia and Bereiter, 2014) on common objects of activity (Paavola and Hakkarainen, 2005) through various reading aloud and reasoning aloud activities around new semiotic work. These revisions are discussed in the Outcomes section and in chapter 5.

In the Outcomes section, I relate our processes for making connections and using prior knowledge to our developing practices for EW. I present arguments, based on the selected episodes, for how these processes involve student agency and a design enabling responsiveness to student thinking (e.g. Bishop, 2021; Hammer, Goldberg and Fargason, 2012) and contingency (Boyd, 2012) in enacting the interactions. These conditions emerge in these episodes, in order for reframing and transfer of learning to be possible for the student, as evidence of internalization of discursive processes being practiced in the social plane in the preceding iterations. The sense of the collective identity emerging in this iteration, building in the sequence of activities involved in preparing the common goal of the class presentation culminates in episode 5. The students' reading aloud and reasoning aloud around the representations establishes them as having a clear sense of our cultural practices, and their identity as epistemic agents in these practices.

Figure 4-5 Map of Design Principles and Enactment Processes applied to findings for Iteration III



4.4.1 Iteration III Kelp Forest – Analysis and Outcomes

Introduction

In Iterations I and II, my intervention consisted in applying the DPs in my Initial Conjecture Map so as to test the Design Conjectures across two units on different topics, one in humanities and the second in science, over a similar length of time, and to establish the characteristics of our interactions around artifacts that we discuss, edit and construct (Wells, 1999). In *Farming*, I made use of students' prior knowledge of EL forms to introduce our meta-talk interactions for our over-writing and languaging to begin to define AL and its uses for epistemic work. Hence, we began to define our activity in the social plane, (Wertsch and Addison-Stone, 1985), through beginning to build agreement on *text* as words and other semiotic signs, so as to have a "shared perspective" (Wertsch, 1997, p. 111) on our work with the EL – AL continuum.

This shared perspective emerged through the EPs in *Farming*, and were continued in *Healthy*, where students practiced more forms of epistemic work in sign-making for constructing representations, as well as in over-writing and re-writing for AL in this science topic. Students began to state their understanding of AL by evaluating their work through criteria for AL elaborated through these two units, thus giving evidence of our parallel understanding of our group and individual work, i.e. our intersubjectivity (Wertsch, 1997), mediated by our cultural tools: meta-talk on these *texts*, or constructed artifacts, and our application of the various sign-making practices for epistemic work.

In *Iteration III Kelp Forest*, it becomes possible to reach new levels of languaging and epistemic work through meta-talk in applying my DPs, as the students have attained a clear awareness of our semiotic tools, and of the processes for applying them. I now tested my Process Conjectures on enacting work around a relatively new topic in science, namely biomes. The students had had lessons on food chains in their previous school year, but the goal of this unit was to prepare a presentation for the mainstream class on a biome and its interconnected species, and thereby reach a deeper understanding of ecology. I wished to

open opportunities for the students to act on their developing sense of authority and authoring, with this goal of sharing our knowledge resources outside our group.

Kelp Forest weeks 1 – 3 : episodes 1-3

In episodes 1 and 2 we continue our practice of working with the concept map: here, it functions as a clear signal of the new unit. In *Farming*, the students used the concept map to report ideas, and began to use it as a visual for a slightly more elaborate explanation, when prompted. In *Healthy*, they initially used it as note-taking, but elaborated it as epistemic work through the application of new semiotic signs as a new level of meaning, while adding new ideas through discussion. As a consequence, here in *Kelp Forest*, when prompted to consult their *Healthy* concept map, Quincy and Ryu in fact began to reason with it in hand, as they compared it with the new work and justified including old terms in the new concept map, or evaluated the use of the concept map. Dai uses his presentation of his map as a basis for extended reasoning, as the Rich Point in episode 1. Hence, the students are creating needs for explanations (Kress, et al., 2001, p. 18) as discussed in the *Farming* Outcomes, but now based on their own epistemic work as a resource, and constructing their own extension to this resource by pointing out *differences* and gaps in text through its thought-generating aspects (Scott, 1998, p. 63).

This activity has therefore developed and changed considerably. Their own *text* now clearly functions as a "thinking device" (Lotman, 1988 cited in Wertsch, 1997, p. 115) and through our practice of *noticing gaps* in text as we perform our read-aloud discussions, the students have begun to enact noticing as thinking and epistemic work. I consider this as evidence of the students' process of transitioning this work from the social plane to the intramental plane: Quincy's individual work to apply a word from his previous work to the new constitutes a form of inner speech, which he then externalized as he was prompted to speak about his new map. Ryu's extended evaluation of the practice, quite unprompted, suggests that he was thinking on the point while constructing the new map. Hence, the work on the concept map and the meta-talk around it constitutes part of our semiotic mechanisms for this transition (Wertsch, 1985, p. 167), as shown by the Rich Point emerging in episode 2. This signpost in our uses of text as semiotic mechanisms is taken up in chapter 5 as part of the discussion on *noticing* and negotiating intersubjectivity.

In episode 3, we turn to representation construction in working with diagrams, as in *Farming* and *Healthy*. In these two iterations, we began the representation work through our read-aloud discussion on the anchor text; here, we continued the research practice from the work in episode 4, and prepared notes and definitions for the energy pyramid. These notes immediately served to carry out representation work on the ocean biome, through interpreting the information on the organisms as anchor text. The read-aloud discussion took place in the groups, without my participation except to encourage and prompt to read again at times. The Rich Point emerged in the students' new representation work, with new sign-making, enacted through familiar interaction moves around *text*, using recently developed semiotic signs. I return to the point of our transformed uses of *text* and other representations through the *noticing* practices, as shown in these episodes, in chapter 5.

Kelp Forest weeks 4 – 7 : episodes 4-6

In episode 4, we return to consider the anchor text as *improvable object*, as in *Farming* and *Healthy*. In *Farming*, we initially used the anchor text to over-write, as through the read-aloud, we identified gaps to be resolved, which involved adding AL. At the end of *Farming*, we began to re-write for "humanities sentences" and students were able to articulate the process. In *Healthy*, the read-alouds involved re-writing for science sentences, applied in authoring for the writing on nutrition in the notebook, using new semiotic signs. Here, our read-alouds discuss the representation work in the anchor text: we *notice* and *identify gaps* by comparing with our newly constructed knowledge resources, and recalling the interaction on argumentation about the ocean biome that took place in the social plane. The students explain and justify their criticism and re-construction of the ocean biome diagram in the anchor text, using AL and science concepts developed in the preceding episode, again exerting epistemic authority and authoring new semiotic signs.

The work in episode 4 continues in episode 5, with over-writing of the sentences in the anchor text, through points initiated by the students. Here, our discussion around the improvable object has transformed: students are noticing gaps in the anchor text, but at the concept level, evaluating it with "it doesn't make any sense" (excerpt 3) and providing clear arguments. Where Ruslan detected a gap in the AL in *Farming*, with "is there another word for 'water'", he now states with authority what the gap is and why. Our interaction in the group

is now that of equal participants with epistemic agency and authority, clearly given form through the echoed phrases, highlighted in yellow; furthermore, our echoed phrases are also expressed in mirrored facial expressions and eye contact, all evidence of our new levels of intersubjectivity and identity in our local culture. The students' use of "we" further confirms that this is a local culture with clearly defined practices and goals. I take up some our interaction moves as evidence of intersubjectivity, in the chapter 5 discussion. The Rich Point emerges in the manner that opening opportunities for students' exerting epistemic authority enables them to make conceptual connections, as Quincy realizes the importance of the keystone species in the biome, and Ryu explains it using AL.

Our transformed practices are becoming evident through our evolving forms of discussion and re-construction around text, but also through the individual epistemic work, as shown by Quincy's and Ryu's writing in figures 20 and 21. The practices of note-taking through study questions and diagrams have evolved to more individual expressions. Ryu is writing points based on the preceding discussion about the anchor text, using the new AL terms to express the points, no longer at the basic level of re-using phrases from the page, as in *Farming*. Quincy is writing in similar vein, and also constructing diagrams about the written text using semiotic signs developed in the course of the iteration, also including his own surmises. I consider these instances of epistemic work as evidence of the students' inner speech (Wells, 1999, p. 116), in dialogue with the text, and hence that the processes on the social plane have transferred to the intramental plane. I take up these points in chapter 5, in discussion of the conditions enabling the students to carry out epistemic work on the EL – AL continuum.

In episode 6, the students present their work on the kelp forest and the keystone species to their friends in the mainstream class. In *Healthy*, the students used their note-taking and re-writing for AL to do a project as a report, which they presented orally taking turns with other class members. Here, they re-enacted the process of epistemic work through discussion around the posters and the organisms in groups, "going deeply into everyone's ideas" and "asking why", in their words.

Outcomes – Iteration III Kelp Forest

This third iteration continues to extend the validity of the Process Conjectures as engendering the suggested outcomes, at new levels of complexity in performance and artifacts. The students produced artifacts in the form of text and representations, applying more complex semiotic signs and multimodal tools through interaction moves that were established in the first and second iterations, but which were now more frequently initiated by the students during this iteration. Hence, the Design Conjectures concerning problematizing text and authoring artifacts through semiotic tools continued to predict student engagement and persistence with challenging content. These conjectures are based on DFs that continue to be productive in promoting students' appropriating new AL and disciplinary practices, taking place in ways that show students increasingly active in initiating meta-talk for languaging and epistemic work, that is, reasoning aloud mediated by artifacts.

The events and Rich Points in this iteration signpost the collective and individual knowledge construction leading to the culminating performance of the students in episode 6. This class presentation consists in their enactment of our cultural practices with their classmates with epistemic goals that are manifestly understood by all the participants. This enactment of our local culture emerges through the process in the preceding sequence of episodes, where the students' epistemic agency and authority are built through activities around improvable objects, by means of interactions that the students were not only familiar with, but had transferred to the intramental plane (Wertsch, 1997, p 110), now expressed in the social plane in new forms of reasoning through transformed activity. In chapter 5, I discuss the progression of the students through the iterations in terms of the semiotic mechanisms (Wertsch, 1985, p. 167) that fostered the students' sense of epistemic agency, authority and identity in this developing local culture.

4.4.2 Iteration III Kelp Forest – Design Narrative

This section sets out the ethnographic Design Narrative for the data selection in Iteration III *Kelp Forest*, presenting the participants' emic perspective through a narrative style which conveys their in-the-moment responsiveness and decisions. This narrative style includes references to gestures and expressions of the participants, in addition to statements about my perceptions or feelings in the context of the interaction, as these impact my decision making for responsiveness to students' ideas (Berland, et al., 2020; Thompson, et al., 2016). Yellow highlights indicate meta-talk.

Part 1 Kelp Forest Weeks 1 – 3 "Well, I wanted to put environment, because I made a connection from healthy. Because we're animals"

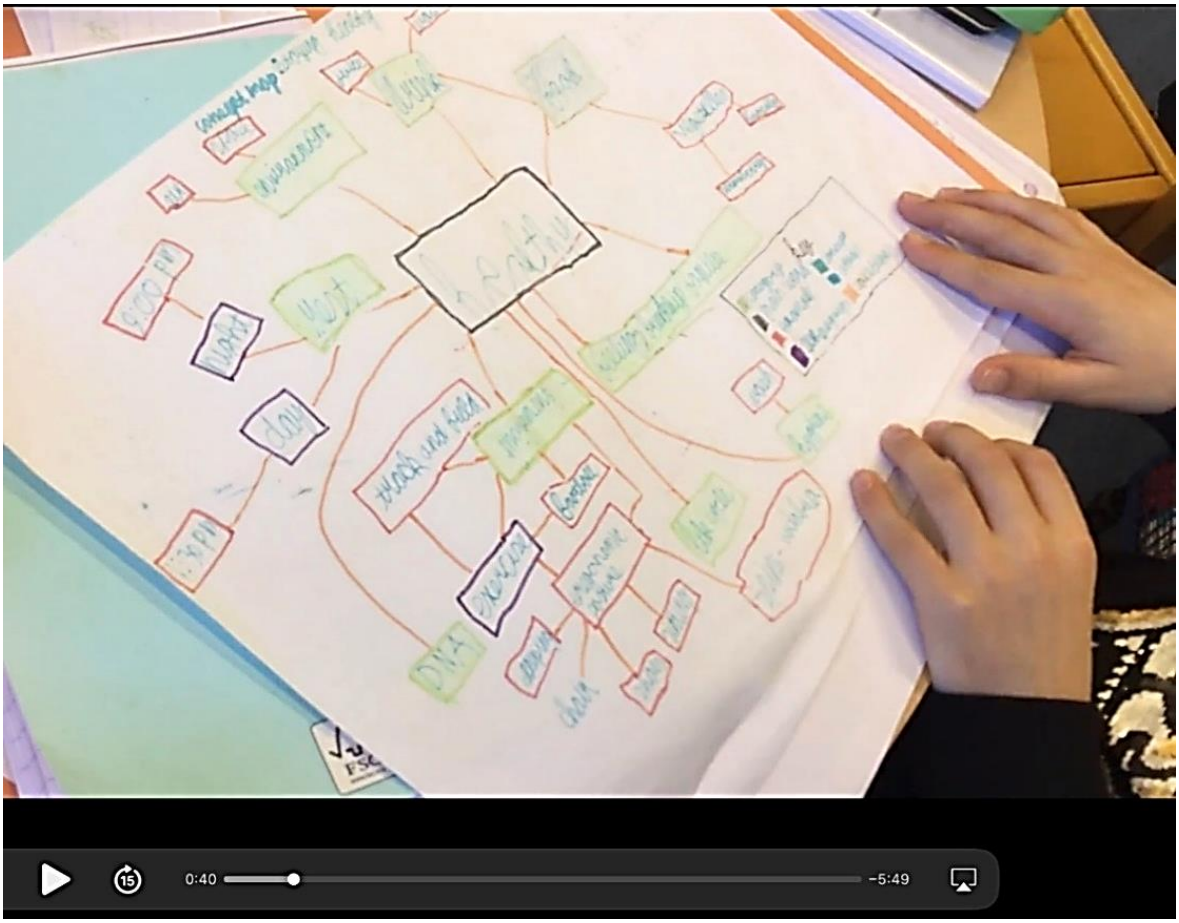
Episode 1 – Concept maps: Epistemic Work through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ Ss writing work *: authoring. arguing and presenting to others* ▪ *Ss state idea generation as a local practice*	Rich Point: "And insect is like speak in middle school or high school", by Dai ▪ Dai presents and argues own points figure 3, figure 4, with *his text as referent* and ▪ *the process of editing his concept map*	Specific Design Principles o building on student ideas o noticing as connection making for reasoning o integrated language and literacy with representations, which are o objects of discussion as "text"
Meta-talk (MT) ▪ words are discussed as ideas *with concept map as referent: reasoning aloud*		

This episode contains our first Rich Point in this iteration, enacted by Dai. I also present our developing practices for purposes of comparison with the start of our preceding iterations, so as to enable intermediate analysis of our developing culture in the Outcomes section (e.g. Pierson and Clark, 2019; Sadler, 2009; Erickson, 2012). Hence, according to our established discussion practices, our use of the concept map idea generation is a basis for a reflection activity on our previous work, and also for opening opportunities for students to generate ideas on their points of interest in this new unit.

The Kelp Forest video recording begins while Quincy is explaining the content of the previous concept map *Healthy*, as seen in the screenshot in figure 1 (see healthy figure 3 for the full view of the concept map). He explains it readily, and I then prompt him to explain the process, in Transcript 1, turn 2 "And so first, we talked about it and then we wrote or how was it?", and he confirms this and states " And then you add more and more and more" (turn 7). I try to involve

the others to comment with another prompt, while Quincy adds that we did a key (turn 9). I develop the point of contingency in the Outcomes section, as instances emerge in each episode in a clear pattern in the students' discussion on the representation work.



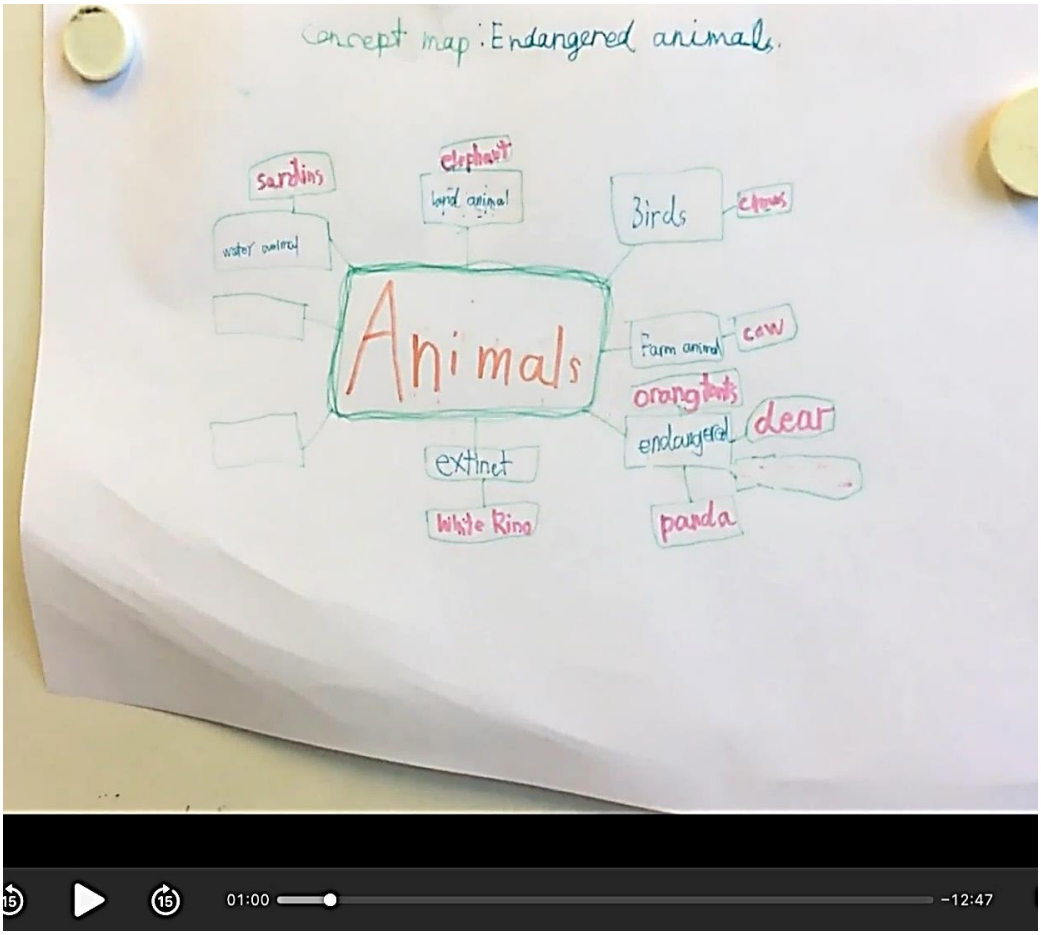
kelp forest figure 1 – Meta-talk: Quincy is reflecting on the previous concept map "Healthy" and explaining the process of preparing it, "First, we talked about it."" And then we wrote. " "And then you add more and more and more." transcript 1 turns 3,5, 7

Here, I ask them to begin work on a new concept map in turn 10, and a few moments later, suggest that they place the old concept map above new white A3 paper, as seen in figure 2. I thereby hope to prompt an internal reflection and some spontaneously uttered comments on the part of the students. I again make comments in reference to the previous concept map, but in terms of the epistemic work in constructing the representation, and not about the words: "How about if we put it here so that you can you have an idea of your color code, but it's going to be perhaps a little different this time". The students make spontaneous comments only later, as seen in episode 2, however, despite these invitations. I discuss the point on prompts for reflection, or inner speech (Wells, 1999, p. 107), in the Outcomes section, and also later in the iteration.

We then proceed with our next discussion point where I begin by asking them what the new page title should be, and Quincy answers immediately with "Endangered animals" (turn 11), a unit title that has already been announced by the teachers in the mainstream class. Dai states "I think will be *animals*" (turn 17). I now feel able to confirm this as the main idea in the centre of the concept map, as I have also responded to Quincy's suggestion: "…, let's follow this (Dai's) suggestion …." (turn 18), and I write it on the board. This shared writing can also be seen on the board in figures 7 and 16 below. I continue to repeat Quincy's point of "putting more" "because all of us, we sort of change our ideas, you know, evolve our ideas, get bigger and different Right? Does that make sense?" (turn 22).



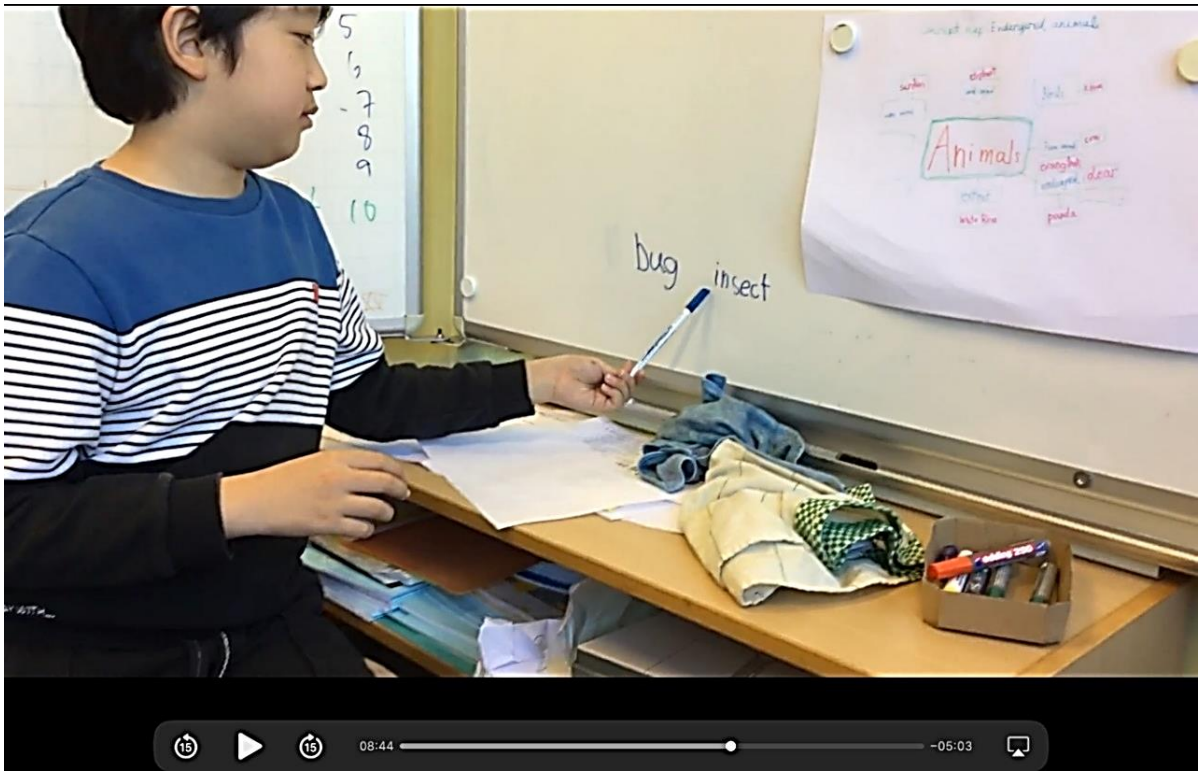
kelp forest figure 2 – Meta-talk. Teacher: "(arranging student's papers with concept maps) How about if we put it here so that you can you have an idea of your color code, but it's going to be perhaps a little different this time" transcript 1, turn 20



kelp forest figure 3 – Epistemic work through meta-talk. Dai: "Well, I'm like, I put bugs here, (pointing to empty box in the concept map) but I don't think bug is a kind of animal" transcript 2, turn 54

The DP of connecting with prior knowledge, as enacted here, now refers additionally to our prior established practices, as shown by Quincy's meta-talk on the concept map, and by my explicit attempt in turn 22 to "frame" our epistemic work as a long-term process (Engle and Conant, 2002). Dai, on the other hand, appears quite firm about his choice of *animals* as title, which I judge by his tone and manner. I write his choice on the board not only because I was hoping to see this word; I am keen to give this student more prominence through this public validation of his view (e.g. Scott, 1998; Boyd, 2012; Webb, et al., 2014), as he had joined our group well after the other students.

I also distinctly feel from his manner that he has ideas that he wished to convey ready in his mind; hence, as soon as possible, I ask him to present his initial concept map work, which I will discuss next. I discuss the issue of prior knowledge with a focus on problems in evoking it, and relate this to framing for transfer and agency (e.g. Engle and Conant, 2002; Engle et al., 2012; Cherbow and McNeill, 2022), in the Outcomes section.



kelp forest figure 4 – Epistemic work through Meta-talk. **Rich Point**. Dai: " (pointing to the word pair with the pen) And *insect* is like speak in middle school or high school" transcript 2, turn 84

The next interaction point in the sequence of tasks in this episode now turns to a presentation of the work in progress and discussion on word work, shown in transcript 2 , after time had been given for individual writing to take place as noted at the end of transcript 1 (turn 31). The DP is for students to have opportunities for noticing each other's ideas and be inspired, and additionally for me to gain more insight into Dai's thinking.

I start the iPad recording when I ask Dai to show what he has so far, as seen in figures 3 and 4. The transcript is edited with some asides and repetitions omitted (in grey), so as to focus on the discussion and epistemic practices that I worked to promote with Dai's concept map and presentation as our new *text* anchoring our discussion.

In his short presentation, Dai has shown his understanding of concept map work as we have been doing it (e.g. healthy figure 1), by writing and then presenting categories as shown here in figure 3, with an example for each category, using consistent colour codes. Now, in turn 47, I try to make explicit yet again our point about "adding more and more" to the concept map (e.g. Quincy in transcript 1 turn 7, also in transcript 3 turn 16) and to our ideas in general, with my prompt: "Well done. Well done. Do you have, this is as far as you got just now. Do you have, I see some other boxes (T indicating empty boxes on the map) Do you plan to do more? You have other ideas." (turn 47). Initially, Dai responds with just "yes", but when I suggest an expanded answer, he echoes the suggestion and also adds to it: "I'm getting to my next idea. I just need some time." (turn 50, Dai echoes, and his addition is underlined). I refer to this point in the Outcomes discussion, regarding possible connections between teacher responsiveness and student agency (e.g. Bishop, 2021).

According to my conceptual framework, I am keen to publicly show that students' ideas and science ideas form the basis of talk (e.g. Duschl, 2008; Berland, et al., 2016). Thus, I prompt Dai with an invitation to say more verbally, since he just stated he had more for the concept map. He immediately points to an empty box in his concept map and states "well, I'm like, I put bugs here, but I don't think bug is a kind of animal" (turn 54, empty box seen in figure 3). He means that he wrote the word bug there and then erased it, and he is explaining why he did this. I invite him to go on with a plain "ok" but with an expression and tone that I am hoping conveys an invitation for reasoning. He adds "insects" (turn 56). There ensues a nearly 5 minute discussion among us all about the pair of words bug-insect, as shown in figure 4, which I attempt to extend with phrases such as "how do you feel about what he just said" (turn 85). Dai repeatedly states his idea that "bug" is a primary school word (turn 82), and *insect* is a middle school word (turn 84; figure 4), despite disagreement from Quincy and Ruslan, who define it as being about relative size (turn 80). Dai remains unperturbed throughout, and the entire discussion is calm and pleasant in tone.

This interaction constitutes our Rich Point in this episode: discussion, facial expressions and gesture around the concept map as the anchor text or semiotic resource (e.g. Goodwin, 2000; Wells, 1999) together present an opportunity for epistemic work through meta-talk about terms in the concept map. In a manner that I had not anticipated, Dai shows that he is a member of the community, by appropriating and enacting our practices to author his

epistemic work (e.g. Hoadley, 2012): he proposes epistemic work to the group for consideration and evaluation (e.g. Damşa et al., 2010).

Thus, through our practices of epistemic work through meta-talk, we arrive at a shared understanding on "bug" and *insect*. Furthermore, I feel that I have opened opportunities for Dai's epistemic work and interpretive authority (Boyd, 2012, p 26), which he has taken up, and so affirmed his identity as an author in our community. I feel that I achieved this by avoiding positioning between the participants by not directly evaluating correctness (e.g. Boyd and Rubin, 2006, p. 142). Instead, through these practices of epistemic work and languaging through meta-talk, I focus on promoting our discussion on student ideas and "creating a need for explanations", as suggested by Scott (1998, p. 59). This Rich Point was therefore generated by several features of our local culture, which I take up in the Outcomes section for this iteration.

Episode 2 – Concept maps: Epistemic Work and Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ Ss writing *work shared and individual authoring. arguing with others* ▪ inferences: Ss infer conceptual connections with prompts	Rich Point: why some animals are endangered: "Yeah, it may be that ...there was too much of the meat eaters", by Ruslan ▪ Ruslan makes inference *with his text as referent* turn 266	Specific Design Principles: ▪ building on student ideas ▪ noticing as *connection making for reasoning* ▪ representations are *objects of discussion as text*
Meta-talk (MT) ▪ words are discussed as ideas with *concept map as referent: reasoning aloud*		

With this episode, I aim to add examples to help describe the evolving character of our interaction and the evolving sense of authoring of the participants about these goals and practices, as noted above. The Rich Point in this episode involves an interaction around connecting with prior knowledge by the students through contingent questions that fostered their contributions in unscripted ways (Boyd, 2012). I will return to these points in the Outcome section.

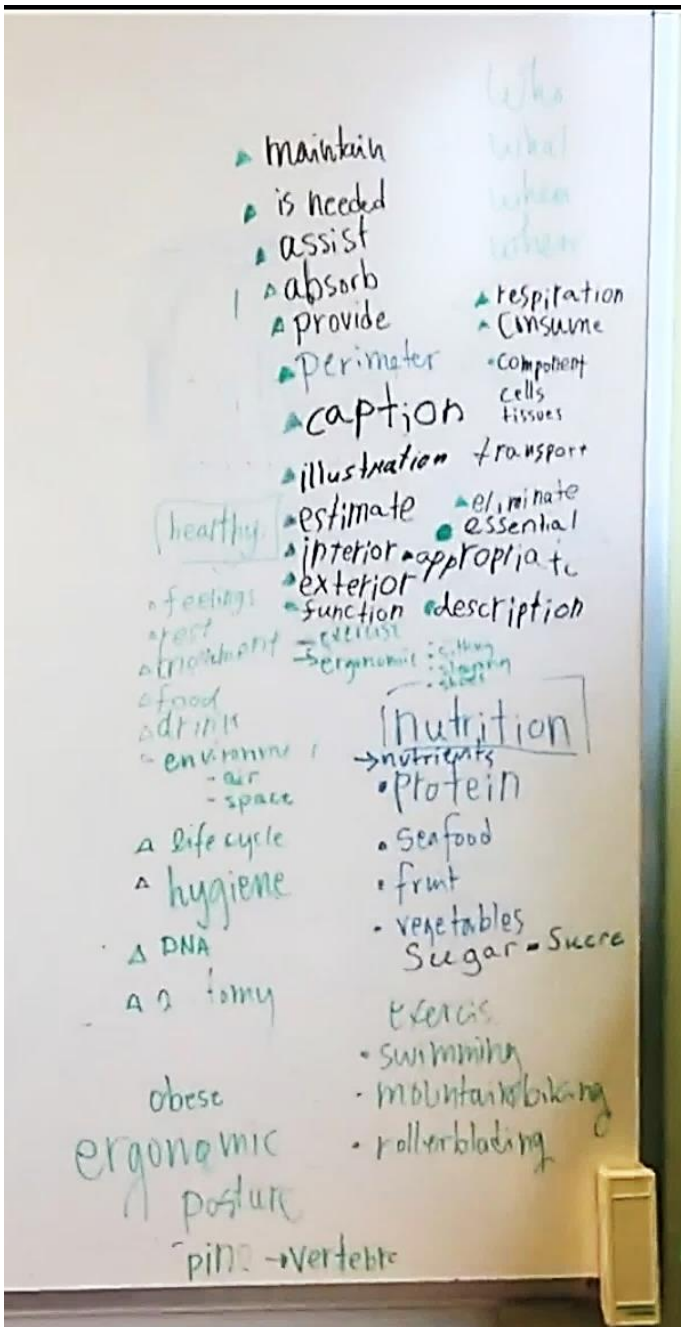
The episode involves the above points and presents the environment that favoured their development. The video recording transcribed in Transcript 3 begins with an ongoing discussion on words and concepts around the concept maps of the participants (figure 6) and the concurrent work on the word wall (figures 5 and 7). In turn 1, I am speaking to Ruslan, who is at the word wall, and I am asking him to talk about the changes to the word wall that we need to make since we have begun a new unit and a new topic with it.

Ruslan argues, "we don't need the blue category" (turn 2), so I echo that in turn 3, and Ryu adds "and healthy" (turn 4) seen in figure 7. We are referring to the groups of words as seen more closely in figure 5, with the green heading "healthy" and the words in blue with the heading *nutrition*. This excerpt of our initial interaction shows more clearly our epistemic work in

interaction centred on our artifacts, as it has evolved in nature from *reporting* to *arguing* and *reasoning* through the student's artifact:

III kelp forest Excerpt 1 – from Transcript 3

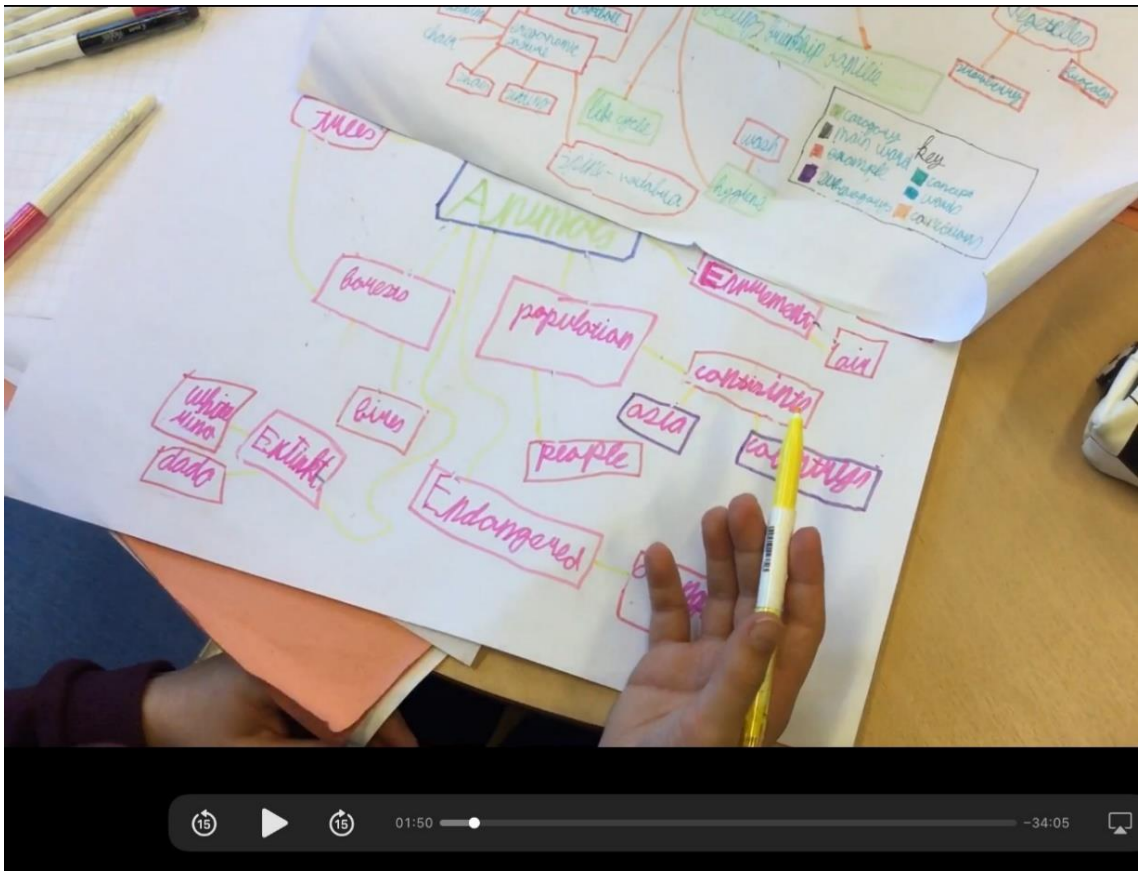
1	0:01.1 - 0:04.1	So in our word wall, what words do we not need? figure 5	Teacher
2	0:04.6 - 0:04.8	We don't need the blue category	Ruslan
3	0:08.0 - 0:10.4	this blue category, we don't need it anymore	Teacher
4	0:11.5 - 0:14.4	and healthy	Ryu
5	0:14.8 - 0:31.3	and maybe about the healthy specifically. But wait, what did one person just to say repeat again about that connection? Repeat again what you said about the connection.	Teacher
6	0:31.4 - 0:37.2	Oh, why I put continents population	Quincy
7	0:37.3 - 0:40.0	and why you wanted to	Teacher
8	0:40.0 - 0:47.4	yeah. Well, I wanted to put environment, because I made a connection from healthy. Because we're animals. figure 6	Quincy
9	0:47.7 - 0:48.2	Mm hmm.	Teacher
10	0:48.8 - 1:00.2	And there was environment and and everybody needs space and everybody needs air. So the same thing here.	Quincy
11	1:00.3 - 1:00.7	Mm hmm.	Teacher
12	1:01.6 - 1:12.3	And because of space, I put continents, countries. And, for example, from a continent Asia.	Quincy
13	1:12.7 - 1:13.1	Mm-Hmm.	Teacher
14	1:14.6 - 1:23.1	And population, people, because we are animals as well. And I'm still going to add more things	Quincy
15	1:23.3 - 1:24.1	such as	Teacher
16	1:24.8 - 1:58.0	such as birds for a population. And I'm going to put more endangered animals and more extinct animals and why I put forests is because today, before I put forests, hm Miss P-- said that a lot of animals died because of forest fires.	Quincy
17	1:58.4 - 2:00.8	aah, in Australia,	Teacher
18	2:00.8 - 2:01.1	yeah.	Quincy
19	2:01.8 - 2:15.7	So that's our current problem. Absolutely. This is really brilliant. Thank you. Let's see. So what items here? (referring to the word wall) So then some of the items from healthy? Are we going to delete all of them?	Teacher
20	2:15.8 - 2:15.9	yes	Ruslan
21	2:15.9 - 2:19.1	No, because some of the word is important	Ryu



kelp forest figure 5 – Epistemic work. Word wall carried over from the unit Healthy, start of the Kelp Forest unit, see figure 13 for the version for this unit constructed by the students

As I work with Ryu and Ruslan who are writing and arguing at the word wall, I also notice how Quincy is working on his concept map, and I decide to ask him to refer to it and so contribute to that work: "and maybe about the healthy specifically. But wait, what did one person just to say repeat again about that connection? Repeat again what you said about the connection" (turn 5). I am

referring to Quincy's comments prior to the start of the recording. Quincy states that "…I wanted to put environment because I made a connection from healthy, because we're animals" (turn 8). He continues with " And there was environment (on the healthy concept map) and and everybody needs space and everybody needs air. So the same thing here" (turn 10).. He continues to explain his reasoning about his concept map (figure 6) where we see these words, as well as *population*, *extinct*, and so on.

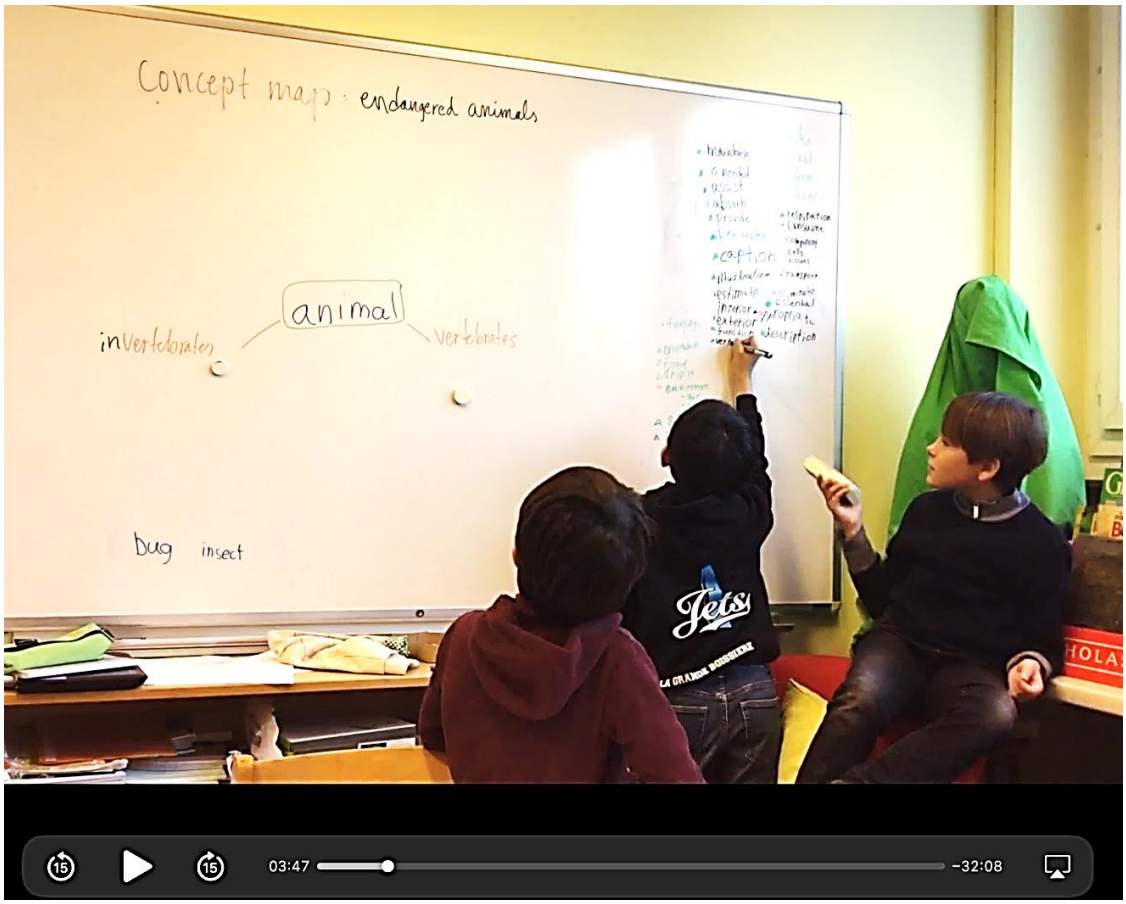


kelp forest figure 6 – Epistemic work through MT. Concept map work, Quincy is pointing to his items while outlining his reasoning for including them. The "healthy" concept map is partly visible, top right. "Well, I wanted to put environment, because I made a connection from healthy. Because we're animals" transcript 3, turn 8

I feel accomplishment that my contingent question resulted in this extended explanation on Quincy's part, showing him making use of the previous concept map in terms of structuring and arguing his ideas, as well as extending these in new directions. Furthermore, he connects with information from the mainstream class, where the class teacher was talking about animals dying due to forest fires (turn 16). I will return to our evolving uses of the concept map in the Outcome section below, as noted also for episode 1 as well as to my

attempts at contingent and responsive exploration of student thinking throughout this iteration and this study (e.g. Bishop, 2021).

With this, I return to my question of what to keep on the word wall in turn 19 as an opportunity for more arguing and shared writing for the students. Ruslan maintains his views – as is his tendency in previous episodes – while Ryu feels free to change his stance and disagree with Ruslan: "No, because some of the word is important" (turn 21). Ryu's stance has consistently been to show he is attending to the discussion ideas as a priority. Although I did evaluate Quincy's extended talk with "brilliant", I believe I showed my valuing his whole contribution and extended reasoning effort by again referring to connections, not a designation of "correctness" as such. I keep on about that in turn 28, where I again label the just preceding student exchanges as brilliant, because "we make the connection". I refer to this in my discussion of epistemic work and our thread of Rich Points in the Outcomes section.



kelp forest figure 7 – Epistemic work through Meta-talk. Word wall, students discussing and editing, transcript 3

Following more discussion about the word wall, I review the purpose of that activity by trying to refer to the preceding lessons (transcripts 1 and 2), where I talked about the big picture, or the main idea, and now suggest to the children that we should look at "the whole context…where those animals live, right? So we're going to investigate all the ideas that are part of endangered" (turn 54). We are looking at the concept maps again: Ryu has been adding to his concept map, and he asks me "is this good" (turn 75). At that moment, I am pointing at items on it and saying "…So we're, see, we're finding how all of these things fit together, endangered animal fits into a bigger picture, right…" (turn 79).

Ryu, however, initiates an extended reasoning sequence about his concept map, beginning with an evaluation on his own work:

III kelp forest Excerpt 2 – from Transcript 3

81	10:48.1 - 11:24.8	I want you to think of the idea. We can't understand endangered animals, except in the bigger picture. We needed a bigger picture. I want you to think about this. And what you think of. Yes. And they will. Yes, yes. All right. Do you see why I want you to see why we are doing it like this? Do you see sort of why we're doing it like this?	Teacher
82	11:27.0 - 11:40.6	Yes. I like making concept maps, plus it's you can also see the idea ideas that was in your head, so you're not forgetting because you already wrote it	Ryu
83	11:41.0 - 11:45.8	and then you can, and then you can...(pausing)	Teacher
84	11:46.5 - 11:47.2	review it.	Ryu
85	11:47.2 - 11:54.7	review it, and when you review things what happens, you. ...(pausing)..	Teacher
86	11:55.7 - 11:56.4	you can think	Ryu
87	11:56.8 - 11:58.1	you can think...(pausing)...	Teacher
88	11:58.4 - 11:59.4	or you can	Ryu
		(extended intervention: Ryu presents and discusses his concept map; T gives feedback)	
119	16:31.6 - 16:50.0	Good, (speaking to Quincy and Ruslan at the word wall) so you are looking here. So here you are, looking at how you did your color coding before, how you determined how you decided. Maybe you are thinking back how you decided. Are you thinking back? How you decided?	Teacher
120	17:02.1 - 17:02.2	yes	Quincy

He continues with explaining his concept map at length and I continue to provide prompts especially in the form of echoes (turns 88 to 118). I understand in that moment that he

wants to exert his authority on the conversation, and I focus on helping extend his talk. I must be consistently responsive in promoting student thinking (e.g. Bishop, 2021;.p. 478). Hence, I give space to Ryu, since he clearly wishes to add arguments, so as to promote his agency in making elaborate contributions (Boyd, 2012, p. 29) and thereby his identity as epistemic agent in our local culture (Brown and Campione, 1994, p. 266).

This interaction is another instance of Ryu seizing opportunities to present his epistemic work, which I later saw must have been inspired in part by Quincy's extended intervention about his own concept map earlier in the episode. In retrospect, as I reviewed my notes later in the day, I realized that his request in turn 75 was really an attempt to initiate this extended point: the real meaning or intent (Gumperz, 2001) of his question, "is this good" was not to have the correctness verified by the teacher as authority. I mention this point in the Outcomes section concerning our evolving interaction and local culture.

Our discussion continues and evokes more terms such as *climate*, when Quincy suddenly mentions the term *food chain* (turn 132), following 18 minutes of discussion in the lesson. I press him to explain where he heard the term, and from turn 142 to turn 220, or nearly ten minutes, the three students try to recount the events of the lesson in the mainstream class where information about food chains was presented, but this recount is very disjointed. Then in turn 221, Quincy again adds suddenly, that "last year we did a lot about food chains".

There ensues another extended recount by Quincy and Ruslan, where both fill in each other's recollections of a lesson in the previous school year, which concerned a problem with a food chain, presented by the teacher as a narrative. Then I attempt to state the real significance of their story, which they still have not connected to our main idea, or to the classroom project: "Is that a good idea? Is that what you want to learn? (animals in the food chain and problems) Do you want to learn this? Yes, I would like us to learn more about habitats and more about the science words so that it will help us do what. Understand why some animals are endangered. Understand again about that fantastic story about the island with the different groups of animals"(turn 266) .

Upon that comment, Ruslan begins to make a connection: "Yeah, it may be that there was too much, or like there was too much of the meat eaters…" I finally provide the term that we have been steering towards for three lessons: "the name for the big picture is *ecosystem*" (turn 267). The

students instantly react to this term: Ryu states that he has heard it before in turn 272, and the others join in, in animated tones. Quincy finally recollects that the teacher had indeed stated that term when narrating the island story (turn 281). This interaction constitutes our "forced Rich Point" (Sandel, 2015), in this episode, as it shows our epistemic work culminating in a new connection in a manner unexpected by the participants. The episode shows an alternation of intentional, spontaneous and "forced" connection making and epistemic work, which I discuss in the Outcomes section in the context of the conditions favouring the emerging identity and authority of the students as epistemic agents in our conversation.

With this episode, we conclude our transition to the new unit through various public acts of our community (e.g. Hickey, Chartrand and Andrews, 2020), including setting goals. In the second half of the iteration, we begin work with an anchor text dealing with Earth's oceans entitled *All About Ocean Life* (Bladon, 2010). I decide to prepare hands-on activities to explore the main idea of ecosystems and habitats, so as to provide the interplay of first hand and second hand investigation (Palincsar and Magnusson, 2001) as discussed in chapter 2. The narrative in episode 3 therefore concerns the Rich Point emerging through these hands-on activities. In turn, this Rich Point, together with our epistemic work and interactions, result in an unexpected interplay in episode 4 where our text based discussion is decisively and markedly taken further by the students.

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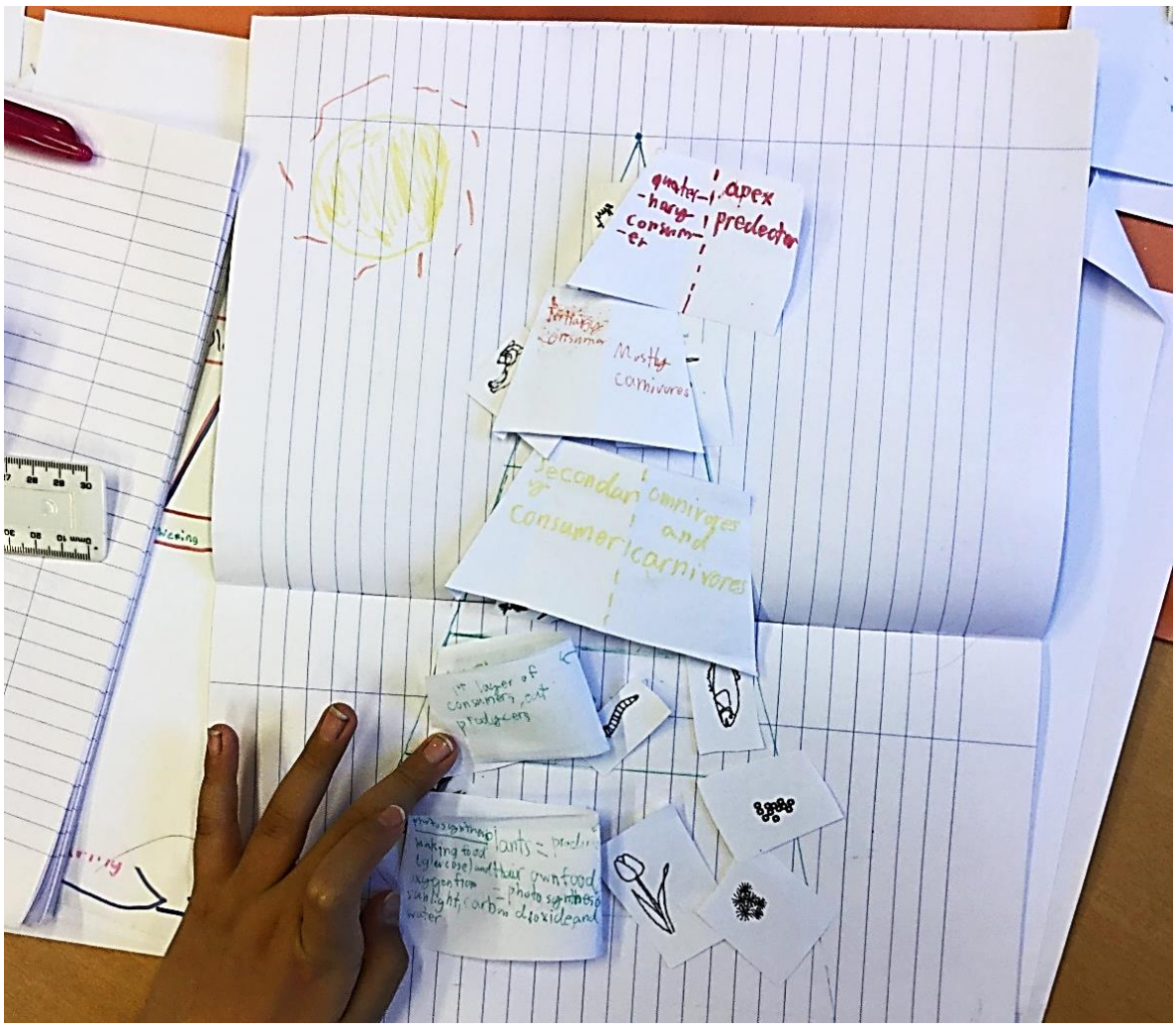
Episode 3 – Representations : Epistemic Work

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *new signs and words as ideas in representations* ▪ *determining choices in semiotic signs*	Rich Point: ocean food web representations, by students ▪ discussion: arguing. interpreting, selecting signs, for ocean food web representations figure 9, figure 10, figure 11, figure 12	Specific Design Principles ▪ improvable objects: *elaboration anchored in Ss constructions and edits of their representations* ▪ identity building: *selecting, arguing, constructing semiotic signs*

I turn to work on developing the students' knowledge base in this unit. In this iteration, my design involves epistemic work focused on representations situated in opportunities for learning how organisms are interdependent and the manner in which this information is organized. Work with hands-on activities involving energy pyramids may provide contexts for the students to extend this active discussion on ecosystems, mediated by representation work. In my design, I plan that by constructing these concepts, enacted as a scientific practice of representation construction, the students may have the opportunity for epistemic agency (Miller, et al., 2018), and more readily make inferences in discussion during and following these activities

Hence, I begin the sequence of activities in this episode by making use of the conceptual representation of the energy pyramid (figure 8) to visually represent the habitat or ecosystem as a complex system (Encyclopædia Britannica, 2022). This representation then may help us situate our learning about the energy pyramid. We learn about its components, terms, definitions and example organisms through this sequence of activities. Through this epistemic work, the participants are able to build a structure for the ideas in the animal island narrative retold by the students in transcript 3, as well as the terminology to discuss

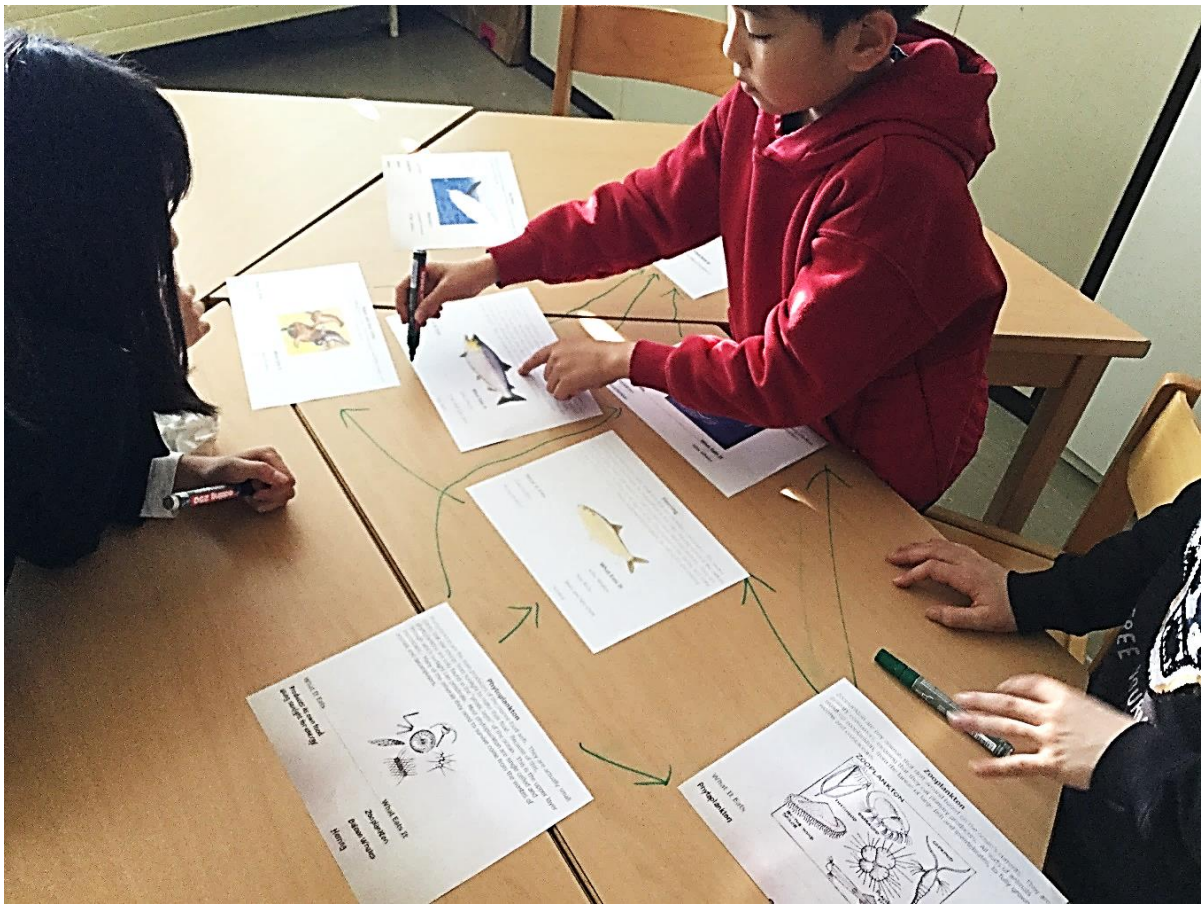
those ideas (e.g. Bybee, 2009; National Academies of Sciences, Engineering, and Medicine, 2021), situated in scientific practices.



kelp forest figure 8 – Epistemic work. Dai's work on the representation of the energy pyramid, with labels, notes, a colour code and bullet points, as well as the hand-drawn Sun, used as knowledge resource in figure 23.

With this aim, I make use of the age-appropriate resources on "Food chains and Food webs" available on the resource collection Enchanted Learning (Enchanted Learning, 1996). These resources provide us with the formal graphic representations of the processes of energy transfer through the organisms in particular ecosystems (Britannica School, 2022), which I can adapt for hands-on activities that the students recognize, such as cutting out, identifying and organizing images of organisms, as well as labelling and writing out definitions for these, as found on the resource page.

The resulting representation of concepts can be seen in figure 8, where Dai has hand-drawn a stylized pyramid in his notebook, placed the cut-outs of the organisms for a terrestrial ecosystem according to their trophic level (Britannica School, 2022), and written labels and definitions researched by him from the Enchanted Learning web page. He has applied his own colour code with bullet points as well. The notebook page shows his own addition of a stylized sun in the top left, which he added as he wrote the *plants* label indicating the terms *sunlight* and *photosynthesis*



kelp forest figure 9 – Epistemic work. Lina, Ryu and Quincy determining the energy flow in the ocean food web by reading the clues in the descriptions. Ryu is reading aloud and drawing the arrows showing the direction of the energy flow

We then turn to discovering organisms in a new biome, namely the ocean food web, through a hands-on collaborative activity to complement the anchor text and the highly structured energy pyramid work in the notebook (Palincsar and Magnusson, 2001). I located this material on a resource page for science teachers (Teachers Network, 2020). The students are collaborating on the same task in two groups, as seen in figures 9 and 11. The task involves constructing a food web for a group of eight ocean organisms, using brief fact cards

provided for each organism as clues. Each fact card states the name of the organism, "what it eats and what eats it", together with a photo or diagram of the organism.



kelp forest figure 10 – Epistemic work. **Rich Point.** This group's completed ocean food web with labels showing the trophic levels as studied, added of their own accord; the students added their names in their respective languages as prompted (partly blurred)

The eight ocean web animals are unknown to the students , except for the orca. For example, the various fish species are initially just different coloured fish to the students, and the plankton not to mention their types, are quite new and surprising. Furthermore, the students must discover that the result turns out to be a web and not a simple food chain. This representation work is therefore more complex than the neatly ordered energy pyramid in the notebook, which was constructed through discussion about organisms of a terrestrial ecosystem, such as tulips, snakes and eagles, with which the students were familiar.

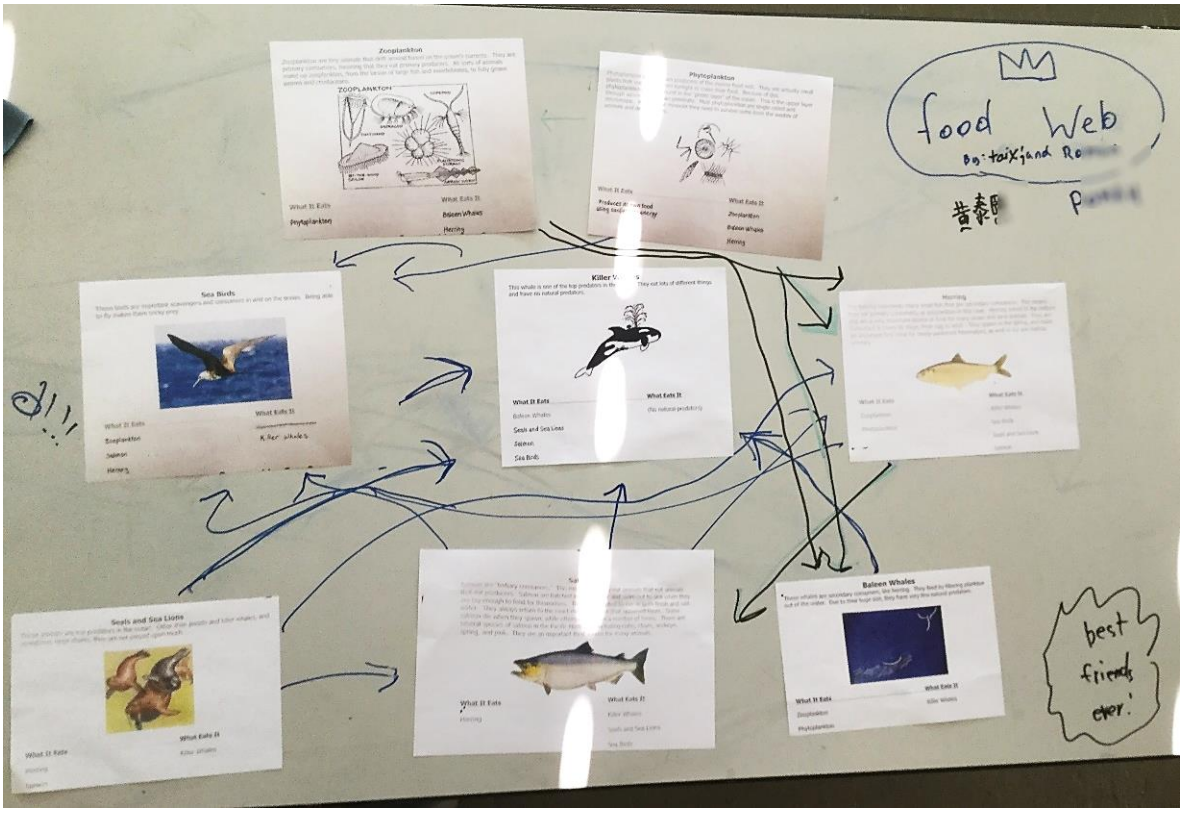
Hence, the students have a lot to read carefully and discuss in their groups, as can be seen in figures 9 and 11. In figure 11, Ruslan and Dai initially adopt a linear food chain, which I attribute to Ruslan's holding to the simple food chain example that he had been *shown* or



kelp forest figure 11 – Epistemic work. Group work by Ruslan and Dai constructing the same ocean food web as the other group, using the same images and information about each organism (unrelated artwork visible in the background)

transmitted in the mainstream lesson as discussed above (transcript 3, turns 132-6). I eventually ask that group to look at the clues again, holding back any other evaluation, and I note that Dai then takes on more initiative to reconsider the clues. They finally present the result as seen in figure 12, where they have written a title and signed it with their names at my suggestion, so it can "look like a poster in science class".

The other group, with Quincy, Ryu and Lina, are much more careful in reading the clues present their result shown in figure 10, and they have added the labels for the trophic levels of their own accord, as well as their signatures. In the moment, it occurs to me to ask the groups to write their names using the scripts of their respective languages, which can be seen in the top left of figure 10 and in the top right of figure 12: there are as many scripts as there are participants, which I strongly feel is a part of their representational work and should be celebrated.



kelp forest figure 12 – Epistemic work. **Rich Point.** Ruslan and Dai's completed ocean food web, with their signatures in their respective languages (partly blurred); they have not added the trophic level labels (a shaft of light crosses the table)

With this sequence of activities, I am attempting to orchestrate for the students the epistemic work needed to construct an ecosystem representation. I hope to thereby present opportunities for agency, as stated earlier: their realizations and ideas emerge as the interaction and epistemic work takes place around the cut-outs, reading aloud, physically sorting and tracing lines with the pen. The students have experienced a Rich Point, as they collaboratively constructed and revised an energy flow representation of the previously unknown organisms. The implications of this semiotic work for our local culture, constructed through these maturing practices, become visible only later, in episode 5.

I refer to the significance of these episodes as a cumulative "forced Rich Point" (Sandel 2015), together with my other comments on our developing cultural practices as noted in the Outcomes section. As stated, the second half of the iteration involves re-engaging in our practices around text with a new anchor text, entitled *All About Ocean Life* (Bladon, 2010), so as to provide the interplay of first hand and second hand investigation (Palincsar and Magnusson, 2001) where we bring to bear our epistemic work with food webs and energy

pyramids as newly formed knowledge resources. Episodes 4 and 5 contain the resulting unexpected interplay with this work and this Rich Point, as our text based discussion is decisively taken further by the students to new levels of authoring and agency.

Part 2 Kelp Forest Weeks 4 – 7 "They had to realize what would happen to the abundant kelp forest without the fantastic sea otter."

Episode 4 – Anchor text and representations: Epistemic work and Languaging through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *new signs and words as ideas in representations* ▪ *determining choices in semiotic signs* Meta-talk (MT) ▪ *reading tasks* are a context for reasoning aloud, Languaging (L) ▪ text and representation over-writing with the AL terms	Rich Point: representation construction and re-construction, by students ▪ discussion: arguing. interpreting, selecting signs, for ocean food web representation figure 14	Specific Design Principles ▪ improvable objects: *elaboration anchored in Ss constructions and edits of their representations* ▪ *identity building: selecting , constructing semiotic signs*

This episode involving our established text-based interaction contains our next Rich Point. We are preparing to read chapter 2 of the text, entitled "Who eats what", as seen in figure 14. The video recording, transcribed in Transcript 4, begins with us already in the process of looking at the images, as shown in figure 13, and specifically the anchor text image seen in figure 14 labelled "a food chain". This text will be

As usual, we have begun by explicitly connecting with our previous activities: we are commenting on this food chain image by discussing how to edit it, and the first exchanges refer to our prior work on the ocean food web and the food pyramid notes in the notebook, described in episode 3 (e.g. figures 9 and 11). In turn 1, I am suggesting an edit to Ryu: "And then instead of "plant plankton" you can write….(pause)" and he answers immediately with "*phytoplankton*" (turn 2). I proceed to point at the cut-out of that organism on the table with one hand and his chapter page with the other (figure 13), so as to physically underscore the

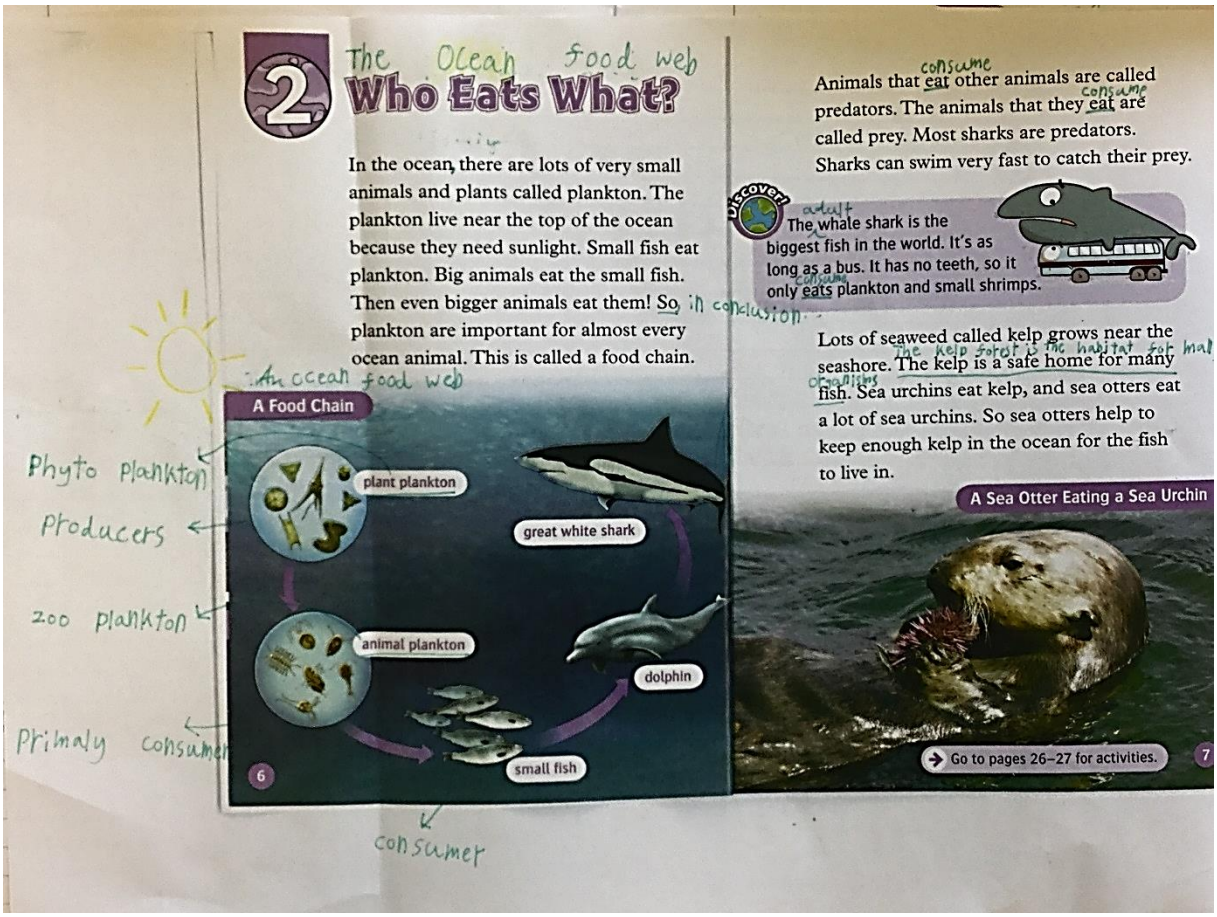
connection. I return to my DP regarding constructing and transforming representations, as semiotic tools and knowledge building practices (e.g. Prain and Tytler, 2012).



kelp forest figure 13 – Epistemic work and languaging through Meta-talk. Comparing the anchor text, seen in figure 14, and the ocean food web activity diagram, seen in figure 10. Teacher: "And then instead of "plant plankton" you can write…(pause)" Ryu: "*phytoplankton* " transcript 4 turns 1-2

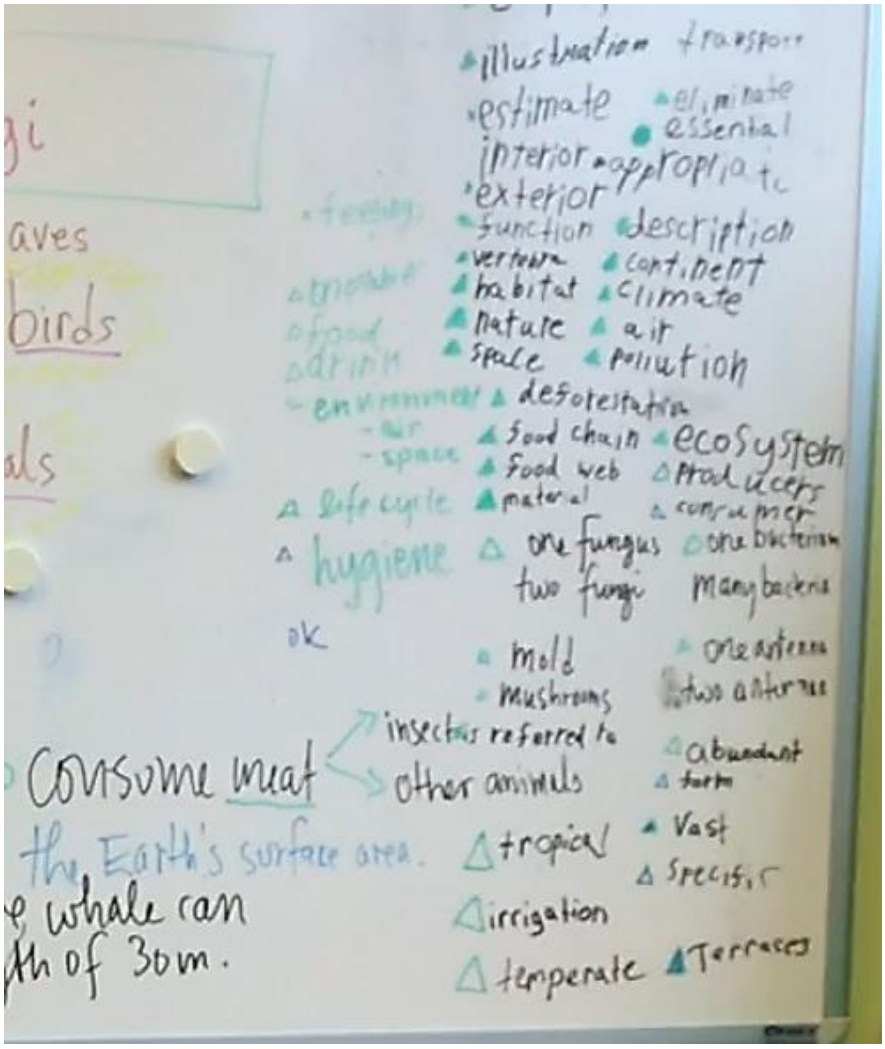
At that moment, Quincy arrives, and I ask him to look at the page and to connect with his own previous work: "… So look at this. Now we're reading this. And did you do this beautiful food chain, except that you did it in the form of a food web?" (turn 3) I also point at the printed photo of his team ocean web activity on the table, which is the same as figure 10 above. "Right away, Ryu had a comment, what comment do you think he had." (turn 5). He then responds with the same corrections as Ryu, as well as identifying the "terrible mistake" I refer to in turn 9, namely the lack of a sun depiction in the diagram. I ask him to explain this in turn 10, "And why do we need

the Sun? Why does the Sun have to be there, because it's the …(pause)" and he responds promptly with "because the *phytoplankton* produces its own food with the help of the Sun" (turn 11).



kelp forest figure 14 – Epistemic work and languaging through MT. ch 2 overwrites in Ryu's notebook as seen in figure 13 and discussed in transcript 4. **Rich Point**. Ryu has added the sun to the diagram, as well as labels indicating the trophic levels, and a title. See figure 18 for continued epistemic work and annotations on this chapter.

This epistemic authority, exhibited by both Ryu and Quincy orally and in their written edits, is our Rich Point in this episode. Ruslan is not present in this episode, but he makes the same observation in Transcript 5, turn 140, in the subsequent lesson, episode 5. I request more edits again by referring to the same previous work, and I have an extended interaction with Ryu over 10 turns about labels for the trophic levels (turns 12 through 21), where I provide the rationale for the labelling, ". But we need to know what role do they have What are they doing They are consumers and…(pause)" (turn 14) and then prompt for the terms that the students used in the energy pyramid activity and the ocean web activity, which are also written by them on the word wall in figure 15.



kelp forest figure 15 – Epistemic work. Word wall, kelp forest unit, constructed by the students over the course of the unit, also carrying over words from the previous unit.

The next episode contains the context of knowledge building through further interplay of first hand and second hand investigation (Palincsar and Magnusson, 2001), where our text based discussion is critiqued by the students through their new knowledge of ecosystems. In this context, the connection between endangered animals and the students' "island story" can finally be made explicit: it emerges in our Rich Point, in which we find our class presentation idea. This episode then becomes our springboard for the activities leading up to our group presentation to the mainstream class in episode 6, which constitutes the final Rich Point, as commented on by the students in their written reflections, seen in figures 29, 30 and 31.

Episode 5 – Anchor text, text and representations: Epistemic Work, Languaging, Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *problematizing: identifying gaps* ▪ *identifying, arguing practices* ▪ *comparing, justifying representations*	Rich Point: " If there is not enough of one thing, then most of the things will disappear", by Quincy ○ Quincy makes inference, following prompting excerpt 4 figure 17	Specific Design Principles: ▪ improvable objects: *elaboration anchored in Ss constructions and edits of their representations* ▪ identity building: *selecting , constructing semiotic signs* ▪ *externalisation of inner speech*
Epistemic work (EW) ▪ *reading tasks* are a context for reasoning aloud,		
Languaging (L) ▪ text and representation over-writing with the AL terms		

This episode continues the text-based discussion from episode 4 using the anchor text in our established way, while making references to our own *texts* from our preceding activities (e.g. figures 4, 5, 8, 10 and 12) as stated. This episode, containing a complete lesson, illustrates how our anchor text discussions and activities have been evolving through repeated experience towards explicit agreement on practices and students as legitimate contributors (O'Connor and Michaels, 1996). The narrative here presents the work needed to build the connection of endangered animals, ecosystems, and the students' "island story" (transcript 3, turns 221-265) culminating in our Rich Point of this episode, in which we realize that we have determined (e.g. Greeno, et al., 1999; Duschl, 2008) the point of interest for our project.

As in episode 4, the text-based work shown in transcript 5 is initiated with a discussion about chapter 2 of the anchor text (figure 18 and seen on the table in figure 16), by making connections to our previous work and inviting critical comments, prior to engaging in the actual read-aloud for which there had not been time in episode 4.

This initial interaction in the episode is shown to better capture the sequence and sense of these quick exchanges by the students:

III kelp forest Excerpt 3 – from transcript 5

1	0:00.4 - 0:09.6	I'm looking at your beautiful work (arranging photos of the students' ocean web work seen in fig. 10, 12 on the table in front of the students), and you realized (referring to the students' comments just prior) that this terrible title, this terrible title (referring to the chapter title "Who Eats What").	Teacher
2	0:10.5 - 0:12.2	And it doesn't make any sense.	Ruslan
3	0:12.5 - 0:27.4	It doesn't make any sense because, Quincy, it can even make us think about…. people, who is people, and then it can make us think about, when you first see the title, it makes you think about what…(pause)	Teacher
4	0:27.9 - 0:28.4	people eating, sleeping	Ruslan
5	0:31.2 - 0:31.7	or not.	Teacher
6	0:32.8 - 0:33.0	yes	students
7	0:33.0 - 0:49.7	Or they'll say, Well, I don't like seafood or who eats what, well I eat a healthy and healthy food, Are we, What topic are we? Are we talking nutrition or what are we talking?	Teacher
8	0:50.0 - 0:54.8	Are we talking about healthy life or are we talking about the web and ecosystem	Ruslan
9	0:56.5 - 1:00.7	yeah! completely terrible, completely terrible.	Teacher
10	1:00.7 - 1:05.3	It doesn't make any sense. When we look at it, it's means like we have 100 questions about this title .	Ruslan
11	1:05.7 - 1:17.4	We have a 100 questions about this title. We have a 100 questions about this title. And (to Quincy) why did you want to highlight the word *ocean*?	Teacher
12	1:18.1 - 1:19.8	Because then you know it's really about that	Quincy
13	1:22.6 - 1:26.1	and people, you said that when we highlight...(pause),	Teacher
14	1:26.9 - 1:36.5	people think, OK, what is highlight for? And so people think, so people say, I know that we need to look at that,	Quincy
15	1:37.5 - 1:41.1	yeah, we need to think about that.	Ruslan

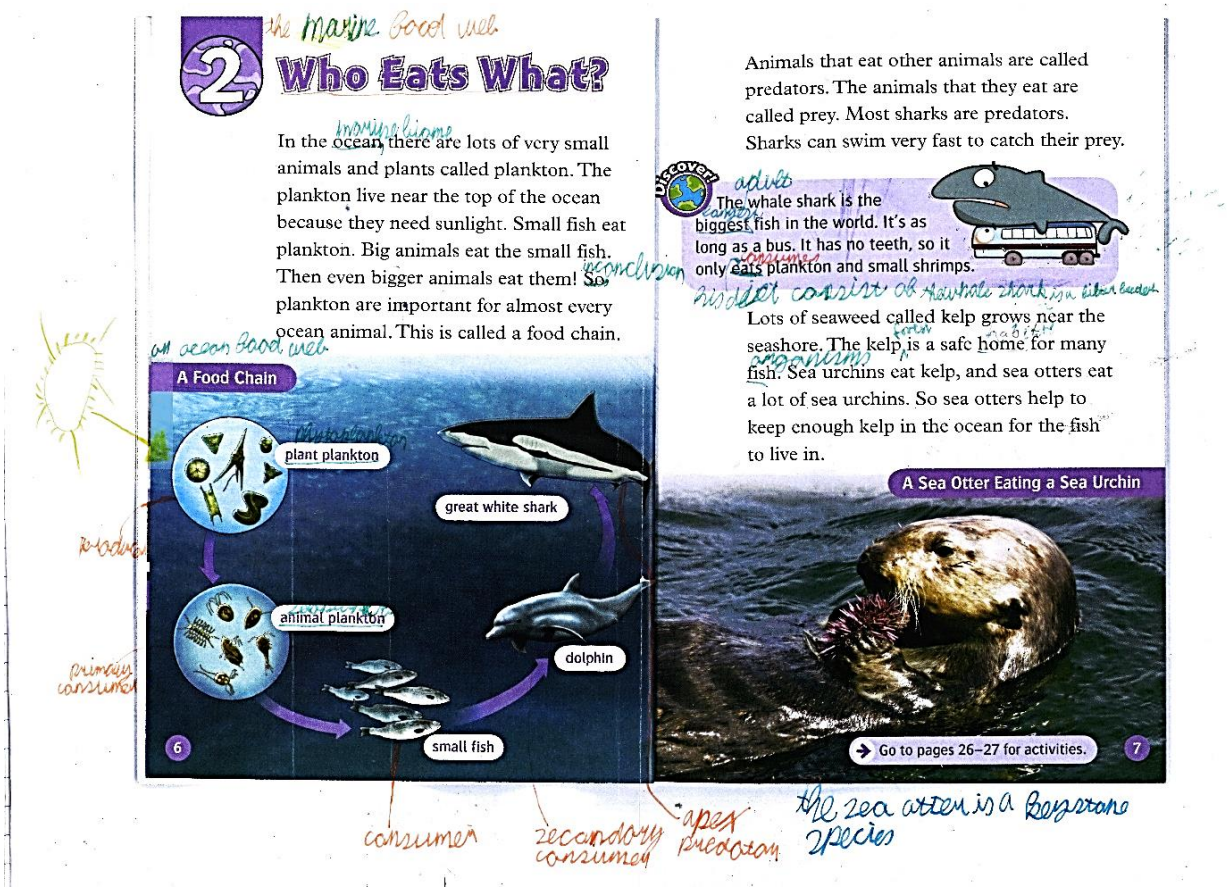
In turn 1, I refer to the students' ocean food webs by pointing to my photos from the activity which are on the table (on the WB in figure 16): prior to the start of the recording, we have been referring to the anchor text title "Who eats what?" and now I ask the students to comment further on "this terrible title" meaning the anchor text chapter title. Ruslan is promptly with me on this : "And it doesn't make any sense." (turn 2).



kelp forest figure 16 – Epistemic work. Ch 2 food webs discussion with kelp forest introduction. Teacher:"... And then we put the two types of plankton at the top" Ruslan "because it starts from there" Teacher and students comparing photos of the students' completed ocean web work (seen in figures 10 and 12) with the anchor text diagram, seen on the table (also figure 14) transcript 5 turns 35-56

I echo this sentence in turn 3 and continue to prompt for "…It makes you think about what" and Ruslan answers with "people eating, sleeping" (turn 4) and also echoes my phrase "Are we talking" with "Are we talking about healthy life or are we talking about the web and ecosystem" (turn 8) using the key term *ecosystem* from the Rich Point in episode 2. He echoes continues with "It doesn't make any sense. When we look at it, it's means like we have 100 questions about this title". I echo this comment and then try to involve Quincy by asking him to comment "…And why did you want to highlight the word *ocean*?" (turn 11), to which he proceeds to give a detailed explanation about the purpose of highlighting, and that the title should include *ocean* with a highlight, "Because then you know it's really about that" (turn 12). In fact, later, he re-writes *Ocean food web* to

Marine food web, as seen in figure 17, as we learn more about the kelp forest, as discussed below. Here, in turn 15, Ruslan echoes Quincy's comment of "we need to look at that" with "yeah, we need to think about that". Although the critical points continue, I have focused on our epistemic work and the particular discourse moves (highlighted in yellow) through which this work became visible, as seen in this segment of the episode. These moves, and this work as object (Wells, 1999), are now features of our cultural practices. I take up these points in the Outcomes section, especially regarding our interactional processes as evidence of our intersubjectivity (Goodwin, 2000) and achieving mutual understanding (Greeno, et al., 1999) on knowledge goals.



kelp forest figure 17 – Epistemic work and languaging. Ch 2 anchor text with Quincy's over-writing during discussion as seen in transcript 5: his labelling of the food web trophic levels, his colouring in of the Sun, and authoring sentences with the key terms *habitat* and *keystone species*. This is our jointly authored text to be used as resource for further writing; it is also a knowledge resource, as it contains the students' annotations on our epistemic work in discovering the key concept for our project.

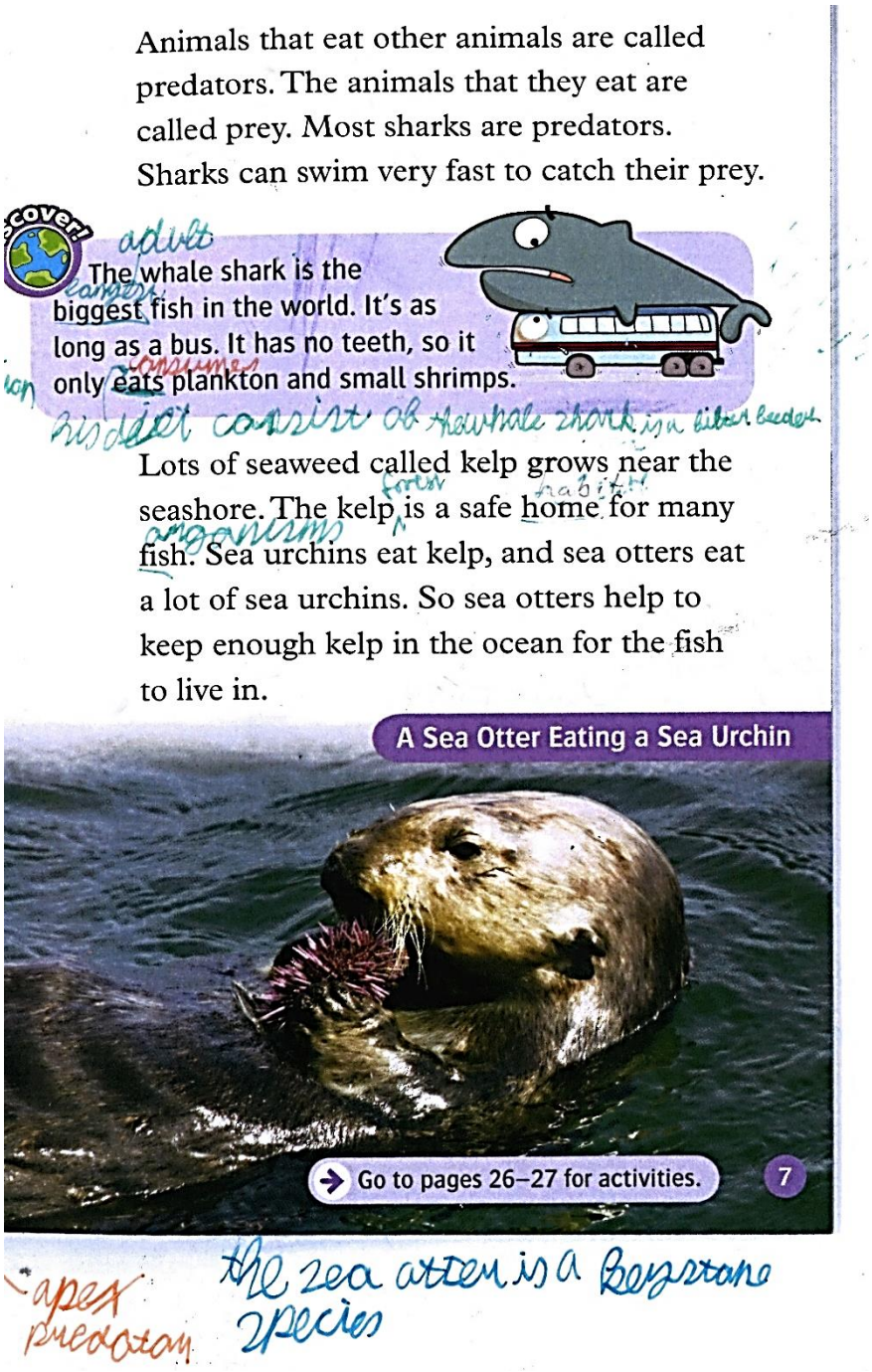
At this point in the lesson, I am feeling quite elated at this immediate and incisive critique on the part of Ruslan and the clear articulation of a strategy by Quincy. The following interaction points in the same lesson continue with student authoritative comments and expressions of agency; hence, I am narrating several points in the lesson so as to

describethe context for these expressions, such as Ruslan's emphatic use of "we" here and in other episodes. I discuss these points in the Outcomes section (e.g. Mercer, 1995).

These critical comments continue to turn 22, and I transition to the read-aloud sequence by requesting that Dai read, as he has not volunteered any critical comments in the preceding interaction. In the same turn 35, I find a way to connect with their ocean web activities shown in the photos, to prompt a discussion about their construction of their respective ocean food webs: it is as an assessment of sorts to see how they present their rationales in retrospect, and in the context of reading the anchor text (e.g. Hickey, Chartrand and Andrews, 2020).

In turn 37, I am pointing to Ruslan and Dai's work (discussion seen in figure 16) which I have now placed on the board using magnets. I prompt with a comment about the apex predator being placed in the centre of their web (seen in figure 12), and Ruslan begins to explain, turns 38-42. He has not explained the plankton, so I prompt him with "…And then we put, we put the two types of plankton at the top" (turn 45), to which he replies, "because it starts from there" (turn 46). I wish him to confirm this idea, so I prompt again with an echo: "everything starts from…" (turn 47) and he repeats it: "from the *plankton* " (turn 48). I echo with "*phytoplankton*" and he goes on to explain the shape of the ocean web that he and Dai constructed: "You look --- from the bottom---- like energy pyramid --- it's gonna be real messy like a ---- square" (turn 50). He refers to the energy pyramid work in the notebook (figure 8) to explain why the plankton are not placed similarly at the bottom of their web. I give compliments on the two groups' having persisted and in Dai and Ruslan's case redone their webs during the activity in question, and steer back to reading. I discuss the epistemic work in this interaction in the Outcomes section

As soon as Ruslan has read the next paragraph in turn 60, Ryu has a point of meta-talk about it: "maybe we can put *consume* " (turn 62). He is referring to the anchor text where it says "animals that eat other animals are called *predators*", and is suggesting an over-write as is our custom. Ruslan has a point of reasoning on the line "the whale shark is as long as a bus" (turn 64) that Quincy reads from the anchor text: he says "I think they made a mistake because when they're born they're not as big as this…" (turn 66) and he explains that it should say *adult*



kelp forest figure 18 – Epistemic work and languaging. Detail from figure 17, showing over-writing and editing by Quincy: *consumes* over "eats" at Ryu's suggestion, and further edits with *his diet consists of*, instead of *consumes*, *habitat* over "home" as discussed in turns 126-8, figure 19, and *the sea otter is a keystone species*.

shark. I express agreement with him and some theatrical surprise at the "mistake" in the text (turn 69), and Quincy immediately suggests that we re-write the sentence in the notebook with our 1-2-3 steps for re-writing (turn 72).

We proceed to discuss this in meta-talk, reviewing sentences in the notebook, turns 73 to 112, and editing directly on the anchor text page next to the image of the shark, as seen in figure 18.



kelp forest figure 19 – Epistemic work and languaging through MT. Teacher and student eye contact and mirroring facial expressions of agreement over the anchor text sentence, "The kelp is a safe home for many fish", "It's a silly word, the correct word is *habitat*" in turn 126. Ruslan is about to state his own criticism in turn 127.

In turn 114, Ryu returns to reading the anchor text, where it says "The kelp is a safe home for many fish". I interrupt, as this is my next signpost to get closer to the Rich Point that I have been orchestrating for weeks: "Wait, this is the *habitat*" (turn 115), and I suggest that we over-write "home" with the term *habitat*, seen in detail in figure 18. This is a term we have already used during our work with the energy pyramid. We discuss where to write it on the page, and I talk about my reason for this over-write, saying that the idea of "a safe home" is "silly": "This is silly. A home is what people have" (turn 126, seen in figure 19). The screenshot in figure 19 shows the moment where I have just uttered that sentence: Ruslan and I make eye contact and exchange what could be termed "knowing smiles" as shared expressions of agreement (e.g. Gumperz, 2001), and as a visible expression of our intersubjectivity (Goodwin, 2000), constructed in this episode as well as through our months together building our local culture.

Ruslan agrees, saying it is not actually safe (turn 127), and I ask them to write, "the kelp forest is the habitat for many organisms" (turn 128, over-writing in figure 18). I am again also preparing our prior knowledge text for our upcoming writing, seen in figure 24, episode 6. Ryu immediately wants to know how to spell *organism* (turn 134), although we have it written in the notebook with the energy pyramid work. Quincy offers to go the word wall to do it, and turns 134 to 152 involve this task. While Quincy carries that out, Ryu brings up the topic of the missing sun in the food web diagram in the anchor text, added in figure 14 and seen in figure 17: he wishes to quiz Ruslan on that point from episode 4. Ruslan, as stated before, makes his critique promptly and clearly: "My comment is, it's (the original anchor text diagram) not very good because it doesn't have the Sun." (turn 140). Ryu thus initiates and demonstrates epistemic authority yet again.

We then return to the point of re-writing the chapter title, which the lesson had started with, at my prompt in turn 153, and the students reply with comments, resulting in the title and highlight seen in Figure 17. I then direct the students to look at the anchor text sentences, "Sea urchins eat kelp and sea otters eat a lot of sea urchins. So sea otters help to keep enough kelp in the ocean for the fish to live in" (seen in figure 18). This is my opportunity to prompt for the connection with the students' "island story", and I include here in Excerpt 4 the rapid exchange of ideas during which our Rich Point emerges in this segment in the lesson:

III kelp forest Excerpt 4 – from transcript 5

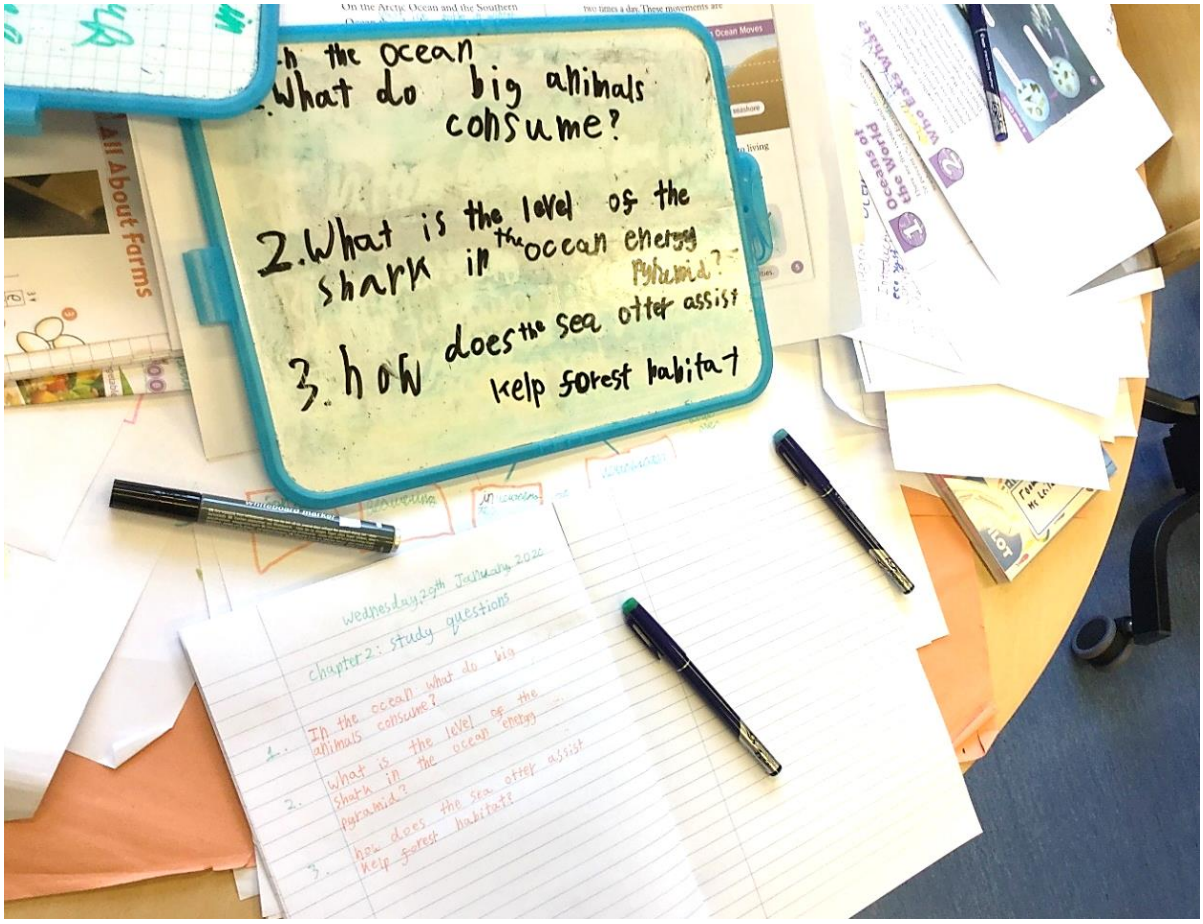
161	31:02.4 - 32:05.1	...(asides) . (pointing to the text) The sea otter is a very important animal. The sea otter kills the enemy, it's the enemy of the kelp. The sea urchin, it turns out, eats the kelp. If there are too many, the kelp forests will disappear. So here is where we get to back to that story. Remember Quincy, you were telling about Mr H-- the last year (he nods), who said that there was not enough of something...(pause),	Teacher
162	32:05.7 - 32:11.9	If there is not enough of one thing, then most of the things will disappear.	Quincy
163	32:12.4 - 32:15.8	Yeah. Imagine if the sea otter isn't there,	Teacher
164	32:17.2 - 32:17.5	the	Quincy
165	32:17.9 - 32:24.7	the urchin will eat the kelp forest and the habitat of all those animals will disappear.	Teacher
166	32:26.3 - 32:26.8	habitat loss	Ryu
167	32:26.8 - 32:27.5	habitat loss	Teacher
168	32:28.8 - 32:34.6	meant that the animal who lives that	Ryu

169	32:36.1 - 32:36.2	the organisms that live in that habitat	Teacher
170	32:37.5 - 32:37.6	or biomes because there's more	Ryu
171	32:38.8 - 33:15.3	we're speaking just about speaking about the kelp forest habitat, the biome is a bigger thing and maybe the biome is affected also. But the biome contains more than just the kelp forest, right? And but the biome is affected and everybody else. You are right about the biome being affected. Absolutely, I see your point. Now, friends. Can I ask you to write three study questions?	Teacher
172	33:16.4 - 33:17.5	Oh, like we did in chapter 1.	Ryu

I rephrase the second sentence above by saying, pointing to the text, "The sea urchin, it turns out, eats the kelp. If there are too many, the kelp forests will disappear. So here is where we get to back to that story. Remember Quincy, you were telling about Mr H-- the last year (he nods), who said that there was not enough of something….(pause)" (turn 161). Quincy instantly completes this thought by saying, "If there is not enough of one thing, then most of the things will disappear" (turn 162). I ask them to imagine if the sea otter is absent, and Ryu uses the expression *habitat loss* which they have been taught in the mainstream class. I am concerned with the correct use of the new terms and concepts, in turn 171, but I quickly redirect the sense of my comment to validate Ryu's epistemic work instead, with "but the biome is affected and everybody else. You are right about the biome being affected. Absolutely, I see your point." When I request that the students turn to writing study questions, Ryu replies with "Oh, like we did in chapter 1" : this, I understand immediately, is not a simple clarification point, as he states it in a very matter of fact way, and using the term "we". I take it is a statement of his feeling of shared authority in the lesson: he knows what our practices are, and he is agreeing that we can turn to this one now. I develop the point of public validation of the students' epistemic work and expressions of agency and authority in the Outcomes section (e.g. Hickey, Chartrand and Andrews, 2020).

Figure 17 shows the epistemic work of this episode added to the work in episode 4: the anchor text with Quincy's over-writing during discussion as seen in this episode; his labelling of the food web trophic levels; his colouring in of the Sun, and authoring of sentences with the key terms *habitat* and *keystone species.* This annotated and edited representation is our text constructed through our *shared writing*, to be used as exemplar for further writing. Equally, it constitutes our knowledge resource for subsequent semiotic tasks for epistemic work: it contains the students' inscription noting our discovery of the key concept for our project. Hence, we have our Rich Point, where we connect with and use as knowledge resources the students' own prior epistemic work – in this unit and in the previous school

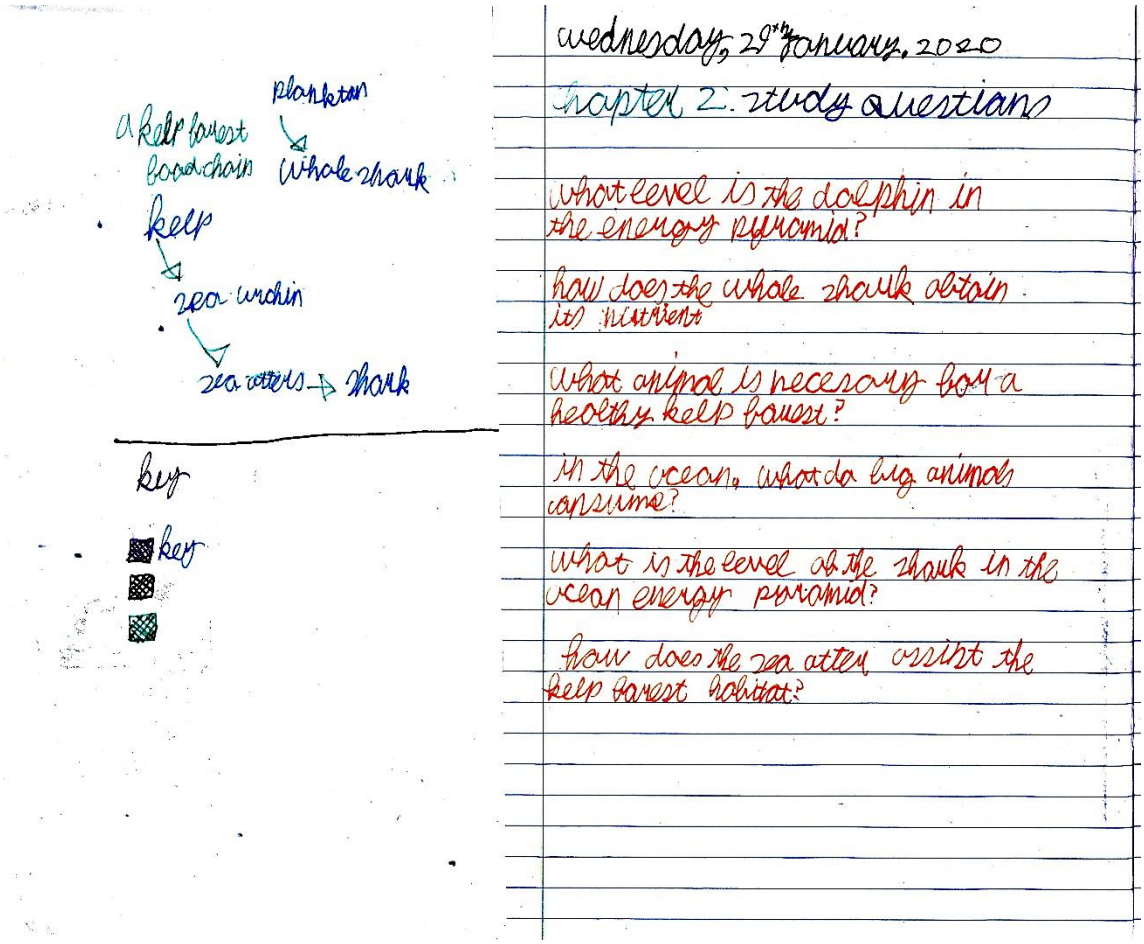
year – with our developing representation and discourse practices in a manner that preserves the students' epistemic agency and authority in our community. Episode 6 is concerned with the manner in which we carried forward these practices and our knowledge of the topic to explore the concept of the kelp forest and sea otter, and to prepare our class presentation on this.



kelp forest figure 20 – Epistemic work and languaging. Ryu's study questions on ch 2 ocean food web first written on the whiteboard, using the new terms as well as other terms written on the word wall, together with copying out in the notebook, seen below the whiteboard.

Having constructed the opportunity for the students to establish the connection with their "island story", I transition to individual writing in our customary task of writing study questions, in turn 171 with "Now, friends", as there should now be time for our practice of individual reflection on the text and writing the study questions. The transition to this task in the sequence is smooth, as it is familiar and also recently enacted with the preceding chapter, as Ryu states in turn 172. As I observe the students and take photos with the iPad

in my manner – which is also an established practice – it soon becomes evident to me that this activity has taken on a new significance for the students.

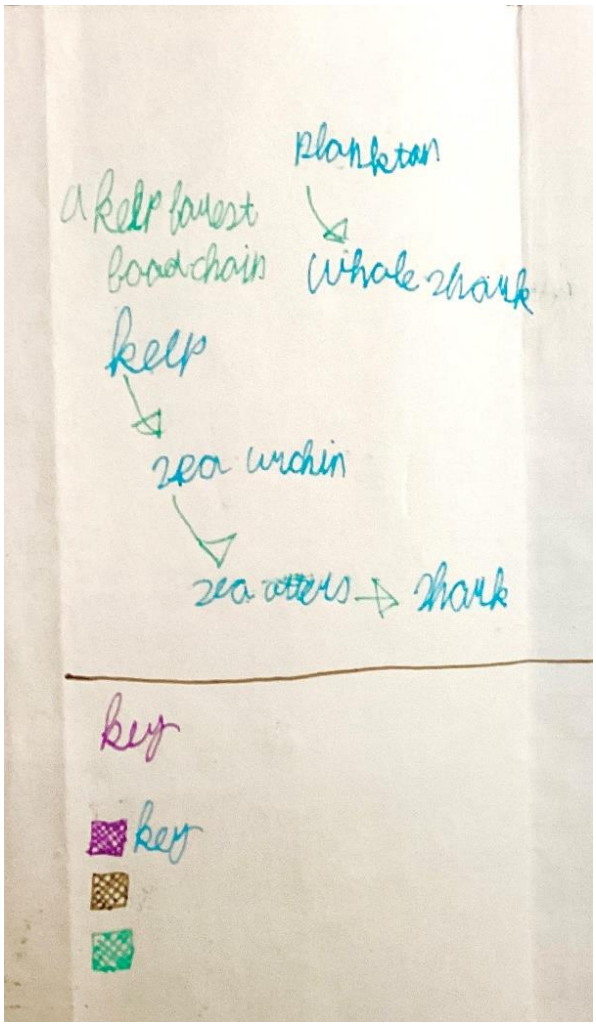


kelp forest figure 21 – Epistemic work and languaging. ch 2 study questions in Quincy's notebook applying terms used in the prior activities in the unit; his own representation construction that he entitled a *kelp forest food chain* on the left side of the notebook double page, see detail in figure 22

I am continuing with my design of fostering reasoning through this semiotic work. Having engaged deeply in reasoning through the text on the social plane, I now wish for Ryu and Quincy to continue with an internal dialogue with the text (e.g. Scott, 1998, p 74). They should have time to extend this internal dialogue and then represent their ideas through the familiar practice of the study questions noted on the personal whiteboard, which is our social space for public accountability (e.g. Mercer and Howe, 2012, p 16).

By this means, I see that Ryu has applied the term *consume*, which he had brought up for discussion, and his application of the energy pyramid terms to the new habitat context in the second question. Furthermore, his third question is about the sea otter, and applies the

academic term *assist* in place of the everyday word help in the text, as well as the term *habitat.*



kelp forest figure 22 – Epistemic work. detail from Quincy's semiotic work: he has drawn his own diagram entitled *kelp forest food chain*, including two food chains; one for the whale shark, and the other for the kelp forest. He has used a colour code, and started to prepare a key.

Quincy has also copied his three study questions from the whiteboard in his notebook as shown in figure 21. However, Quincy has written his own question about the sea otter, "What animal is necessary for a healthy kelp forest? " (third from the top), also making use of the academic terms such as *necessary* in a complete rephrasing of the anchor text, and using *healthy*, from his discussion in episode 1 on *healthy* and *environment*. His study questions are now evidence of his inner speech, externalized through this epistemic work.

On his own initiative, continuing this expression of inner speech, Quincy has carried out other semiotic work (e.g. Tytler, et al., 2020; Bezemer and Kress, 2020): he has drawn his own diagram and titled it *kelp forest food chain*, seen on the top right in figure 21, and in

detail in figure 22. There are in fact two food chains; one for the whale shark, and the other for the kelp forest. In both, he has applied the energy arrows according to his collaborative work with the ocean web in episode 3 (figure 10), and applied a different colour to the title; for the second, he has surmised that the shark is a predator of the sea otter and added it himself, although the anchor text does not state this. He has tried to add a key with colour boxes, which he was discussing in episode 1 and 2. He returns to this work in the next iteration.

Through the work in this iteration, I have come to refer to the students' individual epistemic work with words and representations as semiotic work, which I discuss in more detail in the Outcomes section. The collective and individual effort shown in episodes 4 and 5 on the part of the students leads me to believe that they find the ideas discussed in these episodes to be very engaging and meaningful conceptually (Berland, et al., 2016) as well as on the affective level (Jaber and Hammer, 2016). I therefore make plans to develop our work on the kelp forest as a presentation to the mainstream class (Hammer, Goldberg and Fargason, 2012).

Episode 6 – Text and representations: Epistemic Work, Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ problematizing: *identifying gaps* ▪ authoring: ○ Ss writing work: *authoring based on discussion* ○ Ss representation work: based on discussion, *using own inferencing and semiotic signs* ○ Ss *state ways that ideas should be represented, as representations or terms* ▪ *editing and transforming text*	Rich Point: kelp forest lesson with the mainstream class, by students ○ Ss lead in class presentation - figure 27 , figure 28 ○ Ss extending classmates' EW through MT,	Specific Design Principles ▪ *practices are initiated by students* ▪ *making connections about practices* ▪ *authoring in disciplinary ways* ▪ *constructing personal records of EW* ▪ *sedimentation of practices*
Meta-talk (MT) ▪ noticing: *Ss ask questions to direct talking points for EW*		

In this episode, I first devise another activity in the manner of the ocean food web collaborative activity, designed so as to rehearse the concepts to be presented to the mainstream class. A comparison of two real sites off the coast of California, involving the presence and absence of the sea otter, is to be explored by the students so as to go into detail on its role as the keystone species of this habitat and its various organisms (Center for Biodiversity and Conservation, AMNH, 2020). The activities and interactions described in this and preceding episodes therefore cumulatively constitute their epistemic work to construct their own "coherent explanatory narrative" (Tytler, et al., 2020, p. 224; Sikorski and Hammer, 2017, p. 931).

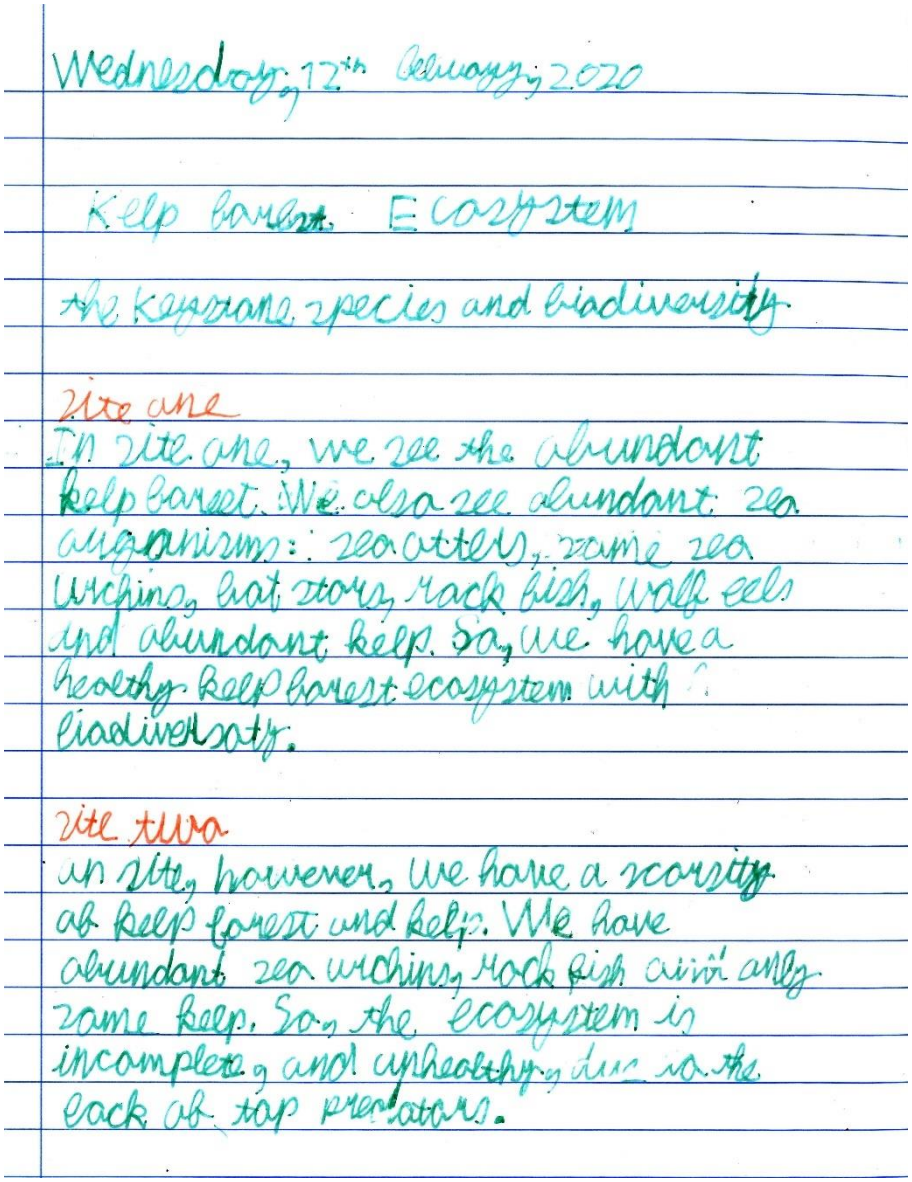
Using the material from this website, I again cut out the organisms and present these as a new puzzle to investigate the trophic relationships in the manner of the energy pyramid activity, as shown in figure 23. The organism cut-outs again include clues. Here, I am mindful of the earlier episodes such as Dai and Ruslan's ocean web work figure 12, or in editing the anchor text, in figure 14, where the students did not all refer to the trophic levels and consult the notebook representations as a resource. Writing about the two contrasting

sites is done collaboratively according to our established practices of creating dialogic spaces (e.g. Parr and Wilkinson, 2016; Rojas-Drummond, 2019) for this epistemic work. As before, we use the WB together and write individually in the notebook, as seen in Quincy's notebook page in figure 24, through discussion around our resources: we refer to the images and the information about the organisms from the abovementioned website, together with our shared writing about the ocean web constructed in episodes 4 and 5. The shared writing process here again also involves meta-talk referring to our word wall, and then discussing noun and adjective pairs of these words, as seen on the whiteboard in figure 25.



kelp forest figure 23 – Epistemic work. Kelp forest organisms and students' joint construction of the kelp forest energy pyramid, combining some previously constructed material in the notebook, as seen in figure 8, to promote reasoning through representations.

The students then work in the Book Creator in our familiar manner, as seen in figure 25: they combine the images and text in order to prepare material for the class presentation as seen in figure 26. These pages are to be shown on the classroom IWB as seen in figure 28.



Wednesday, 12th February, 2020

Kelp forest Ecosystem

the keystone species and biodiversity

Site one

In site one, we see the abundant kelp forest. We also see abundant sea organisms: sea otters, some sea urchins, bat stars, rock fish, wolf eels and abundant kelp. So, we have a healthy kelp forest ecosystem with biodiversity.

site two

in site, however, we have a scarcity of kelp forest and kelp. We have abundant sea urchins, rock fish and only some kelp. So, the ecosystem is incomplete, and unhealthy, due to the lack of top predators.

kelp forest figure 24 – Epistemic work. Quincy's notebook showing our shared writing based on our collaborative work on the kelp forest organisms and energy pyramid, seen in figure 23, and referring to our resources constructed in episodes 3, 4 and 5..

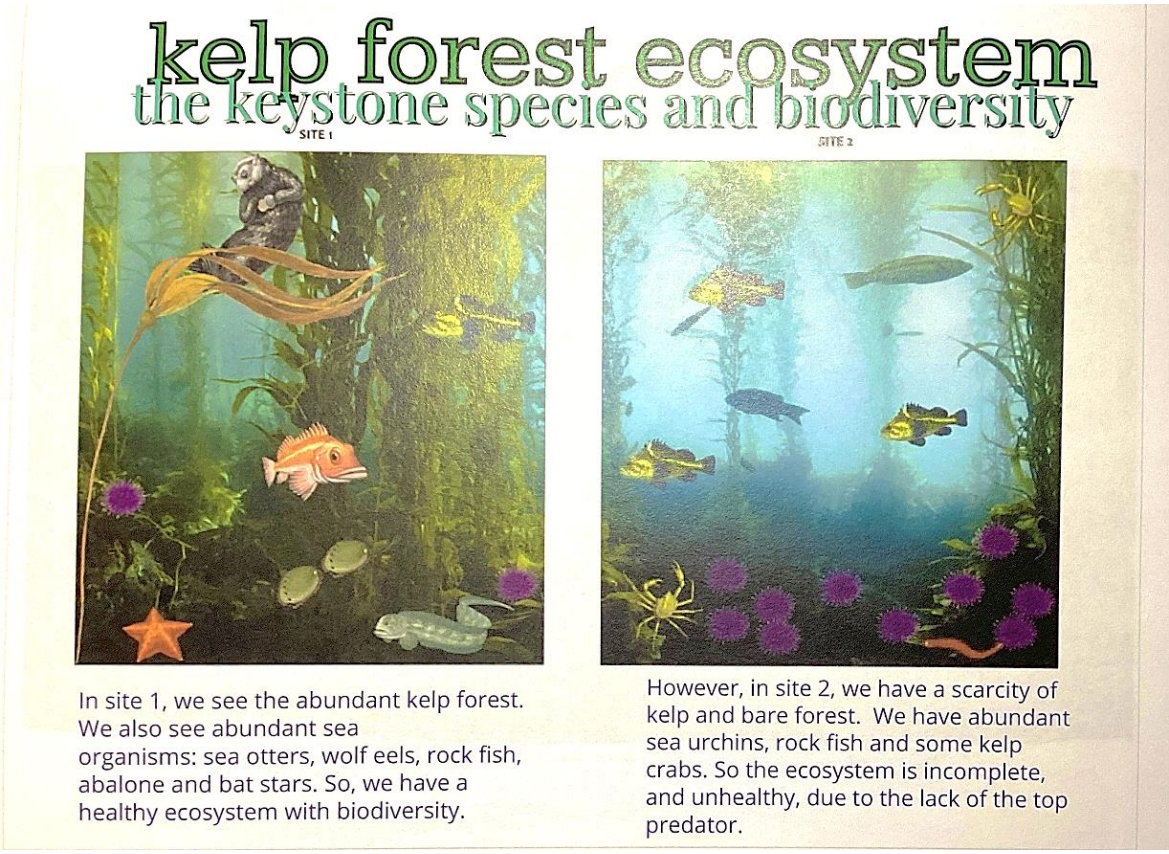


kelp forest figure 25 – Epistemic work. Ryu and Quincy discussing as they prepare the Book Creator pages on the kelp forest ecosystem to be shown as part of the class presentation, one page seen in figure 26

In our Rich Point of this concluding episode for this iteration, the students in turn teach their classmates in the mainstream class, presenting activities on the concepts of the ecosystem and the effect on the biodiversity and the environment due to the presence or absence of the keystone species.

For this presentation, I prepare two posters consisting of photos of actual sites with sea otters i.e. "healthy" and without i.e. "barren" corresponding to the artwork used in our activity as seen in figure 26. The students use these as the context for enacting their own lesson with the class, as seen in figures 27 and 28, using the same organism cut-outs seen in figure 23. Figure 28 shows the classroom tables in the foreground with the posters showing the two sites, and Ruslan, Dai and Ryu at the IWB, presenting the paragraphs and other visuals from the Book Creator pages, as a whole-class follow-up to their group-level discussion and interactive work with the groups of students at each table. During this lesson

led by my students in the mainstream class, I stood by in the background and took photos with the iPad.



kelp forest figure 26 – Epistemic work. A page from Quincy's Book Creator notebook, combining the images from the activity and our shared writing text from figure 24.

The following day, I suggest to the students present that they write a reflection on their kelp forest presentation, as a conclusion to their writing in the Book Creator notebook. We do not precede this writing with discussion, nor do I provide prompts or examples for this task. The screenshots of these pages from the students' respective Book Creator notebooks can be seen in figures 29, 30 and 31.

Each student focuses on different aspects, but all agree on "the fantastic presentation", albeit based on different points. Ruslan states that "I think they learned something" referring to the class, and "it was really good due to they were listening and doing our stuff" (figure 31). Ryu noted how he and the other presenters did not say "Wrong or correct" in speaking during the group work, instead explaining and "going deeply on every ones ideas" (figure 29). Quincy, in figure 30,

actually states the goal of the presentation, in referring to the mainstream class, that "They had to realise what would happen to the abundant kelp forest without the fantastic sea otter". He also explains his own stance to the work, stating how he liked preparing it, and the effort that went into it. He even refers to the academic language of science explicitly: "we wanted the class to know how interesting science is with all those words: abundant irrigation marine biome" (underline added). In the Outcomes section, I argue that these statements are expressions of the students' affectivity and identity (Wells, 1999, p. 122) or epistemic affect and motivation (Jaber and Hammer, 2016, p. 161), and thereby evidence of their commitment to their epistemic work.

In these reflection pages, the three students evaluate the mainstream class students as being interested, "working hard" having ideas and liking the presentation. However, Ryu, Ruslan and Quincy also give evaluative remarks on their own work in it, in very specific terms. Ryu states that "we explained clearly and without saying Wrong or correct, secondly we went deeply on every ones ideas", which are clear statements of how he sees our discourse practices. Similarly, Ruslan states that during the group discussion, he kept asking the group questions: "I was saying why? why? why?". Quincy refers to knowing science words as an aim, and that this makes science interesting in itself. Hence, these written reflections constitute clear evidence that the students are aware of their discourse practices for epistemic work; furthermore, they can state in their own words in what way the cumulative work here constitutes a Rich Point for each of them.

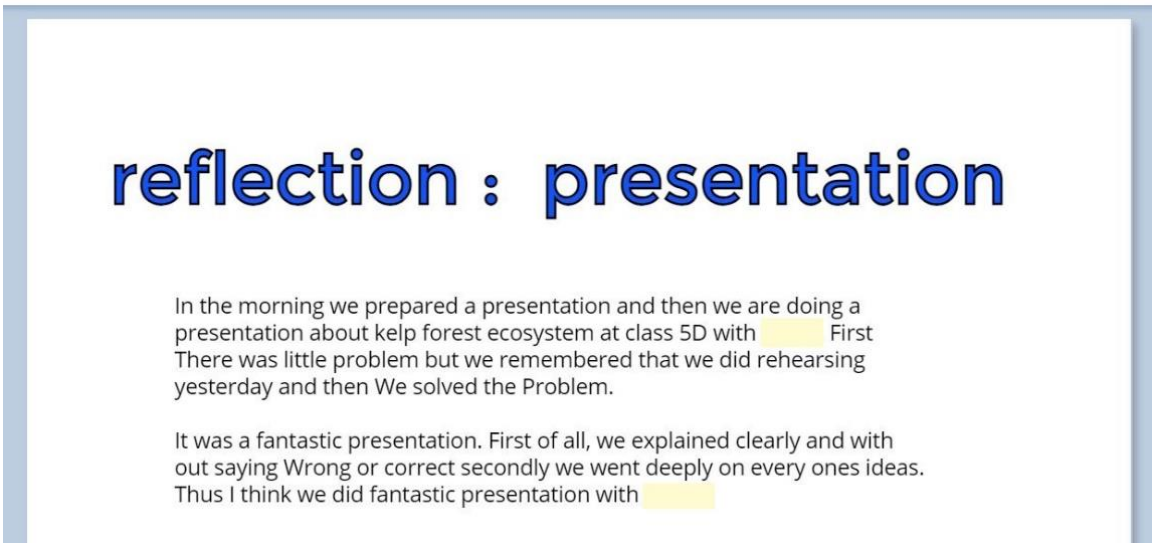
With this final episode in the iteration, I again refer to the Outcomes section, where I discuss our sequence of Rich Points in this third iteration in the intervention, with special attention to the semiotic mechanisms mediating our increasing participation in and control of our discourse practices and external sign forms (Wertsch and Addison-Stone, 1985, p. 177; Greeno, et al., 1999) thus confirming our awareness of and agency in building our local culture. These processes of reasoning aloud, mediated by our improvable objects as artifacts, are shown in figure 4-5, which indicates revisions due to new design knowledge from this iteration.



kelp forest figure 27 – Epistemic work. **Rich Point**. Kelp forest lesson in the mainstream class: Ruslan is leading a group (faces blurred) in working on placing the organisms in the "barren" site, without sea otters, and asking them questions about the diversity of the organisms



kelp forest figure 28 – Epistemic work. **Rich Point**. Kelp forest lesson in the mainstream class: Ruslan, Dai and Ryu are presenting their paragraphs with a projection of a poster on the smartboard, following the group discussion work at the tables as seen in figure 27

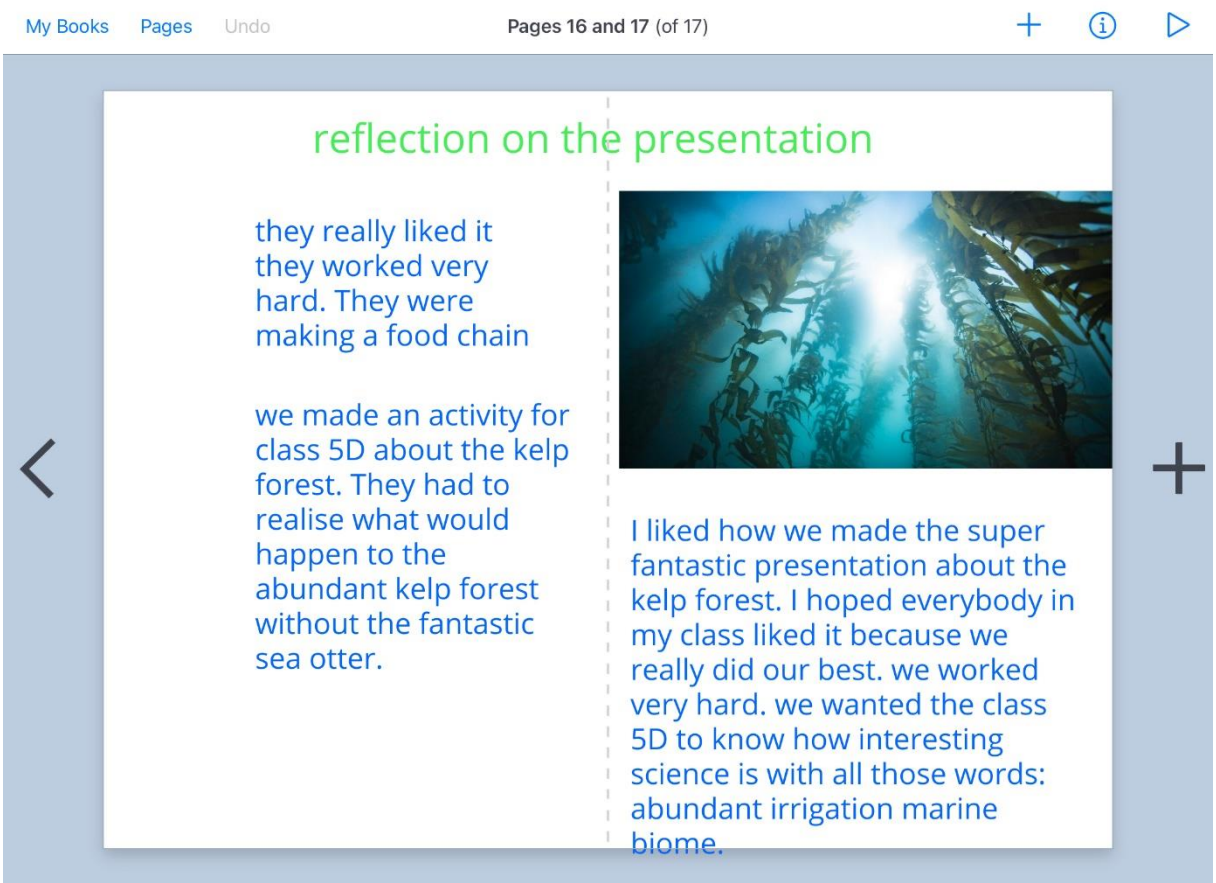


reflection : presentation

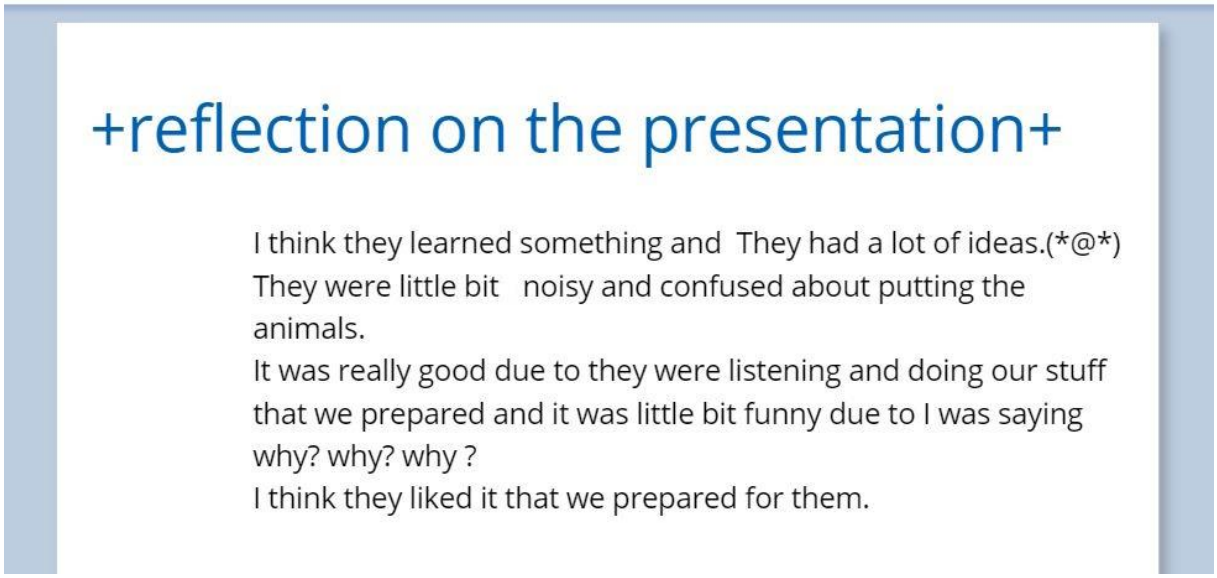
In the morning we prepared a presentation and then we are doing a presentation about kelp forest ecosystem at class 5D with [redacted] First There was little problem but we remembered that we did rehearsing yesterday and then We solved the Problem.

It was a fantastic presentation. First of all, we explained clearly and with out saying Wrong or correct secondly we went deeply on every ones ideas. Thus I think we did fantastic presentation with [redacted]

kelp forest figure 29 – Epistemic work. Ryu's reflection page on the class presentation, written in his digital notebook on biomes and the kelp forest. (student names blanked out)



kelp forest figure 30 – Epistemic work. Quincy's reflection page on the class presentation, written in his digital notebook on biomes and the kelp forest.



kelp forest figure 31 – Epistemic work. Ruslan's reflection page on the class presentation, written in his digital notebook on biomes and the kelp forest.

4.5 Iteration IV – Energy all around us

In this unit, I continue to design instruction with the DPs shown in figure 4-6, carried on from figure 4-5 for *Kelp Forest*, in order to continue testing the DPs and the Process Conjectures. The basic characteristics of the intervention are therefore maintained, as shown in column 2. However, *Iteration IV Energy* builds on the competence attained in *Kelp Forest*, in which the participants (students and teacher) attained a new level in the enactment of these practices, as shown in column 3 of figure 4-5, with *reading aloud* and *reasoning* around anchor text. Interacting around anchor text in *Kelp Forest*, students began to express new levels of explaining and arguing, concerning the AL in text and representations, which they treated explicitly as *knowledge construction*. This growth culminated in representation work in episode 5 and the reflection work in episode 6, which I now carry over to activities in the new unit to test the conditions for transfer of our practices.

In this final iteration, I orchestrate interaction around the new anchor text by prompting for new kinds of representation work, so as to open opportunities for the students to argue and explain these: they *read aloud* and *reason aloud* for AL, through discussing their own generated semiotic sign-making as shown in figure 4-6, column 3. In the Outcomes section, I present the findings for the iteration as evidence of full internalization of our cultural practices on the social plane, seen in the autonomous and individual transfer of these practices to the knowledge construction work in this unit.

Figure 4-6 Map of Design Principles and Enactment Processes applied to findings for Iteration IV

Design principles	Enactment Processes (Mediating Processes)	Iteration IV – Energy
- are heuristic guidelines - define the intervention: instruction is designed so that these principles are put into operation - provide a means-end relation	- basic characteristics of the intervention - result from design features - mediate learning outcomes	- results from **final application** of Design Principles in the Enactment Processes: o **reading aloud** o **reasoning aloud**
Designing instruction with: 1. a variety of modalities will stimulate and engage 2. science anchor texts will provide students with o read-aloud tasks o challenging content and concepts o models for disciplinary literacies o context for language activities 3. daily reading and writing, and connection making between these, will foster habits of mind for the discipline 4. integrated literacy and science will provide students with meaningful contexts for o language tasks o representation tasks o **knowledge construction practices** 5. teacher orchestration of discourse for o purposeful shifts in interactions o dialogic < --> authoritative o connection-making a. will help foster **a local culture** b. will help promote agency in students, c. will help students to enact AL in disciplinary ways highlights indicate conjectured means-end relation terms in **bold** indicate revisions at the end of this iteration, terms in ***italic*** indicate fully mature key discourse processes	**Participant Artifacts** 1. shared writing: AL anchor texts a. annotated through *over-writing* b. annotating: notes and visuals c. *re-writing* jointly and individually 2. authoring own digital texts 3. sketches: note-taking 4. completing and editing worksheets 5. representation construction: concept maps, diagrams, symbols 6. shared writing: a word wall **Observable Interactions** 7. performing read-alouds and presentations: ***epistemic work*** 8. attending to read-alouds and presentations 9. discussion around: a. text-based questions: ***meta-talk*** b. editing moves using ***meta-talk*** and ***languaging*** work c. note-taking moves using ***languaging*** for ***epistemic work*** d. presenting notes: ***epistemic work*** e. giving peer feedback on notes and edits: ***meta-talk*** and ***epistemic work*** f. reflecting on own and other's edits: ***meta-talk*** **Participant Experiences** 10. increasing initiative in task design 11. affirmation of **agency, authority** 12. accumulation of visible **authored cultural artifacts** 13. **participation in and construction of a local culture**, identity 14. engagement with and **definition of the lesson content**	**Artifacts : anchor text** • **text** : vocabulary : EL, AL • **representations** : images : EL diagrams, labels and text : EL, AL **Interactions** o reading aloud noticing words and signs, interpreting sign-making, o reasoning aloud over-writing, annotating, editing with sign-making; **noticing** AL need, **editing**, **explaining**, **arguing** **Artifacts : student generated text** • **text** : over-writing, re-writing AL: • **representations** : diagrams : sign-making AL photos, lists : AL **Interactions** o reading aloud arguing words, arguing editing constructing sign-making o reasoning aloud organizing, explaining arguing on work **Sign-making – constructing,** **generate:** new and apply prior sign-making in new ways EL : Everday Language AL : Academic Language

4.5.1 Iteration IV Energy all around us– Analysis and Outcomes

Introduction

In the final iteration of the design in this study, circumstances beyond the classroom caused a change in the EPs, due to a move to an online learning environment. However, our observable interactions around our edited and constructed artifacts in fact retained many of the characteristics established in the in-person environment. We seized on new ways of carrying out our established practices of sign-making and interactions for epistemic work presented by certain features of the online tools. I argue here that this productivity was possible due to the level of maturity of our local culture reached by the time of the lockdown. Hence, in my discussion in chapter 5, I present my findings on the usefulness of DBR and designing across time and in cycles of activity: by reporting fully on key events and features of each iteration, it becomes possible to reliably account for the pathways and mechanisms for the changes in participation across time, as outlined in chapters 2 and 3 (e.g. Green and Chian, 2018; Bakker, 2018, p. 121; Mercer, 2008).

Energy weeks 1 – 2 : episodes 1-4

In Iterations I and II, I established a shared perspective on sign-making among the participants by means of my designed EPs mediating *noticing* on signs and text for epistemic work, i.e. "establishing the field of shared attention" (Mortimer and Wertsch, 2003, p. 235; Gumperz, 1992) or "shared intentionality" (Sidnell, 2014, p. 366). I noted in the analysis in *Kelp Forest*, that a key characteristic of our practices mediating this shared perspective in our local culture is in the ways that we have come to use the concept map and other representations edited and constructed by us. Whereas in *Farming*, the students were using the concept map to report on prior ideas, and only in one instance used it to change their ideas – with the redefinition of *nature* – in *Healthy*, they began to use it for adding ideas through discussion. However, they were interested in adding semiotic sign-making with a colour code and key to develop meaning through hierarchies and categories, and did so with

persistence, discussing this process as they worked. Thus, with the new meaning-making functions of these semiotic tools, the students were editing their own work as epistemic work, not only adding words to a collection: through our meta-talk practices for languaging and epistemic work, they reasoned, justified, shared, and reconsidered, while inscribing these ideas through new tool use as sign-making on their text as new objects of thought with each revision.

Hence, a process of reasoning *with* the representation on hand had gradually emerged, distinct from using it as a visual support to *tell* some points already written on it, and also distinct from basic note-taking as collecting information. I elaborate on this process and its origins in the course of this section, as I account for ways that our intersubjectivity is attained across the iterations, i.e. how our "external social processes are *transformed* to *create* internal processes" (original italics) as stated by Wertsch and Addison-Stone (1985, p. 163).

In iterations III and IV, the participants articulate how they view and use representations and words as *text* which is an *improvable object*. In *Kelp Forest*, as the students began to construct a new concept map, Quincy reasoned in extended turns *with* the previous and new concept maps on hand, to articulate the reasoning process for preparing the new concept map and using preceding items on it (kelp forest figure 6; kelp forest excerpt 1). Dai, when prompted, used his concept map not only to *tell* his written points, but to articulate his reasoning for editing his own work, which then became a point for extended reasoning in the group. Ryu bids to speak with "is this good" which is now a signal of his agency in shaping the lesson: he decides to evaluate the practice (kelp forest excerpt 2), with "you can see the ideas that was in your head, so you're not forgetting because you already wrote it". When I prompt him to continue, he states, that you can "review it, and you can think". In his extended turn, Ryu is paraphrasing Wells: " ...a written text can be reread..., reconsidered and revised, with each successive version of the text providing the basis for further reflection and reformulation" . (Wells, 1999, p. 268).

Here, in *Energy* episodes 1 and 2, students use the concept map in this way, explicitly and at length. In episode 1, they use it to note new ideas about energy regarding the Sun: the Rich Point emerges as they write the new AL terms that they find interesting, applying their own

semiotic signs derived previously, which are now part of our cultural tools (Wertsch and Kazak, 2005, p. 2; Prain and Tytler, 2012, p. 2757) and resources (Wells, 1999, p.277). In episode 2, the students argue at length about the uses of concept maps and a table of contents in an extended dialogue of meta-talk for epistemic work: it is a new Rich Point in our argumentation, building on episode 5 in *Kelp Forest*. Ryu restates his views that he developed in the Kelp Forest work; the new student, Kassim, attempts to convey a view which is not at the same level of insight, as it is only descriptive; Ruslan compares the two representations and then goes to the WB and *re-constructs* the table of contents to reflect his points, again with his derived semiotic signs (figure 5). I elaborate on my use of the terms in italics below, as I analyse the learning progression of the students in epistemic work and representational competence mediated by our interaction using our semiotic signs.

Hence, the students express their epistemic agency and authority in reflecting about our practices, with the representation as the object mediating their reasoning, even as they are constructing and revising the object. I therefore take Ryu's reflection as a suitable title for the first section of this iteration: "we can see our ideas clearly and then come back" , as he now also identifies this as our cultural practice, using we. Kassim has *noticed* our practice of reflection mediated by the artifacts that we are constructing, but is only beginning to enact this; in episode 8, however, he shows his transformed reflection on the social plane, also using "we" (excerpt 5). As I discuss throughout the iterations and in chapter 5, Kassim needed time for the external activity in the social plane to be transformed in creating internal processes for reflection, which the other participants had already attained to a clearer form at this point.

In episode 3, we engage in representation *construction* in a new level of sign-making around editing *text*, building on our resources developed in the *farming* year diagram, the *healthy* note-taking, and the *kelp forest* biome diagrams; the Rich Point shows Dai also bringing in his prior experience with sign-making. Figures 9 and 10 show Dai's revisions of his KE and heat energy representation through our meta-talk and multimodal tools. As we discuss what the anchor text image should really indicate through our established meta-talk practices around *text*, we identify or *notice* a gap in that representation, which then becomes our improvable object. The students language this gap through signs as our new over-writing for AL. They devise new signs for the new concepts of KE and heat energy, progressing from the

biome and energy pyramid arrows and labelling, which were provided in those activities. We have, in Dai's energy diagram, a new level of authoring through editing a provided representation (Fiorella and Kuhlmann, 2019) as *text* and successively revising our own *text* for our own epistemic work.

In episode 4, we carry out our authoring through editing in our established read-aloud practices. Kassim engages in languaging and epistemic work through meta-talk, over-writing the anchor text followed by our re-writing practices of shared writing for AL. Through the extensive writing and meta-talk, Kassim joins and participates in our practices: the well-rehearsed interaction by the other participants as they read, write and construct signs on the WB enables him to establish the shared perspective on the sign-making references. He has more time to internalize the activity on the social plane so as to transform his internal reflection, concretized as he writes in his notebook. The smoothness of the interaction and writing indicate the degree of intersubjectivity achieved, through our well-established and explicitly recognized semiotic mechanisms (Wertsch and Addison-Stone, 1985, p. 163), which have been built across the iterations as described. This activity as shared cultural practice (e.g. Nasir, et al., 2020; Barab and Duffy, 2012, p. 26; Hoadley, 2012, p. 288) for epistemic goals set by the participants as a common purpose is further demonstrated at an authoritative level in episode 8. I take up the point in chapter 5 as validating the approach to studying learning as changes in practices over time (e.g. Damşa, et al., 2010, p. 196).

Energy online environment : episodes 5-7

With episode 5, we move to the online environment provided by the secure Google learning space managed by the school. We continue our read-aloud practices, in the context of which the next Rich Point emerges, through our continued developments in using representations for reasoning and editing. The students were presenting on small research topics chosen from ideas in the anchor text, through their uses of the familiar Book Creator notebooking tools. Ryu's work in figure 14 showed him as having consciously progressed from telling, as in the farming concept map, to our reasoning with the representation on hand. As discussed with the reasoning on the concept maps, he discusses his research finding while pointing out features of the diagram and image, but also editing his accompanying text concurrently, making more use of the terms appearing on the diagram.

Hence, Ryu is also going beyond interpreting and "telling" what is on the diagram: he is over-writing his own text as he revises his understanding through meta-talk. The students show awareness of the representation as a dynamic construction and representation of ideas and thoughts through this authoring process.

This dynamic re-construction of ideas through representation is carried further in episodes 6 and 7. We carry out our read-aloud practices using Jamboard, the virtual WB with interactive annotation tools available for each participant to act concurrently on the joint object of reasoning. These tools are providing us with new mechanisms for both *noticing* and editing. We continue Ryu's process in episode 6, with editing as we reason on the representation, as a new form of over-writing. This over-writing is more fluid than in the classroom WB, as all participants may work without physically obstructing one another. However, this fluidity is a reflection of our established interaction practices, as we are familiar with our annotation and meta-talk for epistemic work and languaging, and we are used to adopting new semiotic tools to engage in these practices.

Hence, when I suggest beginning to edit the coal diagram through annotations and over-writes, the Rich Point emerges with Quincy seizing the opportunity to author as we are reasoning on the AL and the representation. We engage again in representations across modalities, as the students at home *re-construct* their own version of this coal diagram and our annotations, holding it up to the camera from time to time. This functions as a mechanism to internalize the interactions on the social plane, as there is time to think on the sign-making and also continue discussing, just as the writing of the re-writing steps in the notebook from the WB is a time to reflect on it through the *noticing* process of sign-making with the various tools.

In episode 7, we turn to editing and authoring the text boxes for the coal diagram. We move from authoring as representation construction by means of the diagram *re-constructions*, which we did through shared writing multimodally on the Jamboard and at home. In the shared writing for the text boxes, we are in fact re-writing the anchor text through our over-writing and re-writing practices as in episode 4. We are authoring our own science explanation of the coal formation process: first, through the *re-construction* of the coal

diagram as shared writing for AL; then, through re-writing the accompanying annotations through shared writing for AL.

Throughout this process, the increasingly fluid work with the interactive tools of the Jamboard enable engagement and focusing at a new level for our *noticing* in the interaction around the text. The coloured stickers and zoom pens with the little icons are very amusing just as they help productivity; however, I came to perceive that these amusing features heightened the agency as well as the *noticing* necessary for our intersubjectivity in this new demanding level of epistemic work. The students persist to carry out the over-writing and re-writing for AL, converting my notes that I write through our discussion on the classroom WB to typed text and labels in the Jamboard. These semiotic mechanisms are reflected upon by the students in the course of episode 8.

Energy return to in-person environment : episode 8

In episode 8, the Rich Point develops as the students carry out our cultural practices: they organize themselves to perform our read aloud practice including discussing and over-writing the anchor text, and then seize upon opportunities to *construct* a diagram as authoring on concepts in it. They demonstrate their understanding of the EL – AL continuum by enacting the read-aloud discussion, suggesting and doing their own over-writing. When we discuss a concrete example of heat energy being transmitted, they suggest constructing a diagram. The students proceed without prompting, and apply semiotic tools developed through our prior epistemic practices across the iterations.

Each student constructs his own version, stating what tools and signs he needs: for instance, Ruslan states that he needs a colour to represent the heat (figure 35), or that he should make a key. Quincy clearly articulates (excerpt 6) the knowledge represented in his sequence of panels, together with the semiotic signs that convey the various aspects of the knowledge construction. Kassim, who was new to the group at the start of the iteration, is now able to evaluate and clearly state the purpose of diagrams: "so we understand better what we want to say, and we can see how is it... if It's only some blah blah. We will only know, but there will not be an example. So in our head, it will be more difficult to understand." (figure 38). I therefore take his reflection as a suitable title for this concluding section of the iteration and the study. With it, Kassim paraphrases Wells's position on text as "a resource for intramental activity"

(Wells, 199, p.136), demonstrating that he knows what our cultural practices are, what it means to participate in them and that he has constructed an identity as a member in this local culture.

Outcomes – Iteration IV Energy all around us

With the results from this final iteration, I may now endeavour to draw a learning progression for attaining the High-Level Conjecture proposed by the initial Conjecture Map for this intervention. With the work across time enacted by the participants, in different topics, the Process Conjectures were continually reconfirmed, as the students attained new levels of outcomes towards their understanding of the EL – AL continuum, through increasing control of disciplinary discourse practices involving using and constructing texts about phenomena and processes in school science topics. Therefore, each iteration, as argued in the analysis for each, did not have the sole purpose of applying adjustments to improve a flaw or omission. The iterations were linked by a series of Rich Points which constituted signposts for key events indicating the participants' attaining a certain level of intersubjectivity. In each of these key events, the students bridged the social activity to their intramental functioning and expressed something of their inner speech, through meta-talk. So, in farming episode 3, Ruslan suddenly points to his artifact – his *improvable object* – with his pen and states "is there another word for 'water'": this is his inner speech externalized through meta-talk. The other participants knew what he was referring to, as he gave examples and pointed to our prior work as knowledge resource; hence, this was a moment of us participants calibrating our categories, which was achieved through this semiotic mechanism (Wertsch and Addison-Stone, 1985, p. 166).

As further evidence for these Rich Points as events denoting inner speech, the work taking place in that moment turns into a key resource for all participants, in fostering subsequent work and Rich Points, as noted in the narratives for the iterations. Thus, in kelp forest episode 4, the students are now *reasoning aloud* mediated by finding a gap in the anchor text diagram as a Rich Point. The next Rich Point is connected to this expression of inner speech, as the students now find gaps in the text of the anchor text. The interaction around the text in kelp forest excerpt 3 takes place with students stating their reasoning using AL, and is given form through echoed phrases: this level of meta-talk around objects indicates

the new high level of intersubjectivity attained by the participants, and their identification with this interaction as a culture.

This level is now being expressed in the social plane in extended and detailed form in iterations III and IV, as transformed in the participants' intramental functioning, through carrying out our practices over time. They have practiced externalizing their noticing through *read-alouds*, over-writing words as they see meaning-making is needed through noticing a difference (Scott, 1998, p. 59) to be resolved. Through our work with editing and authoring *text* as representations as well as words, established in Iterations I and II, the students are working at the conceptual level in Iterations III and IV, having established our cultural practices for epistemic work through increasing complexity in semiotic tool use. The DFs in this study have therefore enabled the construction of the semiotic mechanisms by which the students have gradually connected the internal functioning to the interactions and tasks in the social plane (Wertsch and Addison-Stone, 1985, p. 164).

The progression in the EL – AL continuum is conceptualized as increasing appropriation and use of disciplinary literacy, involving interpretation and construction of text as representations and other semiotic signs, as AL forms. Hence, the students progressed from the *word* level in *Farming*, and diagrams such as the farming year which extracted or *reproduced* words from the anchor text, to *re-constructing* the ocean web based on clues interpreted in a text, to *re-constructing* the coal diagram as process in episodes 7 and 8, and finally to *constructing* the KE and heat energy diagram by Dai in episode 3, and the heat energy diagram as process explicitly across time, in episode 8. This progression was enacted by explicitly considering semiotic signs as AL, and applying them in epistemic work through meta-talk in extended sessions of group discussion and *shared writing*.

This developmental analysis of the progression of the students in this continuum demonstrates the need and the usefulness of the design-based research approach as applied in this study. As noted in chapter 3 and in Iteration I, the Conceptual Framework of the study takes a situative view of learning, where participants learn to build signs through a shared history of activity. I drew on Wertsch's (1985; 1997) work on Vygotsky's concepts of internalization and semiotic mechanisms, and Wells's (1999) work on the centrality of writing, as I prepared the DPs of the Conjecture Map, to formulate a connection to the

Process Conjectures that I had derived from my own work. The shared history narrated in the iterations shows how the students came to master the uses of the artifacts by "participating in practices where it is mediating" (Wells, 1999, p. 136). The students arrived at a level of awareness of these practices as a result of participating, but "only after having carried out that action for some time" (Vygotsky 1981, cited in Wertsch, 1997, p. 133). Hence, it was both necessary and useful to enact the DPs across time, so as to account for the processes by which the students came to recognize the significance of representation for epistemic work through increased mastery of semiotic signs, mediated by our forms of interaction around text as improvable object.

In chapter 5, I present a discussion evaluating the effectiveness of the Initial Conjecture Map and its components, through a retrospective analysis the mediating processes and outcomes as I applied the map across the iterations, as noted in the introduction map for each iteration (figures 4-3, 4-4, 4-5 and 4-6). Through figures overviewing the interactions around text and representations through the successive iterations, I will outline the successive steps in developing the semiotic mechanisms that fostered each new level of expertise in the students. I will then propose a synthesis of how these mechanisms were generated and then developed further across time in this study. As DBR aims to provide insight into possible means to solve a problem, this study presents insights into *how* these outcomes were achieved, and I therefore provide certain recommendations for how similar learning environments may be constructed (Bakker, 2018, p. 104).

4.5.2 Iteration IV Energy all around us – Design Narrative

This section presents the ethnographic Design Narrative for the data selection in Iteration I *Farming*, presenting the participants' emic perspective through a narrative style which conveys their in-the-moment responsiveness and decisions. This narrative style includes references to gestures and expressions of the participants, in addition to statements about my perceptions or feelings in the context of the interaction, as these impact my decision making for responsiveness to students' ideas (Berland, et al., 2020; Thompson, et al., 2016).

The data gathered in the Design Narrative section is in three parts, defined by the instructional setting: Part 1 contains four episodes enacted in the classroom setting of the previous iterations; Part 2 contains three episodes enacted in an online environment; Part 3 contains one episode with a return to the original classroom setting.

I refer to excerpts from this transcript and also as before include screenshots as part of a multimodal transcription (Bezemer and Mavers, 2011) for their visually revealing features concerning our epistemic work mediated by our *texts* and our participation structures.

Part 1 Energy Weeks 1 – 2 *"…writing a concept map … we can see our ideas clearly and then come back"*

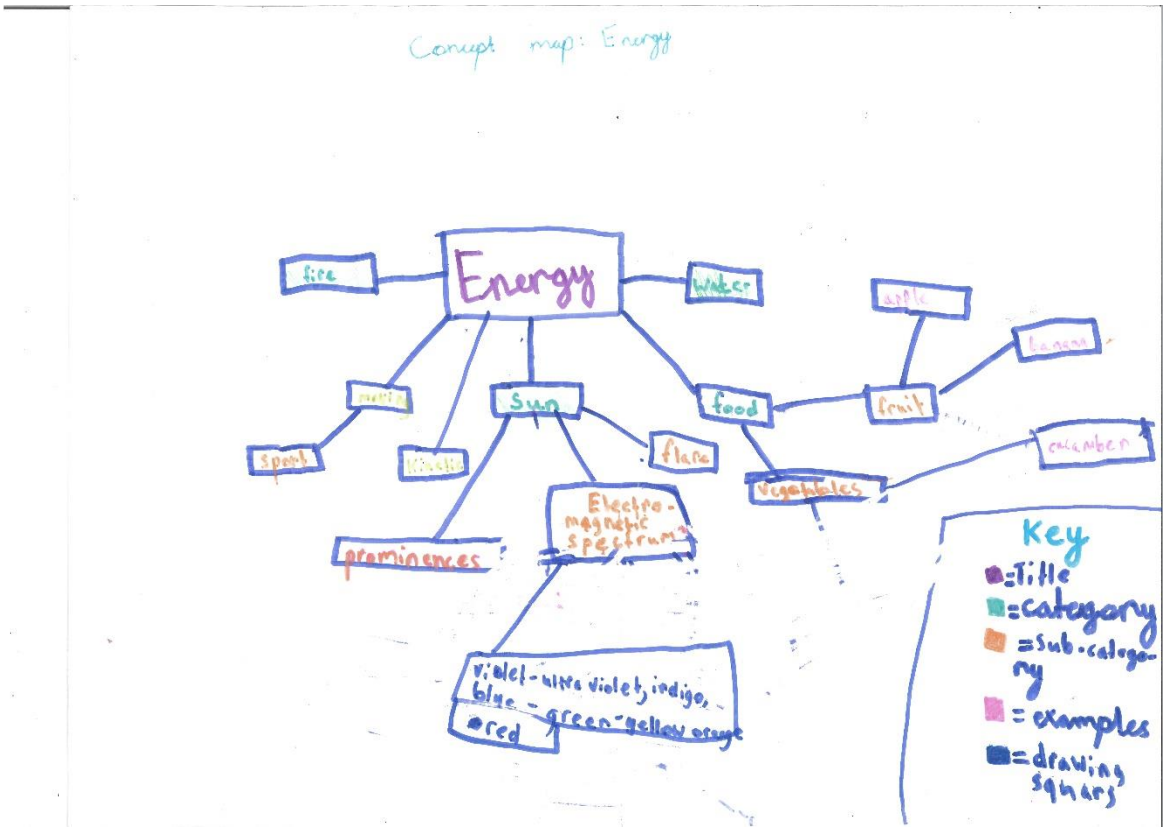
Episode 1 – Concept map, anchor text and representations: Epistemic Work through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *Ss authoring: through own and requested words, shared writing* ▪ *applying own sign-making for new ideas*	Rich Point: "solar flares and prominences", by students ▪ *students re-orient the purpose of the task and the lesson* as note-taking and goal-setting, by adding new terms from discussion, using their own sign-making, figure 1	Specific Design Principles ▪ *building on student ideas* ▪ *noticing as connection making for reasoning* ▪ student agency
Meta-talk (MT) ▪ *words are discussed as ideas with concept map as referent: reasoning aloud*		

The first Rich Point of the new unit emerged from this transition lesson consisting of a discussion around our concept map work. As with the previous concept maps, connections to preceding work were discussed through student initiative; this time, however, the discussion soon changed direction according to student interest emerging in the epistemic work with the new material, and the task changed to note-taking using the students' own semiotic sign systems.

As before, we have our previous concept maps on hand as knowledge resources produced by us, while also looking at new resources such as an information book for schools about the Sun and a web site showing a diagram of the electromagnetic spectrum, as seen on the laptop in figure 3

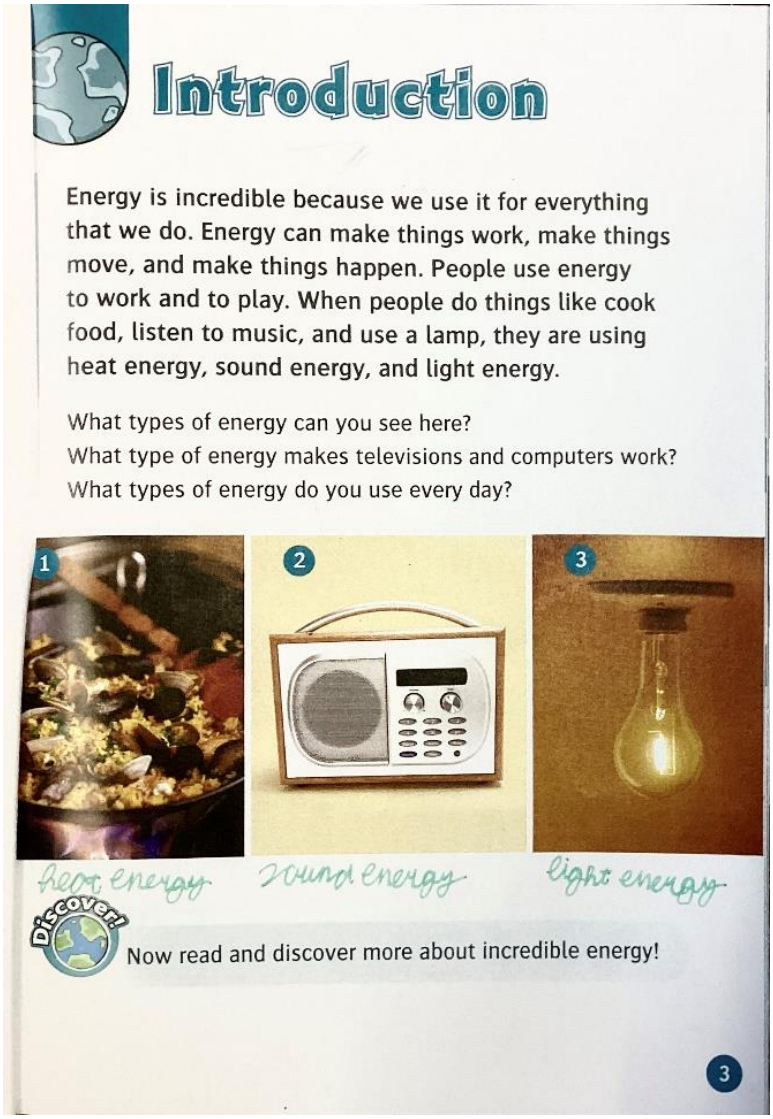
We concurrently begin to read the Introduction page to the new anchor text, titled *Incredible Energy* (Spilsbury and Spilsbury, 2011), seen in figure 2 with Quincy's annotations. The students label the images on the page, as we have been doing with the previous anchor texts and our other semiotic work. However, the students do not discuss points for over-writing in the anchor text, nor do they show interest in the questions there after annotating the images. They noticeably focus on viewing images of the Sun in the reference book: noting that they have selected this as "shared object", I provide the terms *prominences* and *flare*, as we view and discuss the impressive solar flares on the various colour photos.



energy figure 1 – Epistemic work. **Rich Point**. Ruslan's concept map, Energy, with terms emerging from points made by students in discussion: *prominences*, *flare*, *EMS*, applying his own semiotic signs.

These terms are noted on Ruslan's concept map in figure 1, and mentioned later by Ryu in excerpt 1 below (turn 5), indicating the importance of these ideas in the students' minds. The discussion around these images and the concept map work takes up the first two lessons entirely, for which I change my planning. The students clearly wish to develop their new knowledge artifact, using the concept map task in a new way: to externalize their thoughts during new epistemic work.

Hence, I saw that my planned focus on the Sun quickly developed in a different direction through the dialogic characteristics of our interaction. The students seized the opportunity to pursue their own connections and goals, which I perceived from the responsive way they engaged with the visually impressive Sun reference material and their eagerness to discuss new terms, and immediate use of the terms in their concept maps. Therefore, this epistemic work constitutes our first Rich Point in this iteration, showing the students exercising their epistemic agency and authority in shaping the course of the lesson for goals that they were forming as they engaged with the new material together as a new common goal.



Introduction

Energy is incredible because we use it for everything that we do. Energy can make things work, make things move, and make things happen. People use energy to work and to play. When people do things like cook food, listen to music, and use a lamp, they are using heat energy, sound energy, and light energy.

What types of energy can you see here?
What type of energy makes televisions and computers work?
What types of energy do you use every day?

1 heat energy

2 sound energy

3 light energy

Discover!

Now read and discover more about incredible energy!

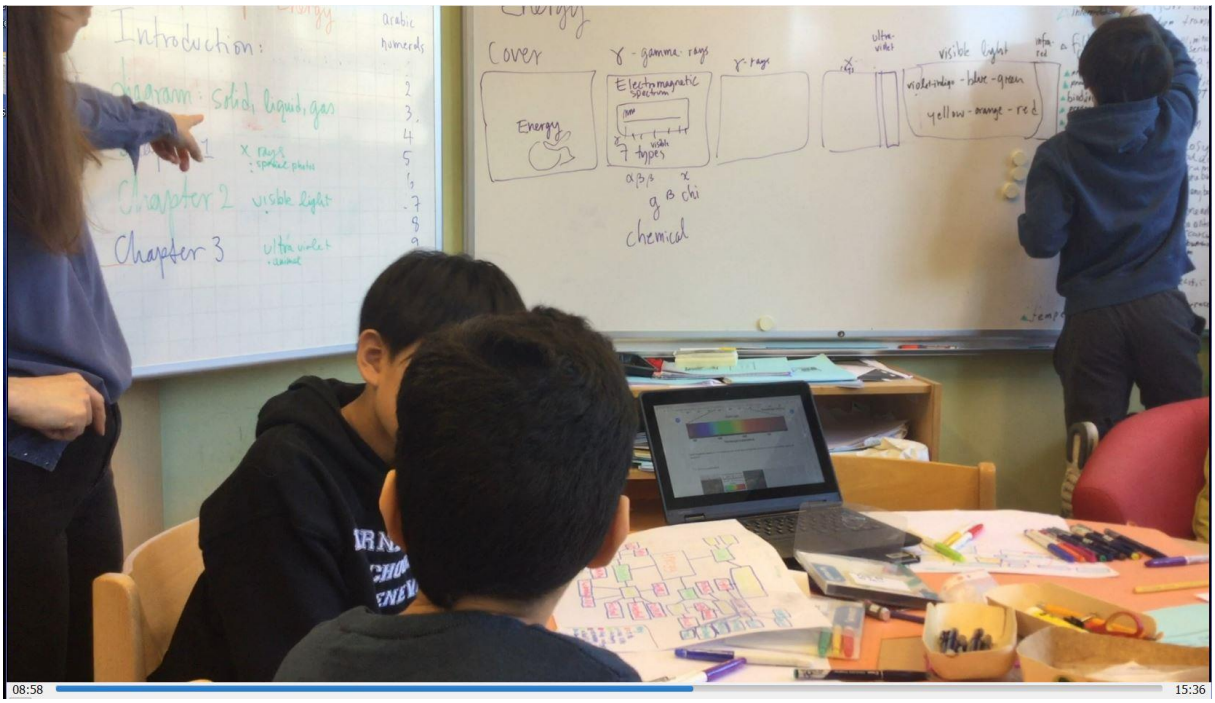
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energy figure 2 – Epistemic work. Anchor text Introduction with Quincy's annotations in green pen.

Episode 2 – Anchor text and representations: Epistemic Work through Meta-talk

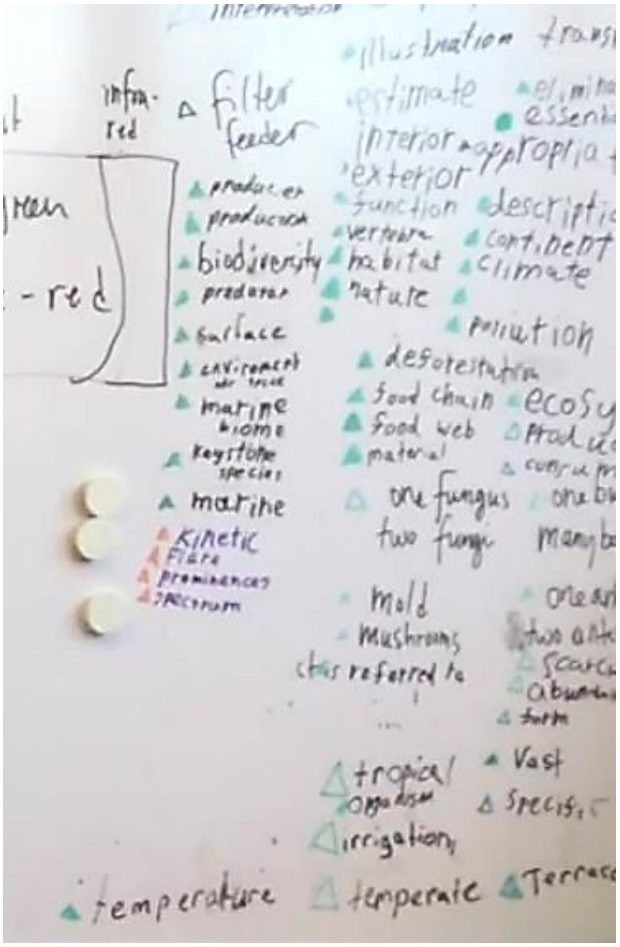
Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *editing text : authoring. arguing* ▪ *stating ways idea generation is a practice* Meta-talk (MT) ▪ *discussion on concept maps is a practice of reasoning aloud*	Rich Point: arguing and explaining about concept maps "we can see our ideas clearly and then come back", by Ryu ▪ evidence of intersubjectivity: students present arguments about purposes of concept maps and other epistemic work excerpt 1	Specific Design Principles ▪ *identity building: Ss exert authority* in taking up points, in authoring writing; in justifying practices ▪ *improvable objects*

Our next Rich Point emerges in the discussion shown in energy transcript 1, with a focus in excerpt 1. The students initiate a discussion on their own epistemic work, each stating arguments on the purpose of these, with justifying examples. This follows logically from their re-purposing of the concept map task in episode 1. Here, Kassim is already showing an



energy figure 3 – Epistemic work. **Rich Point**. Energy introduction discussion, concept map compared with the table of contents; Ryu's new concept map visible on the table, Quincy is doing new writing on the word wall; teacher pointing to the new table of contents written with students; image of EMS diagram shown on chromebook screen on the table and copied on the WB.

understanding of participation in our practices, as the other students recognize his arguments as contributions to the debate on our cultural tools and artifacts.



energy figure 4 – Epistemic work. Closeup of the WB showing the word wall at the start of Energy unit, with the new unit words – in purple with orange bullet points – new terms added by the students to their previous work, see also figure 33

The transcript begins with an ongoing discussion about note-taking: we are comparing concept maps with the table of contents that we are now writing on the WB (on the left in figure 3) about the new anchor text chapters and also the pieces of work that we are authoring. Ruslan has been explaining his view of the difference between a table of contents and diagrams or concept maps, and I ask him to restate, in turn 1:

Energy excerpt 1 – from transcript 1

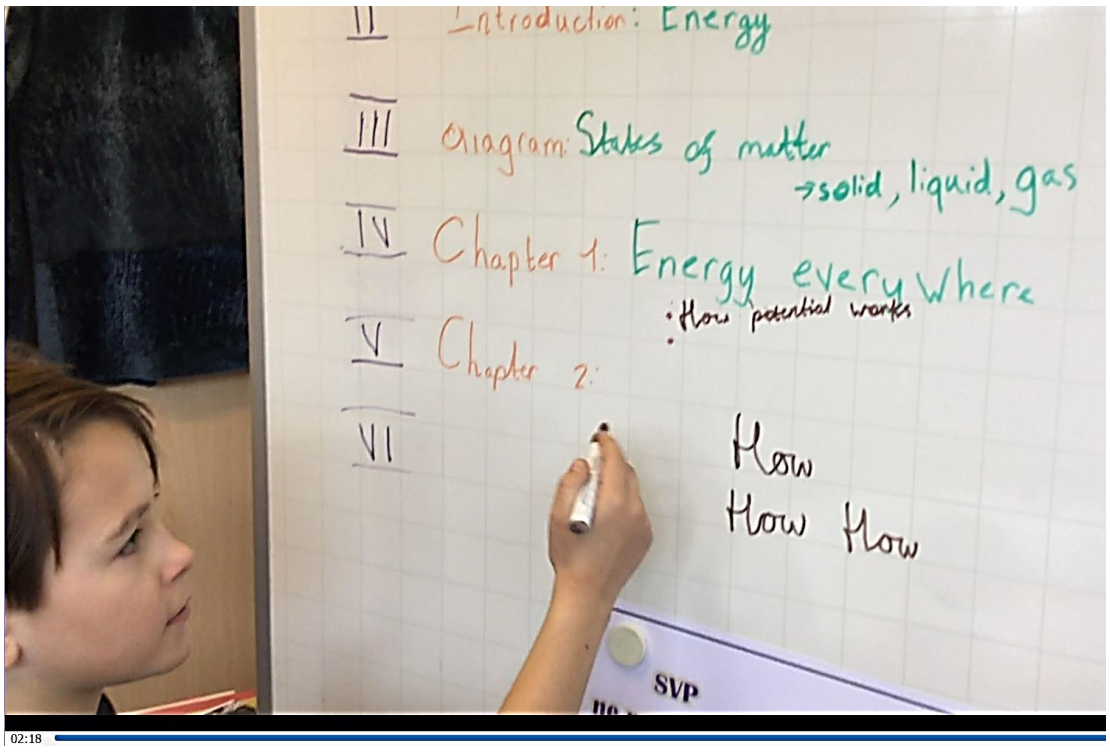
1	0:02.4 - 0:26.7	I think you're saying that a table of contents is really it's a type of notes, but is, is, how is it different, I still don't know. (T speaking while adjusting iPad) Tell me again how it's different from, tell me again, how it's different from the concept map, because now I forgot	Teacher
2	0:27.7 - 0:38.0	The concept map is kind of notes, and diagrams it's, it's not, the table of contents it's kind of what what you did,	Ruslan

3	0:39.3 - 0:48.9	but how is that different from? So I'm still not sure, OK, because is that not what a table of contents is? It's what you did, yes (indicating student)	Teacher
4	0:52.2 - 1:34.0	So in my idea, I think uh the table of contents is like what we did and we can come back so if there's no table of contents it's like where are we now again. And so I think the table of contents is for that and the energy and concept map, as I said before, and it's to put our idea here, so I think 15 days later, if you don't write a concept map, you will forget everything. (he pauses)	Ryu
5	1:35.6 - 1:37.9	For example, *prominences*, it's (pauses again)	Ryu
6	1:38.5 - 1:48.5	hard to remember the first time. If we were writing a concept map, you can we can see our ideas clearly and then come back	Ryu
7	1:50.4 - 2:19.8	and come back to it. But but but here also we can see some ideas. (pointing to the board and table of contents) OK, I didn't finish writing the names of the chapters. OK, I didn't do that right? Not yet, because we didn't do it yet, but. How is how is OK, I get I get that. Aren't both of these things to help us remember? Yes.(students agree) Now, Kassim come back to what you were saying, please do you remember what you just said. (aside in Russian, to Ruslan)	Teacher
8	2:21.0 - 2:30.7	So like a concept map, it's like you show one idea, only one idea like this is the idea.	Kassim
9	2:30.9 - 2:33.5	And here and	Teacher
10	2:33.8 - 2:38.6	Here you divide the idea is in the idea that there is a lot of little ideas	Kassim
11	2:38.6 - 2:54.6	A lot of little ideas, whereas, right. That's another word on the on on the one hand and on the other hand, repeat on the other hand, on the table of contents ….	Teacher
12	2:59.6 - 3:12.7	doesn't show lots of little ideas. And on the concept map, there is lots of little ideas in the idea	Kassim
13	3:14.0 - 3:15.6	in the big idea. (indicating another student)	Teacher
14	3:17.2 - 3:20.6	I disagree with Kassim about the table of contents	Roman

Ruslan rephrases his point in turn 2, and I try to extend the point. He is referring to his note-taking in the concept map task in episode 1, and I wish to hear him elaborate on that development. However, Ryu wants to speak on that: he clearly defines the table of contents and the concept map, "So in my idea, I think uh the table of contents is like what we did and we can come back so if there's no table of contents it's like where are we now again. … concept map, as I said before, and it's to put our idea here, so I think 15 days later, if you don't write a concept map, you will forget everything" (turn 4). He pauses, looking at his concept map, and gives an example, "For example, "prominences", it's…" (turn 5) again pausing, "hard to remember the first time. If we were writing a concept map, you can we can see our ideas clearly and then come back" (turn 6). He is externalizing his inner speech as he prepared his concept map, as evidence of his appropriation of that task as a "tool for recall and reflection" (Wells, 1999, p. 270). He consistently uses the term *idea* instead of *words* or

vocabulary, for instance: he even begins his turn with "in my idea". Also prominent is Ryu's use of *we* and *our*, contrasting with *you* in "you will forget everything". During his one minute turn, no one interjects or moves, despite the relative length and the two pauses and the many points that the others were ready to state, which I consider as evidence of the sense of "we" clearly permeating our group: the students' knowledge of our practices and developing identity in constructing our local culture.

In turn 7, I take up his term *idea* by asking more questions to invite the others to continue contributing to the point about ideas and remembering. In his turn, Kassim takes up the term idea as well, speaking clearly and slowly, I think in imitation of Ryu's careful manner. He contrasts the table of contents and the concept map while I also prompt him to use the connecting word "whereas" (turn 11). Ruslan waits to be nominated although he is very emphatic in stating his point: "I disagree with Kassim about the table of contents" (turn 14).



energy figure 5 -Epistemic work. Ruslan is re-constructing the entire table of contents according to his views on representation of these ideas, using his semiotic signs including colour code.

Ruslan goes on to describe his point in his usual eager style (shown in transcript 1) and re-constructs the entire table of contents on the board as seen in figure 5: in the continuation of the lesson we go on to find that he means adding bullet point details or key words to the

table of contents. We also continue work on our concept maps and the word wall (figure 4, new words in purple), as is our custom, while I observe Kassim carrying out our routines.

In this lesson, I visibly take up my use of the iPad again for this iteration, with Kassim being the new participant. In figure 5, I am using the iPad to follow Ruslan carrying out his epistemic work: in our local culture, I am publicly signalling the locus of this work, and attributing importance to the student and the work. This special mediating use of the iPad can be seen culminating in episode 8, e.g. figure 40 and figure 41.

The transcript of this lesson, from which I selected Excerpt 1, shows each participant except Quincy giving views on note-taking and remembering ideas. However, he goes on to do the word wall writing as seen in figure 3, by his own choice. My turns for over five minutes in this lesson segment consist mostly of questions, such as "how is that different from" (turn 3) or other question-like invitations such as "I think you are saying" (turn 1) or "I think what I understand from you is…" (turn 23) to which the student responds by extending his own contribution, as in turn 24. I keep emphasizing the "we", as in turn 29, and opening opportunities for student argumentation on our practices, in this case concept maps and writing notes on the board. Within these interactions, Kassim is emerging as a keen new participant in our practices, through our strategies for sharing epistemic authority in our local culture.

Episode 3 – Anchor text and representations: Epistemic Work and Languaging through Meta-talk

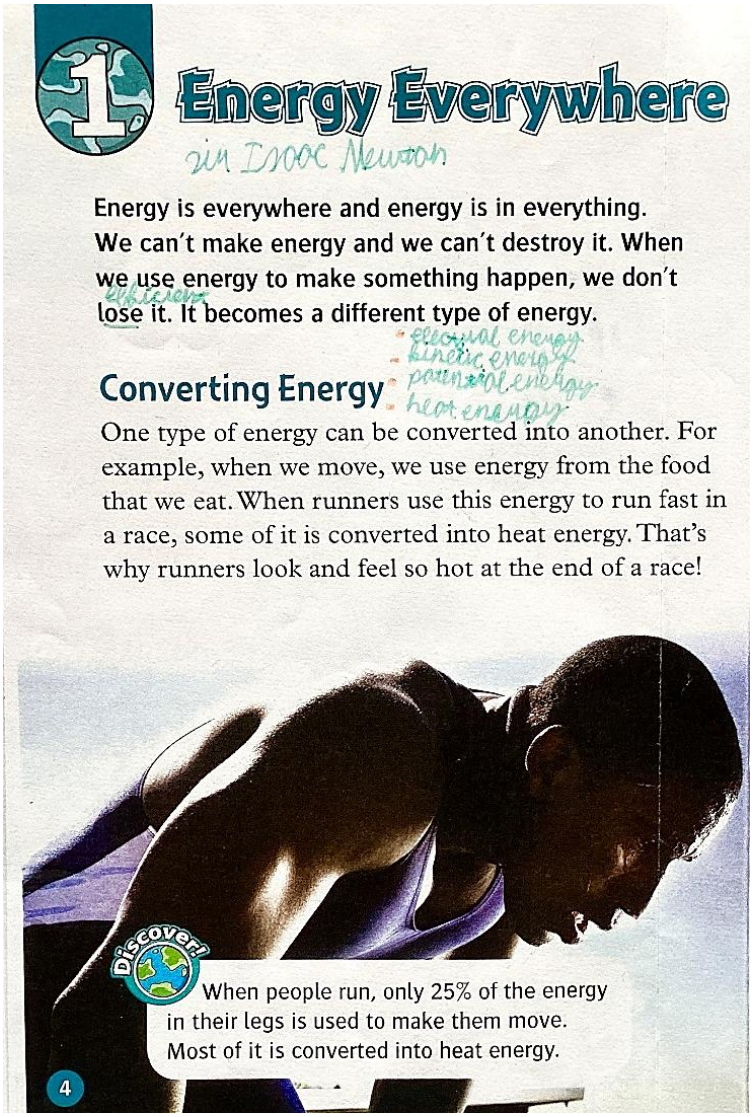
Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ *new signs and words as ideas in representations* ▪ *determining choices in semiotic signs*	Rich Point: energy diagram as AL, by Dai ▪ Dai constructs his own diagram showing heat and KE through a series of revisions, applying his own semiotic signs as AL figure 10	Specific Design Principles ▪ *improvable objects*: elaboration *anchored in Ss constructions and edits of their representations* ▪ *identity building:* selecting , constructing semiotic signs ▪ *authoring text in AL as knowledge resource*
Meta-talk (MT) ▪ noticing: ideas require "correct" terms and *signs*		
Languaging (L) ▪ *words are objects of reasoning: own writing and representation work becomes knowledge resource and improvable object*		

Following the transition week, new Rich Points emerge, shown in the next two episodes, indicating continued progression in our epistemic work on representations: surprising new elements of complexity in student thinking become visible through new representational challenges and languaging. In the process of retrospective analysis, these points emerged as essential for carrying out our culminating activities after our return to the in-person learning environment in the classroom, presented in episode 8 as the end of this study.

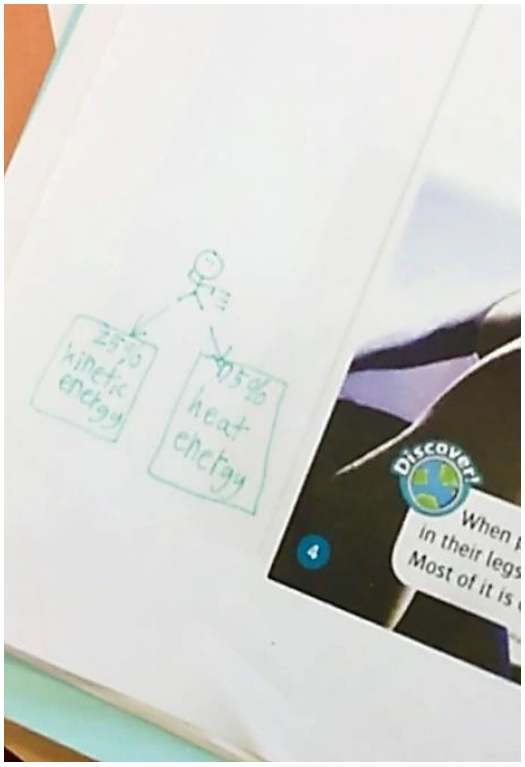
We proceed with our read-aloud practices around the first chapter of the anchor text, carrying out our note-taking and over-writes through discussion. The first page of the chapter is shown in figure 6, with Quincy's note-taking. His bullet points and over-writes are written in green: of his own accord, he has annotated bullet points to summarize the types of energy discussed on the page (Encyclopædia Britannica, 2020).

As in the previous iterations, I wish to do semiotic work as annotation again, to make our thinking and epistemic work visible and manipulable (Duschl, 2008). However, I am aiming

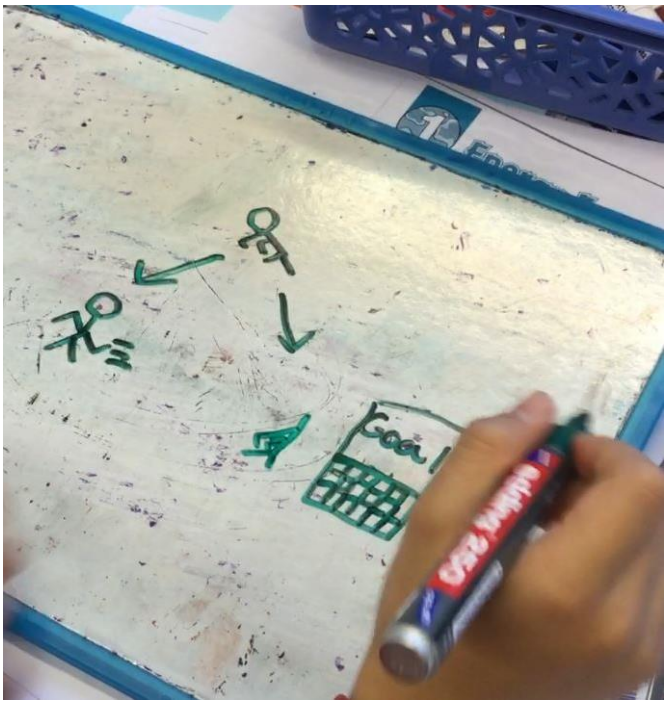
for more opportunities for student initiative in the semiotic work to keep progressing in our representational competence to work with our developing ideas in science and our scientific literacy (e.g. Gilbert, 2013; Prain and Tytler, 2012; Lehrer and Schauble, 2019). Through this focus, I wish to continue building on, or sedimenting (Pierson and Clark, 2019), our practices which have been centred on knowledge resources about energy: in health and nutrition, in the energy pyramid and ocean biome, and now in new forms of energy. Hence, I suggest a new representational challenge (Tippett, 2016; Tytler, et al., 2020; Prain, Xu and Speldewinde, 2023) in this episode, as we discuss our epistemic work, i.e. our reasoning process (Hubber, Tytler and Haslam, 2010).



energy figure 6 – Epistemic work and languaging. Quincy's notebook, first page of chapter 1 showing his bullet point annotations, and the text box Discover, used for the diagram work shown in figures 7-10.



energy figure 7 – Epistemic work. Chapter 1, a screenshot detail showing Ryu's first attempt at representing the kinetic and heat energy of the athlete in a diagram, on paper.

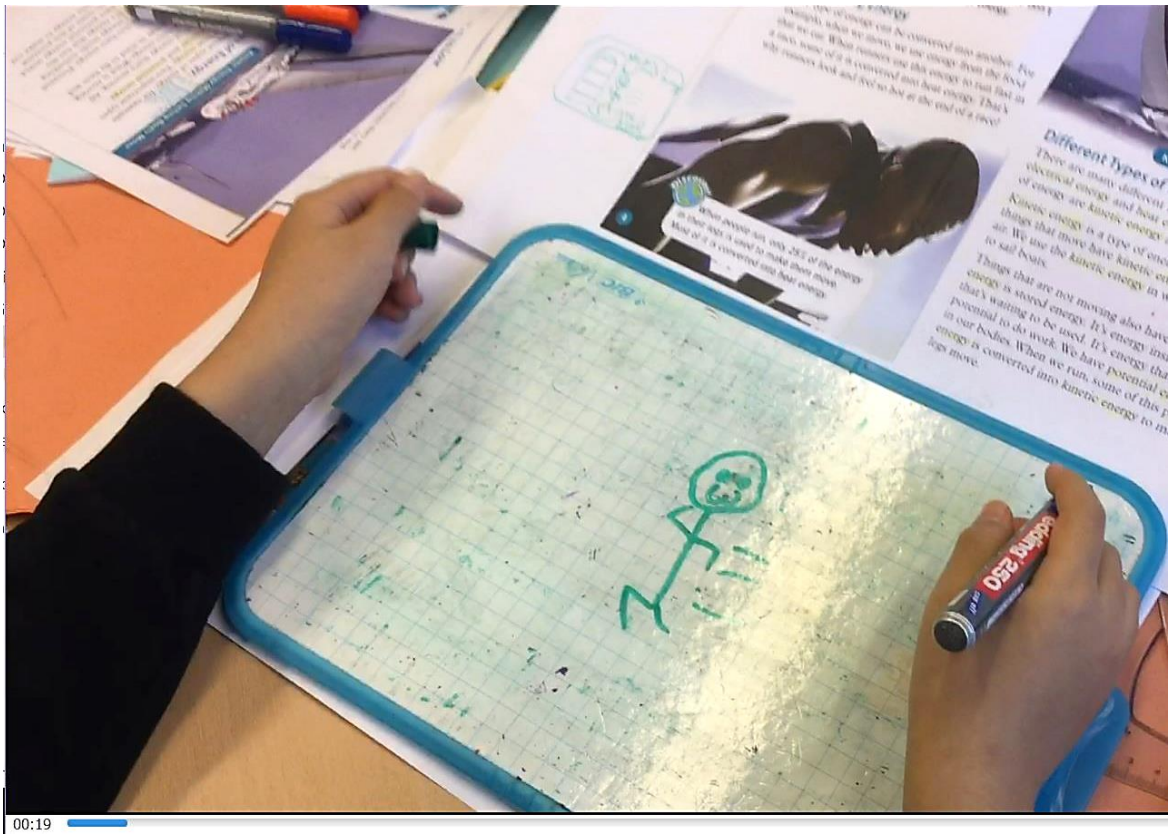


energy figure 8 – Epistemic work. Chapter 1, a screenshot detail showing Ryu's second draft representing the kinetic and heat energy of the athlete in a diagram, on his whiteboard.

Transcripts 2 and 3 contain the exchanges during which the work in figures 6 through 10 are constructed. In transcript 2, I have started the recording following our usual interaction around the read-alouds and over-writes of the anchor text, and am now walking around with the iPad in my hand as the students are attempting to draw a diagram to *improve* the representation of the idea about heat energy and kinetic energy using in the runner in the anchor text, in figure 6. As I walk around, I repeat my suggestion "Make a diagram that explains this" (turn 6).

I state our epistemic goal for doing so in turn 1 "So the photo just shows a person getting ready to run to use kinetic energy…", as we have been note-taking but now we wish to explain what the photo does not make very clear. I am hoping that the students can notice the perspiration

on the brow of the athlete in the photo, relate this to their own sporting activities and connect that with the heat energy as stated in the text box.

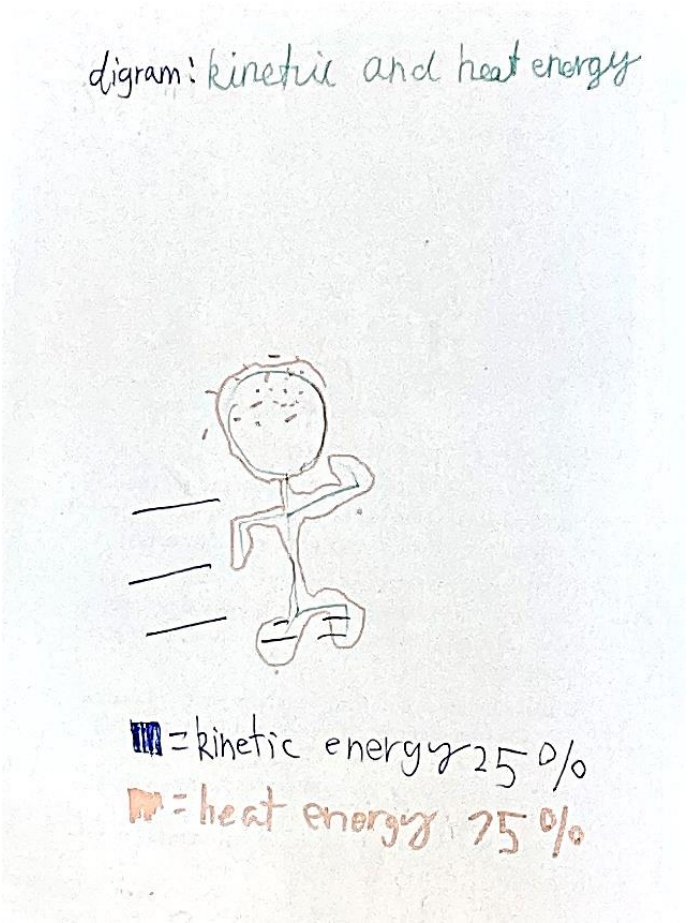


energy figure 9 – Epistemic work. Chapter 1, a screenshot showing Dai's second attempt at representing the kinetic and heat energy of the athlete in a diagram, on his whiteboard, transcript 3 at omin19. It shows three horizontal lines, which I point out to the others later. The first atte mpt is in the margin of the anchor text, next to the photograph showing the athlete, but he erases that later.

Initially, Ryu treats the task as basic note-taking: he writes two text boxes in the margin as shown in figure 7. I point this out in turn 6, where I say that he has not explained the heat energy or the kinetic energy (KE), and that he needs to show it: "How can you show kinetic energy?" Quincy immediately states, "it's running" (turn 7), and I reply, "Yes. So how are you going to show that? You make the stick figure look like... what? " (turn 8) and he replies, "Like he's running" (turn 9). Figure 8 shows Ryu using arrows to indicate movement in some way, but it is not clear if this sign refers to the stick figure moving.

Figure 9 shows Dai's work on his whiteboard, his second attempt at a diagram. He has drawn three horizontal lines, which I take up later in discussion. Unfortunately for the transcript of our dialogue, I am still focused on engaging with Ryu and am not prompting Dai

to meta-talk on his work. In turn 3, I state "… show, please, the heat energy and the kinetic energy. Please. Because that's what science people do. They try to represent. In particular, things that you can't really see.." and so attempt to restate our goal for this activity but also implicitly for our local culture. In turn 7, I ask the students to repeat "we are trying to represent" (turn 8) and then suggest that they use a colour code.



energy figure 10 - Epistemic work. **Rich Point**. Detail from Dai's notebook, diagram of KE and heat energy: his third version of his diagram, now showing his personal use of symbolic representation of motion and heat by means of colour, dots and lines

Figure 10 shows Dai's completed diagram with a title, colour code and key at the bottom, produced by him during this episode. Dai uses the layout based on the concept map work. Dai's insights, not included in the transcript due to the recording having stopped, are his use of the horizontal lines indicating motion and the orange halo around the blue stick figure indicating heat. He has even added orange dots on the stick figure's head, indicating perspiration, and little blue lines on the legs to show what is moving specifically. This use of the orange halo emerged from my criticism of Ryu's orange coloured stick figure discussed in turn 19 of transcript 3. Dai has separated the heat from the stick figure, to show where it is

located as perspiration on the body, in answer to my request in turn 3. His initiative to use heat energy as a halo, and lines on the legs as moving parts references a webtoon symbolism. I know from our conversations that Dai reads a lot of webtoons such as "One Punch Man", where characters exerting their "powers" are shown as having a halo of sorts and motion is shown as straight lines around and behind the character (One Punch Manga Online, 2019). These ideas will, it turns out, form an essential knowledge resource for us, as will be seen in subsequent episodes of this final iteration.

Our epistemic work in this activity constitutes a Rich Point for all of us, as we begin to explore new ways of re-constructing anchor text or each other's text through semiotic work, captured in my phrase "that's what science people do" (transcript 3, turn 3). I return to this point in the Outcomes section in my discussion of our practices in our local culture and our progression in disciplinary literacy. This Rich Point, with our semiotic work as shared writing and as improvable object (Wells, 1999) around which our interaction becomes our shared public space, will lead to our culminating Rich Point in episode 8, where the students will demonstrate their maturing representational competence in epistemic work (diSessa, 2004).

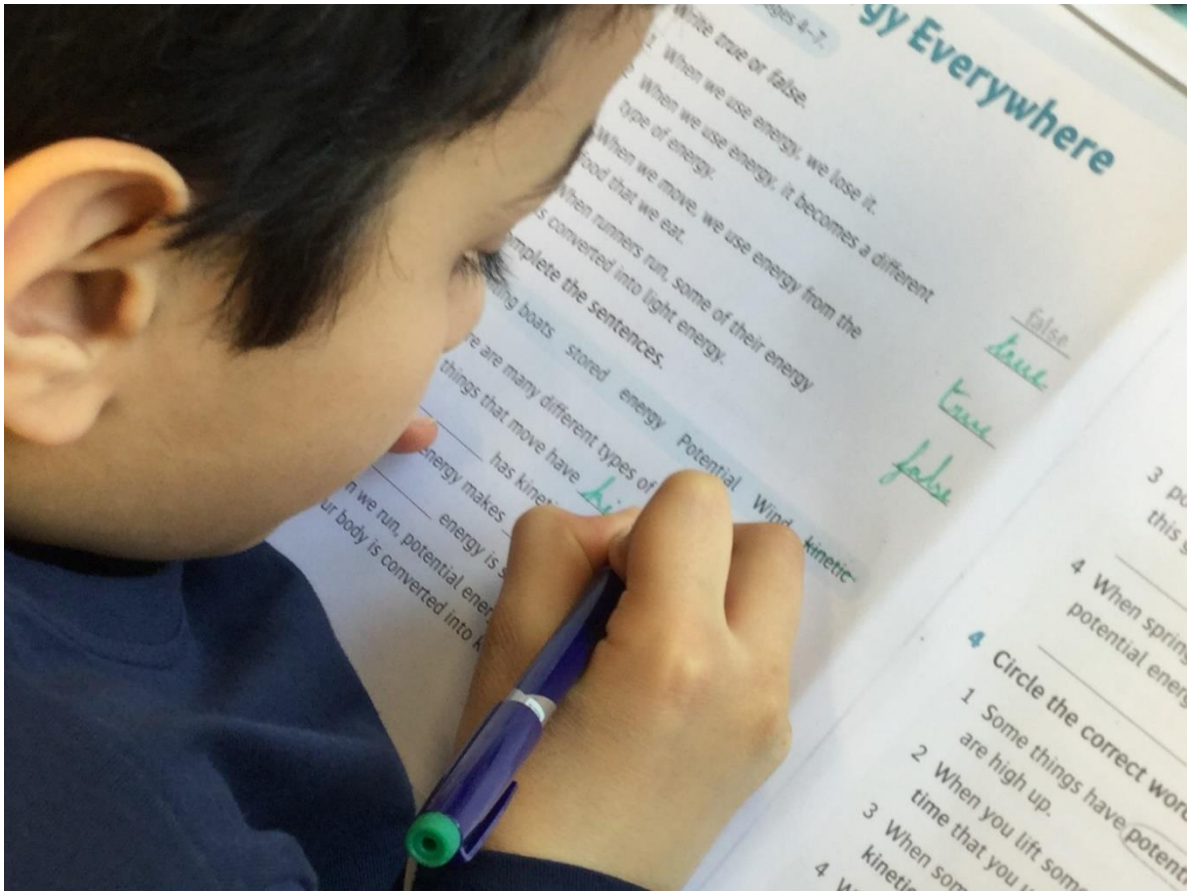
Episode 4 – Anchor text: Epistemic work and languaging through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ noticing as EW: *explaining and arguing* Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud Languaging (L) ▪ *words are objects of reasoning: own writing and representation work becomes knowledge resource and improvable object*	Rich Point: shared writing: re-writing for AL, by students ▪ writing: authoring text through languaging and meta-talk re-writing practices figure 12 figure 13	Specific Design Principles ▪ *improvable objects*: elaboration anchored in Ss constructions and edits of their text ▪ *identity building: selecting, constructing semiotic signs*

In the last day of the in-person learning environment setting, we carry out our usual read-aloud and writing work using the activity page for the chapter 1 in the anchor text. Our Rich Point develops as Kassim smoothly adapts to our practice of languaging through meta-talk for our shared writing and epistemic work. With the work in these episodes, Kassim has assimilated our variety of interaction around using our semiotic tools for constructing artifacts through our practices of meta-talk and languaging for epistemic work. It will then be possible to carry this work to new levels of representation competence as AL, in the shared writing and reasoning aloud in the subsequent episodes.

Kassim can be seen working on this page in figure 11, using the original instructions on the page for tasks such as true/false or gap-fill using given terms. As in the previous iterations, this activity page is completed individually, and Kassim performs these tasks with ease along with the other students. For Kassim, the next new activity in participating and thus enacting his membership in our local culture (e.g. Mercer, 2004; Greeno and Gresalfi, 1999; Greeno, 2011) is our re-writing steps and the interaction around this work. I am not including the transcript of this lesson as it transpired much as our previous ones, through our cultural practices established during previous iterations: referring back to previous languaging

writing, discussing the academic terms of the chapter annotations, and performing shared writing on the WB through discussion.

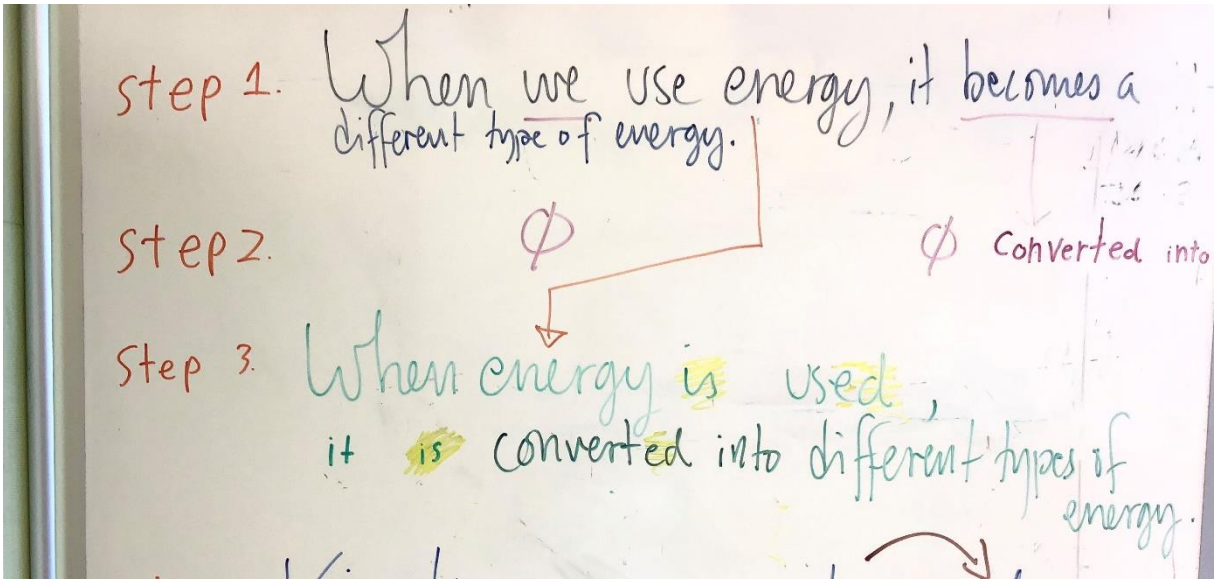


energy figure 11 – Epistemic work. Kassim is completing the activity page for chapter 1 using the original instructions on the page. As in previous iterations, the completed page then forms the improvable object of our meta-talk and languaging for science, resulting in Kassim participating in our practices of re-writing the everyday forms used on that page into AL, through discussion, as shown in figures 12 and 13

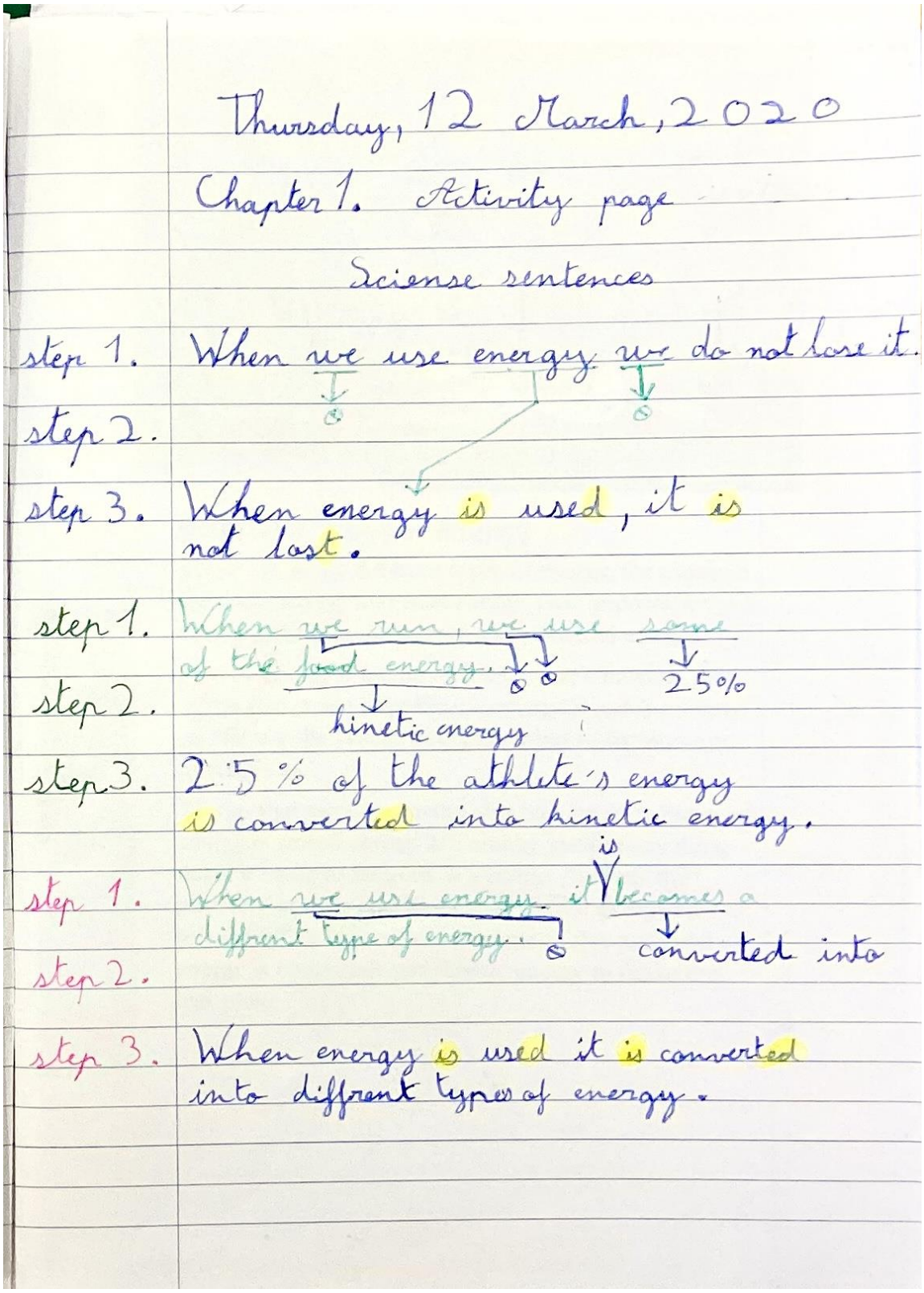
Figure 12 shows a detail from our shared writing through meta-talk on the WB, where Ryu has continued to actively engage, as he did in *Healthy*. He has written the step numbers in red, on the left, and I have written the sentence to be considered in blue. This sentence, as usual, was selected by us through discussion. Ryu has then added the languaging annotations in pink, which he wrote as we discussed in the group. He wrote in *converted into* which we annotated in the anchor text, figure 6. I helped to write the words in green in step 3, but Ryu wrote "it is" and added the yellow highlights to make the passive construction more salient. The students wrote these steps into their notebooks as can be seen in Kassim's page in figure 13. Kassim highlights the passive forms in yellow and indicates the added academic terms brought up in discussion. By the third case, he has also

clearly decided on his colour code for the components of the re-writing process, thus showing evidence of his inner speech (Wells, 1999) in this evidence of his externalizing of our practice of re-writing for moving from EL to AL during epistemic work..

With this episode, I wish to focus on our maturing cultural practices: they are clearly perceptible to Kassim, the new student; we, the participants, are of one mind as we proceed methodically through several cases of re-writing (including some not shown on this figure); Ryu is coming to the board and co-authoring. I elaborate on these points in the Outcomes section, where I present Kassim's induction into our culture as a series of Rich Points for him as well as for us, providing evidence for our intersubjectivity and inner speech, and confirming our cultural identity and practices on the social plane.



energy figure 12 – Languaging through MT. Detail from teacher and student shared re-writing on the whiteboard, with my writing in dark blue and green, and Ryu's writing in red and pink including underlines, symbols and arrows; "it is" in step 3, by Ryu; yellow highlighting also done by Ryu. This shared writing is then copied in the notebook by each student, seen in Kassim's notebook page, figure 13.



energy figure 13 – Languaging and epistemic work. **Rich Point**. Notebook page of re-writing steps based on the activity page exercise seen in figure 11, and re-written through meta-talk and languaging as shared writing, seen in figure 12. Kassim highlights the passive forms in yellow and indicates the added academic terms brought up in discussion. By the third case, he has also clearly decided on his colour code for the components of the re-writing process, thus showing his emerging practice.

Part 2 Energy – online environment "_so the *formed*, yes, is like how it changed ___ "

Episode 5 – Text and representations: Epistemic Work and languaging through Meta-talk

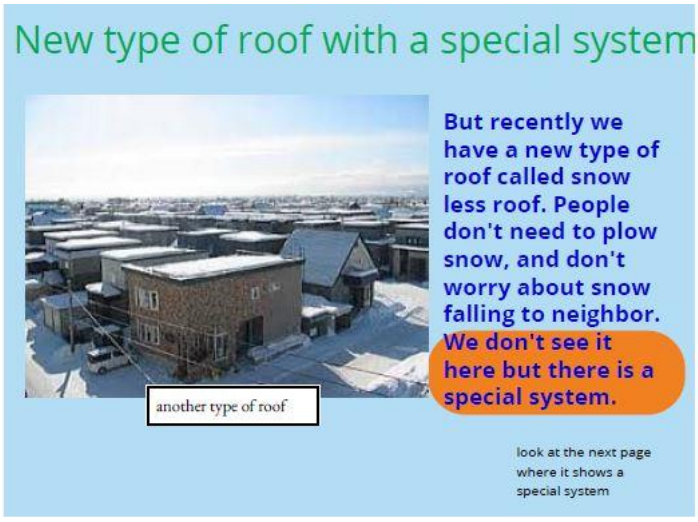
Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ explaining and arguing with *signs and words as ideas in representations*	Rich Point: presentation: representations and explaining with AL, by Ryu ▪ discussion: *student arguing. interpreting, selecting signs*, figure 14	Specific Design Principles ▪ *improvable objects*: elaboration *anchored in Ss constructions and edits of their text* ▪ *interplay of text: interpreting and constructing interplay of modalities*
Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud		
Languaging (L) ▪ *words are objects of reasoning: own writing and representation work becomes knowledge resource and improvable object*		

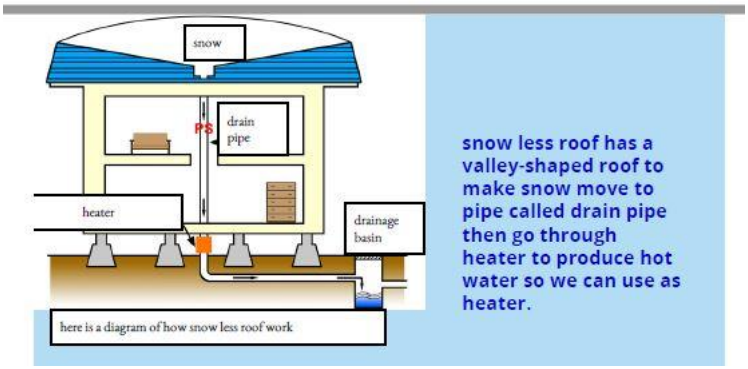
Our work in the unit continued in the online environment, with the anchor text serving as springboard for exploration of various topics arising from it, such as energy-efficient housing designs being developed in the countries of the various participants. This work now involved learning to interpret more kinds of diagrams (e.g. McTigue and Flowers, 2011; Gilbert, 2013; Cirkony, Tytler and Hubber, 2022) while researching a self-selected topic within the question, and presenting these findings to us online, such as Ryu's work in figure 14. The students used the Book Creator software as before to construct and share information in thematic "books" of their own.

In response to the new learning environment, I adapted my design in several ways in the initial lessons. Meet environment. It turned out that this type of task carried over quite smoothly into the online environment, in a way that I will describe next. Crucial affordances for interaction were in fact made possible with the functionalities of the online meeting

tools, which fostered our epistemic work in ways both productive and new in terms of multimodalities.

In this episode, Ryu is presenting such a topic: as homework, he has written a short text box in the second part of figure 14, making use of the terms in the labels present in the diagram.





energy figure 14 – Epistemic work and languaging through MT. **Rich Point**. Ryu's online presentation of his Book Creator notebook on energy and housing: here a page on housing adapted to the climate. His sentences are not corrected for spelling or punctuation. He edited the text online through our discussion while he presented, as his languaging using the key terms on the diagram helped him sequence the points in his writing of his explanation.

The two pages in figure 14 are shown as edited by Ryu, in the moment of our interaction online. For the most part, I did not systematically correct spelling, grammar or punctuation on these Book Creator activities produced while the students were home in lockdown. I wished to ensure that they were happy about doing these tasks at home, where I could not encourage them as I used to do in our classroom setting. The emotional well-being and

feelings of competence of these students were foremost in my mind during these early days of this unprecedented lockdown situation.

Therefore, in the course of each student's sharing of their Book Creator homework assignment and presentation of this short research material, our discussion focused explicitly on the academic terms and ideas, and on interpreting the diagrams that the student used to support his point. This focus is also in accordance with my DPs to foster science ideas as the basis of interaction (e.g. Berland, et al., 2016; Engle and Conant, 2002; Duschl, 2008). Our Rich Point here emerges in Ryu's interest and resilience in carrying out languaging for epistemic work on his text during our discussion as a group online. As he notices during that meta-talk that a point is being made, either from his own talk or in response to the interaction of the participants, he is immediately able to language the idea by retyping it, as the rest of us look on. His meta-talk with us, using the key terms on the diagram, helps him sequence the explanation, while the familiar interactive functionalities of the Book Creator present him with new opportunities for noticing ideas and responding to them with fluidity, to foster his languaging and epistemic work.

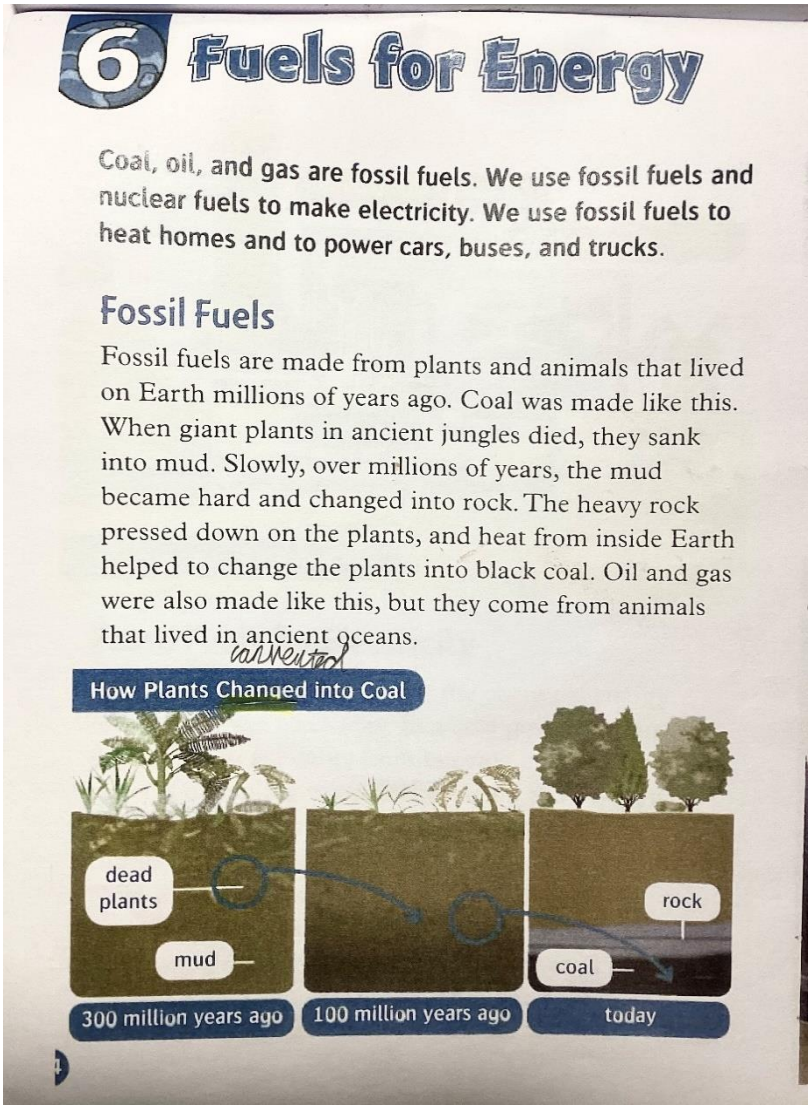
This episode came to set the structure for our subsequent online interactions and activities. In it, I concentrate my responses on Ryu's talk as he presents online, and on his rationale for selecting these images: this student text now constitutes our anchor text. Hence, it also constitutes our *improvable object*, in the manner of our paper anchor texts, diagrams, and other semiotic work around which we have been interacting together in the previous iterations in constructing our local culture. These new developments in our local culture of *shared writing* around text as words and representation came to characterize our activities online continuing with our epistemic work and languaging through meta-talk. We use new modalities generatively to draw or select images and explain (Fiorella and Kuhlmann, 2019), to enact our established practices in ways that enable the students to work at new levels of epistemic agency and authority, as will be seen in the next two online episodes.

Episode 6 – Anchor text and representations: Epistemic Work and Languaging through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ explaining and arguing with *signs and words as ideas in representations* ▪ *problematizing: identifying gaps* Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud Languaging (L) ▪ *words are objects of reasoning: own writing and representation work becomes knowledge resource and improvable object*	Rich Point: multimodal shared writing and re-writing with AL, by Quincy ▪ Quincy writes and re-writes coal diagram labels without prompting figure 18	Specific Design Principles ▪ *improvable objects*: elaboration *anchored in Ss constructions and edits of their representations and text* ▪ *interplay of text: interpreting and constructing interplay of modalities*

Several weeks of work transpire in the manner of the interaction in episode 5, giving students time to internalize and transform the epistemic practices first carried out on the social plane. A new Rich Point emerges through the modality of a new locus of interactive work, namely Jamboard. This is a virtual whiteboard in the Google Workspace for Education set of tools (Google for Education, 2023), designed for use by participants within the Google Meet online virtual meeting environment; it has been replaced by alternatives since 2024 (Rothstein, 2023), such as Miro (Miro, 2025). This modality allows participants to share in various ways, not just view and talk to each other, or sharing a screen as in the Book Creator page shown in figure 14, as shown in the preceding episode. In the sequence of interactions presented in this episode, we work together using Jamboard to continue to enact our established text-based practices. We use the expertise gained in working as shown in episode 5; however, the students seize upon the functionalities to generate new ways of exerting their epistemic agency and authority while languaging and annotating on the improvable object.

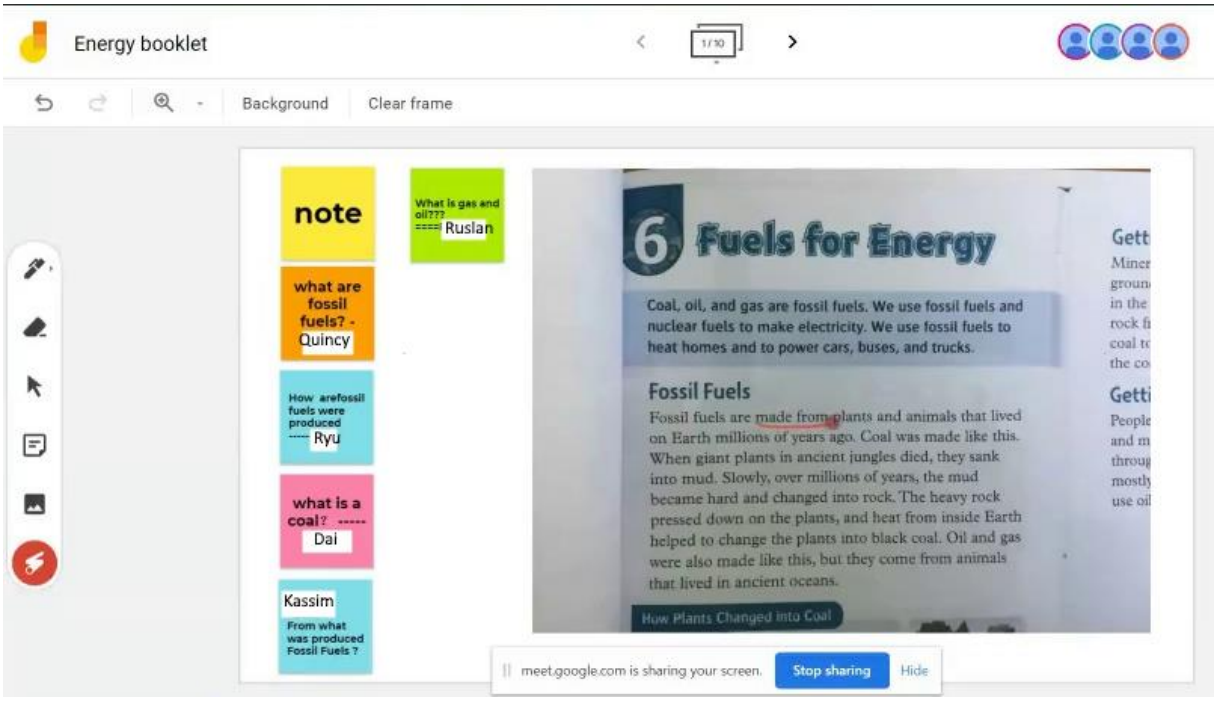
Chapter 6 of the anchor text is titled "Fuels for Energy", and in part concerns the process of fossil fuel formation. The first page of the four-page chapter is shown in figure 15, from Quincy's paper notebook. Our work with the process concepts on this page developed into a Rich Point for us, although we realized this only three weeks later, in the context of another process, in episode 8. This Rich Point, constructed over two days, forms part of our reflection and discussion in the concluding episode of the iteration



energy figure 15 – Languaging through MT. Quincy's paper copy of the anchor text, with his over-writing of "changed" as *converted* during meta-talk.

Here, figure 15, we see Quincy's annotation over the word "changed", where he has written "converted" (see excerpt 1, turn 21). Quincy and the other students have the paper copy of this page and their respective notebooks at home in front of them, while we are also working together online in a Google Meet environment, as stated. As seen in figure 16,

while each student is looking at their paper copy at home, they are also viewing the same page on the Jamboard, where I have inserted a photo of the page through the functionalities of the Jamboard tools.



energy figure 16 – Epistemic work through MT. Ch 6 coal formation part 1 at 04m14. The Joamboard online whiteboard with the anchor text image and student study questions on coloured "stickers". The teacher is using the "zoom" pen functionality to focus on the concept of process by drawing a temporary colour line under "made from". The icons on the top right corner indicate the presence of the other participants; their names on the stickers have been edited.

Transcript 4 shows the first part of this Google Meet online session, while figure 16 is a screenshot from this session, showing the page of the Jamboard, the interactive toolbar to the left and the participants shown as icons on the top right. Here in this instance, one participant is for the moment looking at another page of the Jamboard, so his icon does not appear above right; however, there are 5 students in this lesson as can be seen in figure 17.

The screenshot shows the moment where the students have each written a study question using a coloured sticker or digital post-it (I have edited the screenshot to noticeably replace their names by the usual pseudonyms). I am using what we are calling the "zoom" pen in our group: it is a tool in the toolbar on the left, which is used with the mouse. Each participant is shown with a different colour line and a little icon on the page: for me, it creates a temporary pink coloured line as I move the mouse. I include here the initial

interaction in the session, where it can be seen how we are enacting our familiar read aloud practices with the study questions and meta-talk, with certain important differences that I now try to respond to with design innovations.

Energy excerpt 2 – from Transcript 4

1	0:02.1 - 0:17.3	How did the coal happen over time? (using zoom pen to draw a box around the text sentence "Coal was made like this") Then this question doesn't really work. (pause) ok.	Teacher
2	0:18.0 - 0:39.9	My question on that is that, um, (pause) like on the first sentence, yes, on the first sentence, it said that lived on Earth.	Ryu
3	0:42.6 - 0:44.2	uh repeat, please.	Teacher
4	0:44.2 - 1:00.2	Millions of years ago. And I'm so I'm trying to ask the question how? How long? fossil fuels are made from	Ryu
5	1:00.8 - 1:08.6	how it how it started. The fossil fuel. Yeah. Yeah, I see your point because your answer, yes (indicating student)	Teacher
6	1:09.2 - 1:18.7	And the answer is supposed to be plants and animals that lived on Earth millions of years ago.	Ryu
7	1:18.8 - 1:36.2	Excellent, excellent. That is because you have pointed out , Ryu, a very important point that we should know from this page.	Teacher
8	1:38.4 - 1:38.6	yes.	Ryu
9	1:39.7 - 2:15.9	You are focusing on a very important point. I'm proud of you and you are making a question about the important point so we remember it better. This is why we make study questions. Well done, well done. Let's look at how you made your study question, though,.... We cannot use the word *produce* here	Teacher
10	2:18.6 - 2:20.3	in the, and we say,	Ryu
11	2:21.2 - 2:21.6	yes,	Teacher
12	2:22.7 - 2:25.2	Then what can we say?	Ryu
13	2:25.5 - 4:16.5	Excellent. Excellent question. Because *produce*, *produce* is like making, ..asides .So now we're discussing Ryu's question. Can everyone see that here?.... Yes. What should we say instead of "made from"? (underlining with the zoom pen, figure 16) Because that's the word that you're (referring to Ryu and his question) trying to work on.	Teacher
14	4:19.2 - 4:19.7	Yes.	Ryu
15	4:21.0 - 4:50.0	What can we say? Can anyone have another idea.... What can we say instead of *produce*	Teacher
16	4:54.2 - 4:54.6	made?	Ruslan
17	4:55.6 - 5:16.8	Yes, well, made didn't help. Made is not science. So what we're going to say is this. *Fossil fuels are*. (teacher is typing it in the sticker on the Jamboard) Can everyone see what I'm typing	Teacher
18	5:18.5 - 5:18.9	Yes	Ryu

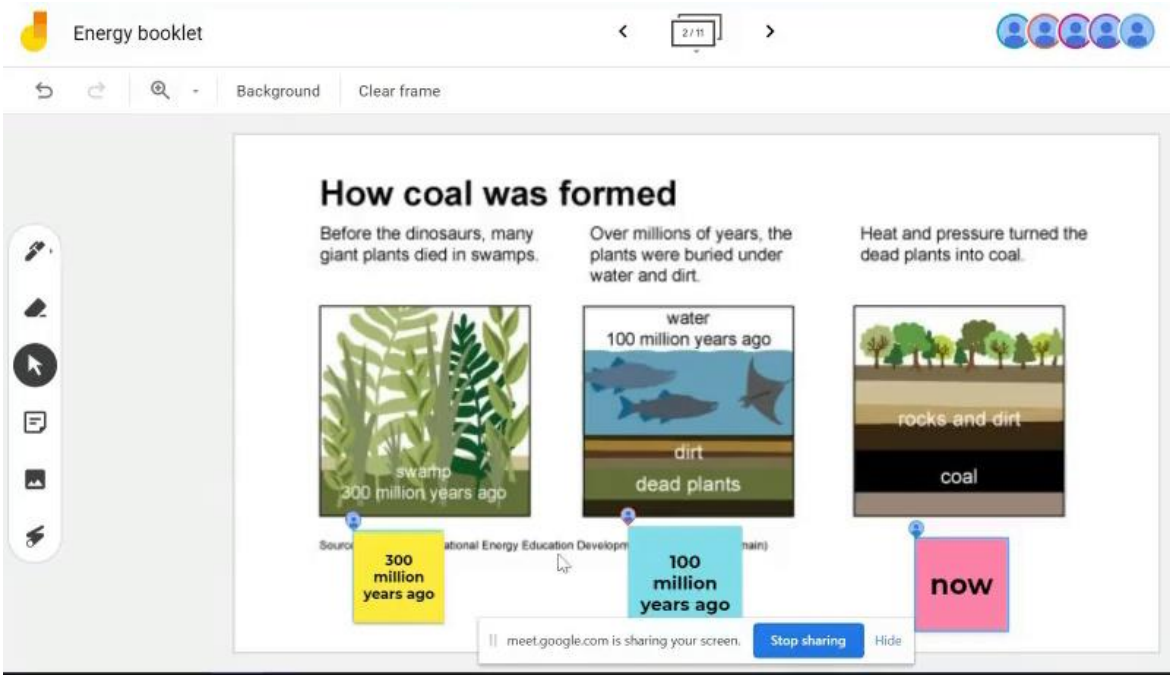
19	5:24.4 - 5:31.9	(begins to read aloud what the teacher is typing in the sticker) *are are the result of a long process of*	Quincy
20	5:33.2 - 5:34.3	*converting*,	Teacher
21	5:35.5 - 5:46.7	(reading aloud) *of converting plants and into compressed*... (pause) Oh yes!	Quincy
22	5:53.2 - 7:09.5	All right. So that's what we're really trying to talk about. .... I'm going to go to Google and search, and ..... (inserts image from the online search function of Jamboard) That's right. Do you see?	Teacher
23	7:12.2 - 7:12.6	Yes.	Ryu
24	7:13.6 - 7:19.3	So we're really using we have to use the word *formed*. (the diagram title is How coal was formed) figure 17	Teacher
25	7:24.2 - 7:30.0	OK. So the *formed*, yes, is like how it changed.	Ryu

Ryu has written a study question "How are fossil fuels were produced" (seen in blue in figure 16), and the transcript begins with my feedback to him about his question. I have noticed his use of the term "produced", but I just state that the question does not "really work" (turn 1) because it does not refer to time, underlining the time expression in the text with the zoom pen. Ryu just continues and elaborates to justify his question: "Millions of years ago. And I'm so I'm trying to ask the question how? How long? fossil fuels are made from" (turn 4) to show that he was indeed thinking about fossil fuels over time. I stay on his point by calling attention to the verb *produce*, and how his question was worded, while still attending to the *content* of his point. This moment is occurring in figure 16, where I am underlining the corresponding sentence in the text, focusing on the words "made from", and Ryu in turn pursues the matter, asking "then what can we say" (turn 12) again echoing our use of "we" in our culture. I give more compliments, emphasizing that "So now we are working on Ryu's question" (turn 13) explicitly emphasizing that this lesson has started by focusing on a student's epistemic work.

I start typing in a new sticker on the Jamboard as I speak, "*Fossil fuels are*."(turn 17). Quincy reads aloud, without prompting, "*..are are the result of a long process of...of converting plants and into compressed*...(pause) Oh yes! " (turns 19, 21). Quincy has over-written "converted" on his page as seen in figure 15, although I did not see him do it in the online environment, which is a drawback of this environment as I could not compliment him, being unaware of his work.

At this point in our interaction, I begin to improvise to find a new way to work with both a given representation, our languaging and epistemic work, and our own construction of representations.

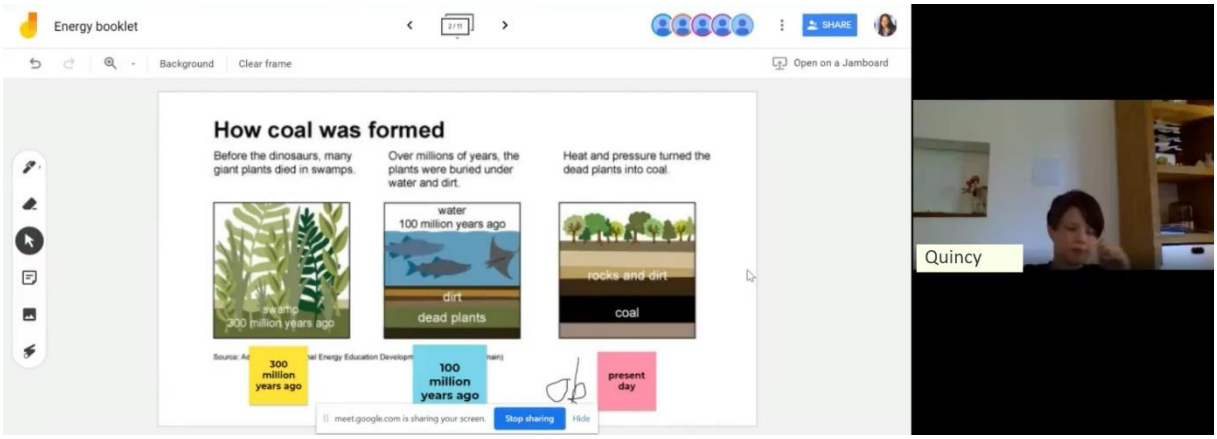
I begin with changing the text. The diagram drawings are also surprisingly lacking in clarity. I use the functionality of the Jamboard tools to quickly search online, in turn 22, and I insert a more detailed one from an online resource for schools named "Energy Kids" (U.S.: Energy Information Administration, 2020), as seen in the screenshot in figure 17.



energy figure 17 – Epistemic work and languaging through MT. Ch 6 coal formation Jamboard lesson part 1 at 14m27. Shared writing work, deconstructing and reconstructing the representation as epistemic work. The coloured stickers are typed by the students, as can be seen from their little icons attached to each sticker.

After placing this new diagram on a new page in the Jamboard (page numbers can be seen top centre) in turn 22, I begin by calling attention to the title, which includes the word *formed*, in turn 24, using the zoom pen to make a temporary box around the word. Ryu immediately states, "OK, so the *formed*, yes, is like how it changed" (turn 25) and I rush to validate his point, in turn 26, and as I speak, I uses the zoom pen to underline *buried* and then make a box around *heat* and *pressure*, over the third panel. With his comment, Ryu is conveying his

understanding that this interaction was about his point: it is more of his inner speech being externalized as he has done previously.



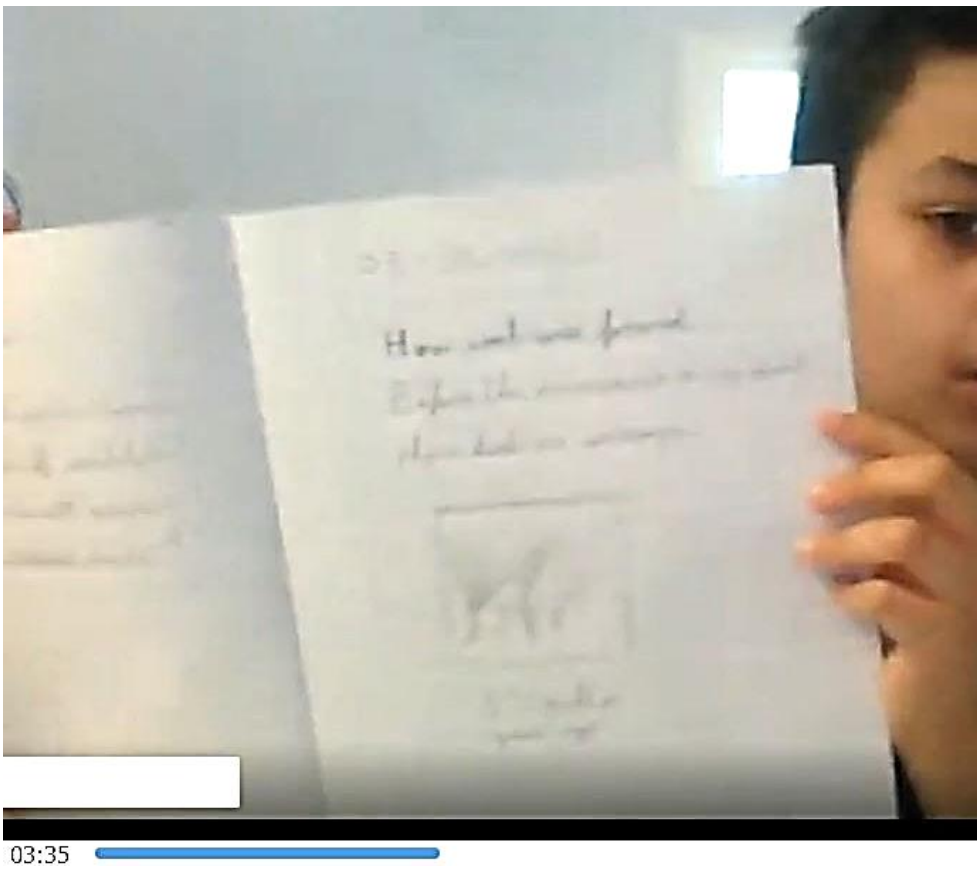
energy figure 18 – Epistemic work and languaging through MT. **Rich Point**. Ch 6 coal formation Jamboard lesson part 1 at 16m02. Quincy has re-written the pink sticker, and drawn an *OK* using his zoom pen function.

I wish to have the students annotate the page in some way, and I restate, again pointing with the pen, "Three hundred million years ago, it takes a long time because it is formed through heat and pressure. ...We say *formed* because there is one *form* here you have a plant and then it changes the *form*... So, Ryu, your point is brilliant. That is why we have to use the word *form*" (turn 28). I have framed it as coming from Ryu's meta-talk about the term *formed* meaning "changed", which was in fact an expression of his epistemic work as he engaged both with the diagram and his original study question. In turn 40, I now suggest that they write new stickers with the time expressions for each panel, as seen in figure 17.

A new point emerges with the third sticker in pink, "now" (figure 17). I ask the students to consider the word, "what do we say in science?" (turn 40). I state that "...in the science we don't say now, we say *present day*" (turn 50), and Quincy immediately retypes the sticker accordingly (seen in figure 25) without any prompting.

I then ask the students to draw the panels in their paper notebooks at home (turn 50). They begin to do so, now and then holding up their notebook to the camera as Kassim does in figure 19, where we can just make out the title and the first panel in pencil, with the title, the sentence as well as the time expression from the sticker in the Jamboard. I stop the

recording, as they are given time to do this while the online session remains open with all the participants' cameras and audio on. The interaction continues without recording, as we go on to discuss the representation work that the students have been doing during the session.



energy figure 19 – Epistemic work. Ch 6 coal formation Jamboard lesson part 2 at 03m33. Kassim is holding up his notebook to the camera during the online work. He as been asked to draw a copy of the diagram in figure 16 in his paper notebook at home; he has included the time expression from the colour sticker in the Jamboard. The work is initially in pencil

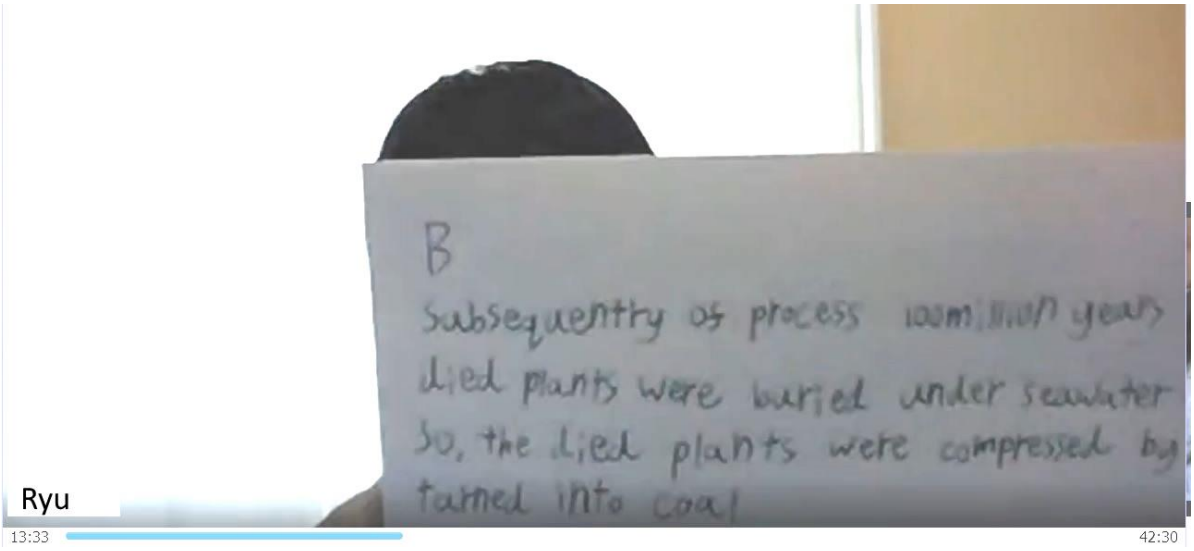
Episode 7 – Text and representations: Languaging and Epistemic Work through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ explaining and arguing with *signs and words as ideas in representations* ▪ *problematizing: identifying gaps* Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud Languaging (L) ▪ *words are objects of reasoning: own writing and representation work becomes knowledge resource and improvable object*	Rich Point: multimodal shared writing and re-writing of text and diagrams with AL, by Quincy ▪ Quincy re-writes coal diagram text boxes without prompting, with AL figure 23, figure 24	Specific Design Principles ▪ *improvable objects*: elaboration *anchored in Ss constructions and edits of their representations and text* ▪ *interplay of text: interpreting and constructing interplay of modalities*

This episode begins with reviewing the writing in the Book Creator concerning the Kelp Forest, with its two panels showing the effect of the presence or absence of the keystone species on the ecosystem in a very visual way. The material in this episode is part of a large event (Greeno, 2011) begun in episode 6; nevertheless, to explain it, I "zoom in" (Kelly, 2014, p. 354) and distinguish a separate key event, as it presents a Rich Point in new modalities and opportunities of shared writing. Here, our meta-talk around our epistemic work and languaging reaches a new level of fluidity due to the modalities of the Jamboard, our facility with it, and our intersubjectivity.

The over-writing, re-writing and shared writing process for this coal diagram continues in the Google Meet environment: the students are at home while I am based in the classroom. In the classroom, I am able to make use of the WB to project the session while using my teacher laptop camera and microphone to capture myself and my work on this whiteboard, (see figures 23 and 24). For my narration of this second episode in this environment, I am

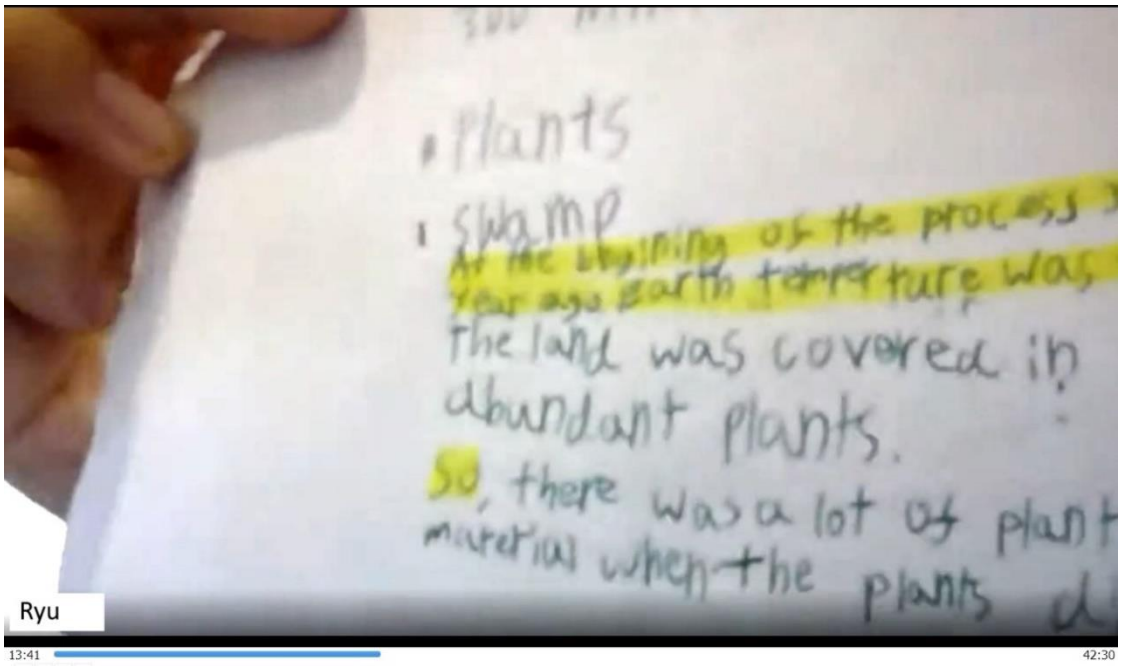
referring to a series of screenshots without the transcript of the session. I feel the sequence of screenshots is essential in order to better convey a sense of the ecology of our local culture, as enacted in this hybrid environment; I have conveyed our dialogue in this environment in episode 6, transcript 4. I consider these points in the Outcomes section, as I discuss these observations in the context of my DPs and process conjectures.



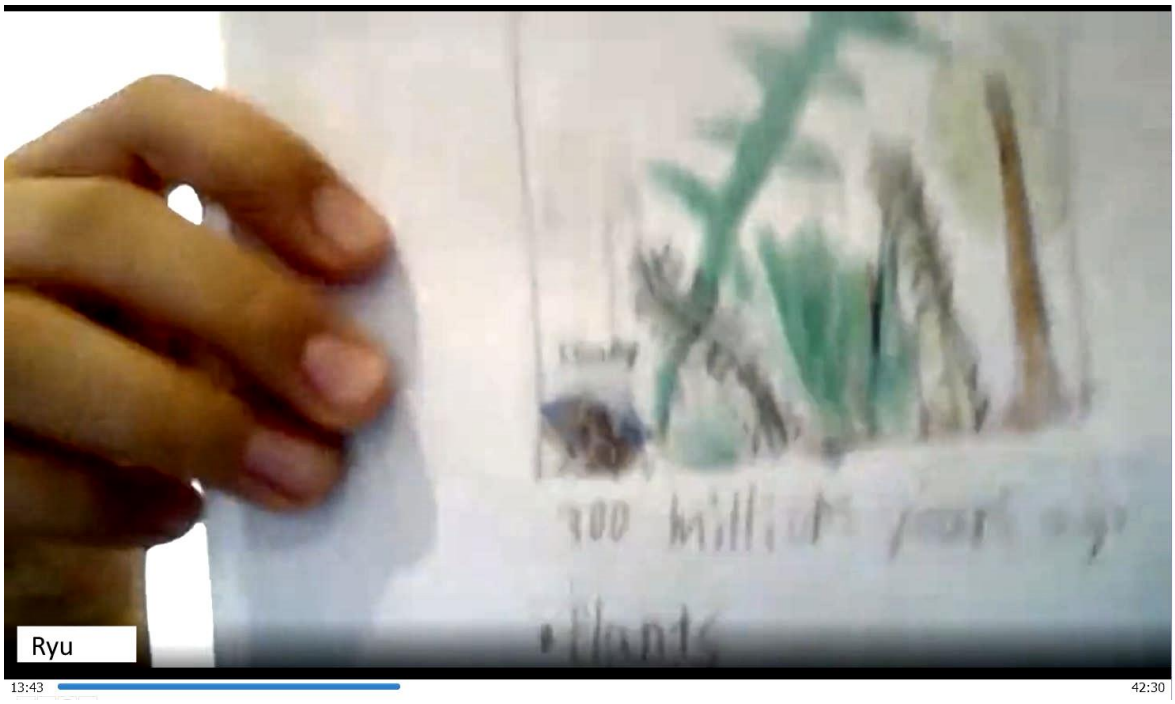
energy figure 20 – Languaging and Epistemic work through MT. ch 6 coal formation shared writing at 13m33. Ryu is holding up his own writing so far for the middle panel of the coal formation diagram. He has inadvertently written about both the middle (B) and end (C) panels in one paragraph. I take this point up for discussion, figures 22 and 23

I begin with reviewing the students' Kelp Forest writing in terms of the paragraph structure, including topic sentence, evidence and concluding sentence. Then the students attempt a paragraph for the first panel of this diagram, (noted as (a) later in figure 25), having written bullet points under their colour diagrams in the notebook. Figures 20, 21 and 22 show Ryu's work for this panel, which he developed through arguing and justifying his points here: he has copied the time expression from the Jamboard, written *plants* and *swamp* as bullet points, and then written sentences using these as well as academic terms we have been using, such as *abundant* and *material* from our word wall.

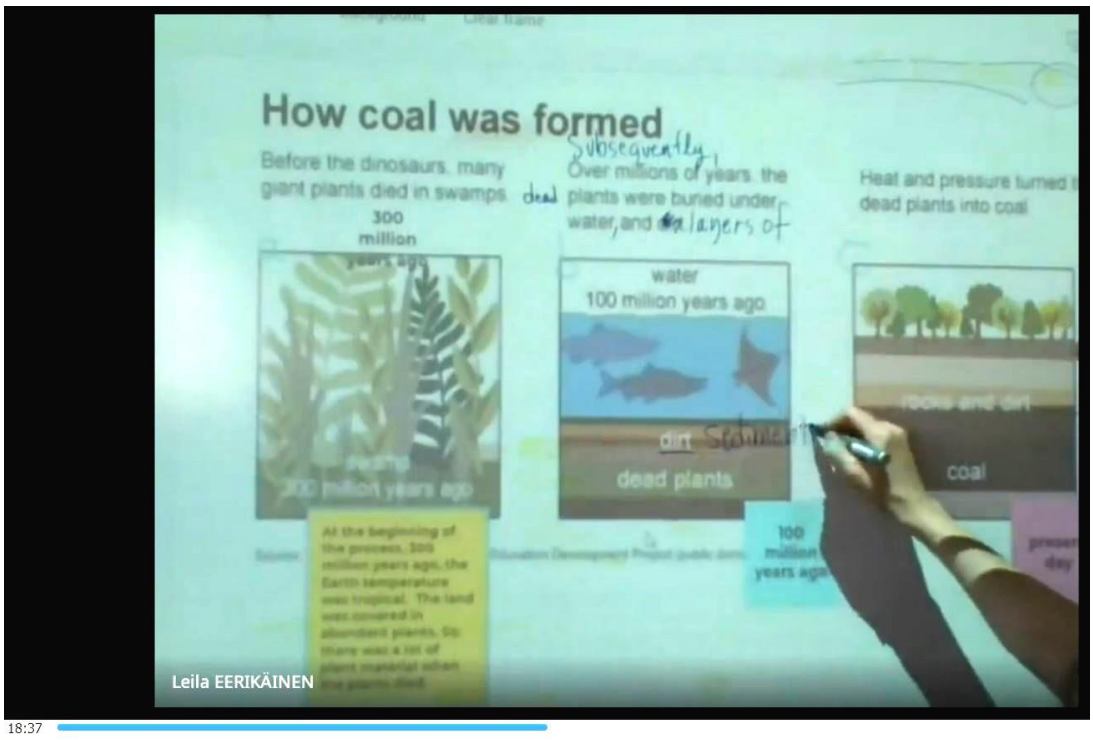
In these figures, Ryu holds up his writing for panel B, the middle panel, for the participants to see and for our feedback. We turn to discussing more about what is going on in the panel, during which I over-write on the diagram, on the whiteboard, as in seen in figure 23.



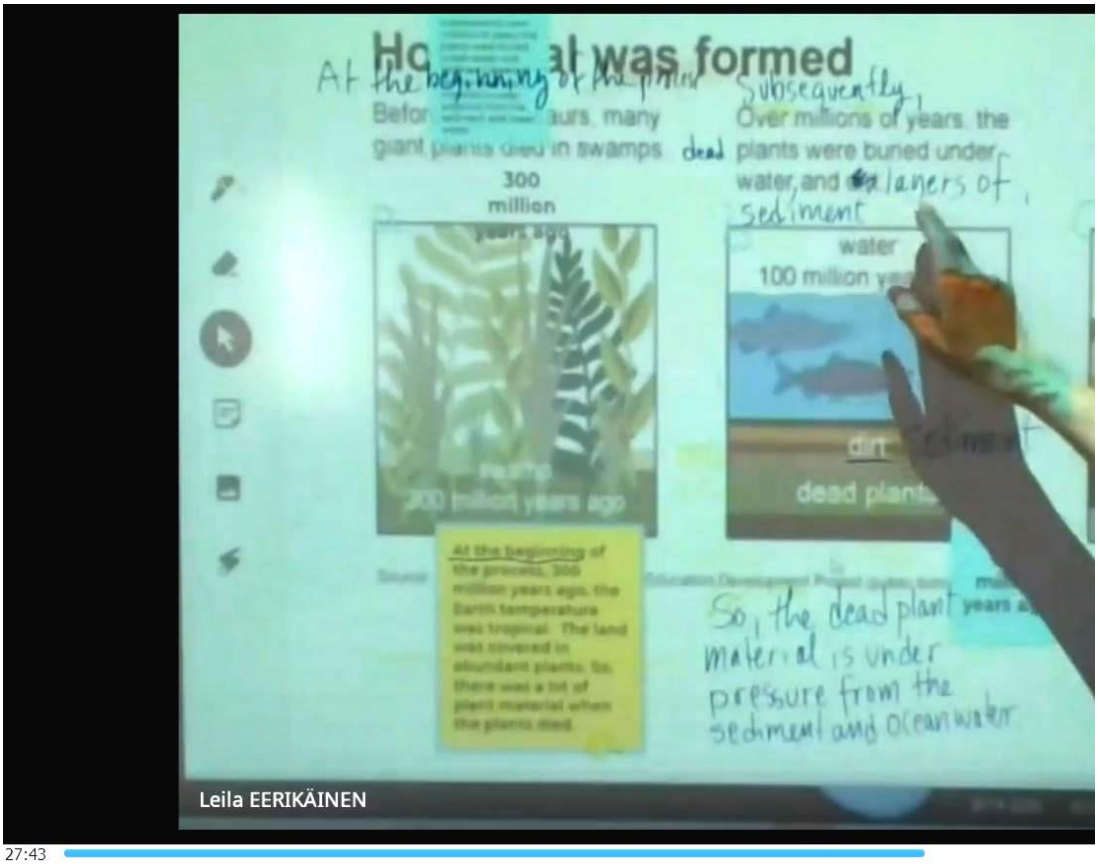
energy figure 21 – Epistemic work through MT. Ch 6 coal formation shared writing at 13m41. Ryu is holding up his notebook for the other participants to see. He has highlighted the topic sentence and the concluding *so* .



energy figure 22 – Epistemic work through MT. Ch 6 coal formation shared writing at 13m43. Ryu's coloured-in diagram with the time expression and the bullet point, which he is holding up for viewing



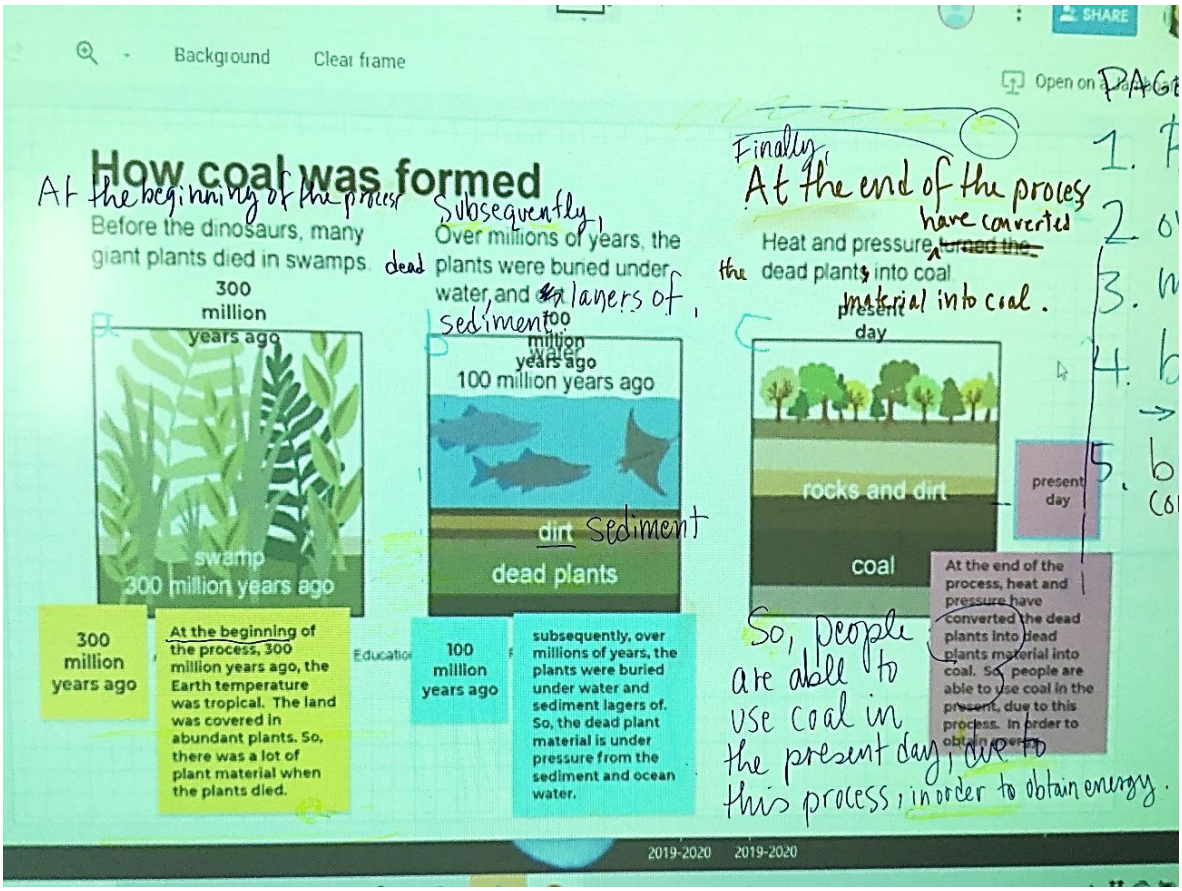
energy figure 23 – Languaging and epistemic work through MT. **Rich Point**. Ch 6 coal formation Jamboard shared writing. The teacher is in the classroom, writing some of the material on the classroom WB where the online meeting is projected, working in the established process of over-writing the anchor text; here over-writing the term *sediment* over "dirt"



energy figure 24 – Languaging and epistemic work through MT. **Rich Point**. Ch 6 coal formation Jamboard shared writing. Quincy is typing the shared writing into the blue sticker, top left, so as to incorporate the over-writes and re-writes from the languaging and epistemic work.

Thus, in figure 23, I am writing out the term *sediment* next to the word "dirt" in the diagram. I have already written in *dead* for the plants, and crossed out "dirt" in the text box, while discussing the point that Ryu omitted in his paragraph. I state to Ryu that he omitted mentioning the layers and therefore did not fully explain the panel. By meta-talking the term *sediment* while pointing to it, in figure 24, I am also focusing on the point in the diagram where this is occurring, and thereby the concept of layers of material accumulating.

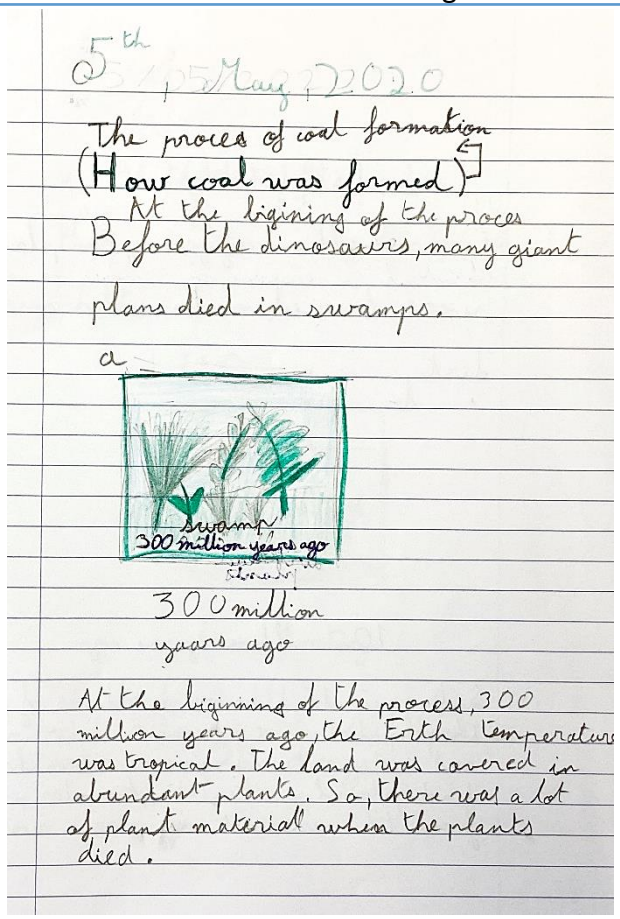
I write another *so* sentence at the bottom of the panel on the whiteboard, using the over-written words *pressure*, *sediment* and *ocean water*. These are then typed by Quincy in the blue panel in figure 25.



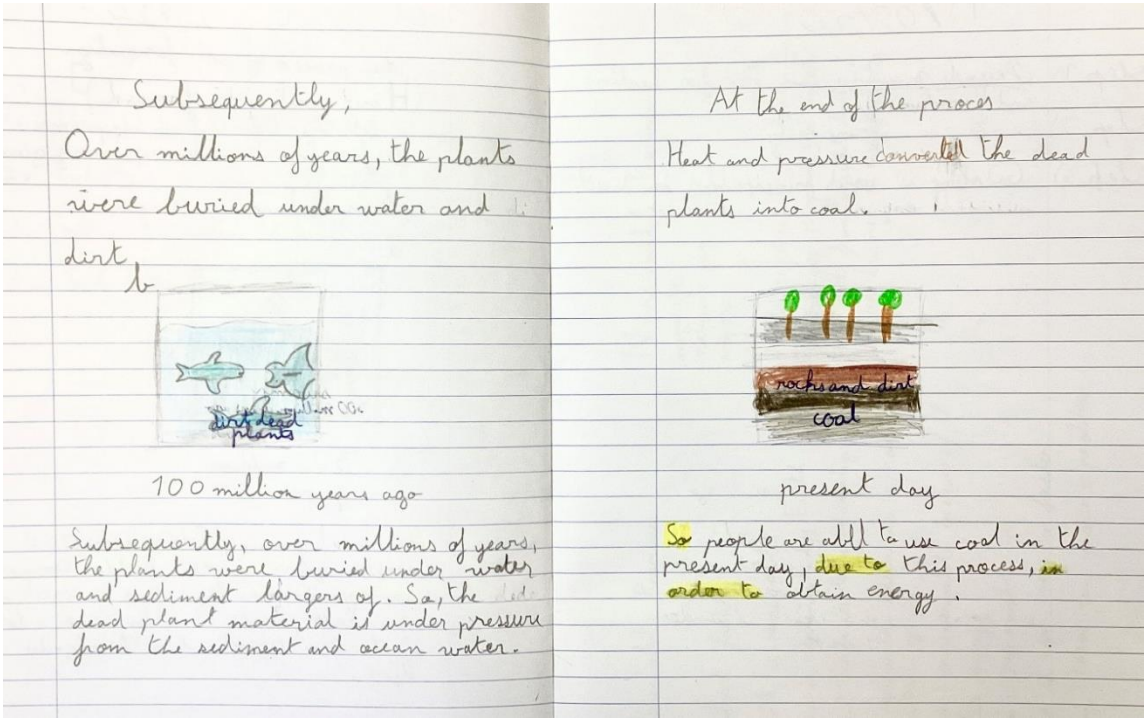
energy figure 25 – Epistemic work through MT. **Rich Point**. Ch 6 coal formation Jamboard shared writing. The iPad photo captures the WB at the end of the meta-talk, languaging and epistemic work, showing the shared writing process which makes this work visible. Each sticker is now in place under the appropriate panel, with the over-writes and re-writes typed out neatly by Quincy. The remaining *so* sentence in purple pen has the yellow highlights that the students put in their notebooks. It can be seen typed by Quincy in the pink sticker, lower right.

Figure 24 shows Quincy typing the blue sticker on the top left: he is typing out the whole re-written section while the other participants and I are still speaking. He also typed out the yellow sticker for the first panel, while figure 25 shows the completed pink sticker for the third panel, next to the shared writing in blue pen on the WB. Meanwhile, each participant is then re-drawing or re-constructing (Prain and Tytler, 2012) this diagram and copying our shared writing in their respective notebooks, so that in the end the completed work is seen in figure 25 on the WB and Jamboard, and in the notebook in figures 26 and 27 below.

This episode, conducted over three days and in this online environment, used different modalities and participation structures which were arranged so that the epistemic work and the languaging for it were made visible and manipulable for all participants. I discuss our maturing local culture as evident in our practices with semiotic work, in the Outcomes section. These activities and interactions turned into a Rich Point for us all, which we understood in the moment through our visible interaction and artifacts. However, the Rich Points in these episodes have a cumulative effect which we only realized later in a culminating episode for the unit, to conclude the data presentation for this study.



energy figure 26 – Epistemic work. Kassim's paper notebook, showing the first panel of his re-drawing of the Jamboard coal formation comic. The original text from the online diagram is written above Kassim's diagram, while our shared writing appears under it



energy figure 27 – Epistemic work. Kassim's notebook, panels 2 and 3 of the coal formation process diagrams and writing. The shared writing appears under each diagram.

Part 3 Energy – return to in-person environment *"...making a diagram ... so we understand better what we want to say, and we can see how is it,"*

Episode 8 – Text, anchor text and representations: Languaging and Epistemic Work through Meta-talk

Enactment process	Evidence	Design Principle
Epistemic work (EW) ▪ explaining and arguing with *signs and words as ideas in representations* ▪ *problematizing: identifying gaps* Meta-talk (MT) ▪ writing tasks are a context for reasoning aloud Languaging (L) ▪ *words are objects of reasoning: own writing and representation work becomes knowledge resource and improvable object*	Rich Point: " I learned it from that diagram", by Quincy ▪ Quincy presents his energy diagram without prompting Excerpt 6	Specific Design Principles ▪ *improvable objects*: elaboration *anchored in Ss constructions and edits of their representations and text* ▪ *interplay of text: interpreting and constructing interplay of modalities*

This final episode took place in a lesson filmed at the end of May, transcribed in Transcript 5. At this point in time, the authorities have lifted all lockdown restrictions.

The episode begins with a discussion of ideas and terms on these student posters in the context of a read-aloud of chapter 2 of the anchor text, titled "Heat Energy". In turn 2, I am echoing the words in the chapter subheading, "How Heat Energy Moves", seen in figure 30. "...How heat energy moves, so how heat energy is transmitted.... You first thought of "transformed", but but but here transformed is what happens here (pointing to the student posters)" (turn 2). I am trying to start the lesson by making the explicit connection to the diagrams on the posters, which are a collage of the diagrams that we reconstructed during the lockdown. Quincy points out his use of the word "transmitted" in his poster, turn 7. I give compliments on this instance of making connections: "...that's what you are trying to remember because these are words that you wrote from using what we learned..." (turn 8).

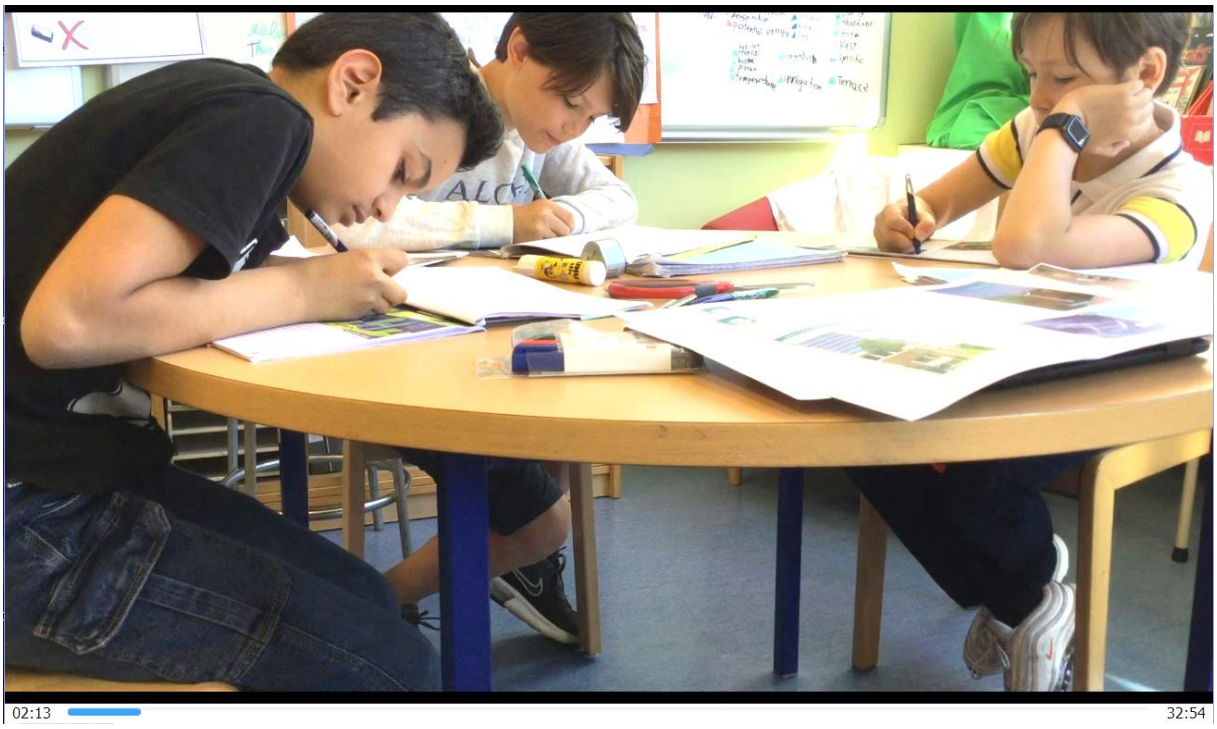
The students proceed to organize themselves to continue with the read-aloud, after over-writing the sub-heading with "is transmitted" as seen in figure 28. I set the iPad down facing the students and go away. Meanwhile, in turn 14, Kassim begins to read aloud, holding the pen to follow along on the text, as seen in figure 29: "heat energy doesn't stay still, it moves from from, uh, (pauses and looks up to recall a different word;) an object".



energy figure 28 – Languaging through MT. Review work with chapter 2 "Heat energy", from Quincy's booklet, with over-writing on the text (see also figure 47)



energy figure 29 – Languaging through Meta-talk review energy ch 2 at 02min06. Kassim: "(reading from the booklet) heat energy doesn't stay still, it moves from from, uh, (pauses and looks up to recall a different word;) an *object* (Ruslan thumps the table with his arm, Quincy sits up and gets set to write. Kassim has uttered a different word in place of the one in the anchor text)" (Turn 14)



energy figure 30 – Languaging through Meta-talk. review energy at 02min13 Quincy: oh first let's write *object* (he smiles at Kassim; pause while all three write the word in their booklets) (turn 15)

Immediately, Kassim interrupts himself, as he encounters the word "thing" in the text. He pauses and looks up, at the same time as Ruslan thumps the table with his arm (seen in the blurry arm in figure 29). Kassim utters the word *object* instead, and Quincy sits up. He suggests, "oh first let's write *object*" (turn 15), smiling at Kassim. All three proceed to over-write "thing" with *object*, in figure 30 (see also the anchor text, figure 28).

Kassim keeps reading, and in turn 44, "when heat, when heat is transmitted between, uh, (interrupting himself) "things" is not a science" and Quincy again suggests *object*, but Kassim has the idea to use the term *matter*. I interrupt him to discuss the term as referring not only to inanimate objects but also living things, although I do not use those terms. I refer to Ruslan, patting his shoulder, and the table, patting that (turn 46). In a flash, it occurs to me to then say,

Energy excerpt 3 – transcript 5

46	5:28.4 - 5:52.4	... OK, so heat. If you lean your arm (patting Ruslan's arm) on this table, what happens	Teacher
47	5:52.8 - 5:54.0	after, you're, it gets	Quincy
48	5:54.6 - 5:56.1	you're *transmitting* *Quincy simultaneously*: *transmitting*	Teacher and Quincy
49	5:56.4 - 5:56.9	the heat	Quincy
50	5:57.0 - 6:21.1	to the table. So these are two *objects* (alternately patting the student's arm and the table). These are still two *objects*. Yeah. One with more heat energy, a system. Your body is a system with heat energy. This table doesn't have any (patting the table, students chuckle). So if you put your arm there, after a moment, that part of the table is a little bit warm due to what (pauses)	Teacher
51	6:21.8 - 6:30.4	due to the heat, transmitting the heat energy to the table (all, excitedly)	all

The students respond eagerly to this suggestion of the concrete example, and speaking simultaneously, provide terms and phrases as we create this instance of the point in the anchor text. I feel elated, and see that it is a moment to capitalize on for writing with our science terms, to concretize our epistemic work. I interrupt this exchange with my signal "well done", to then request that we write the description of this concrete instance of heat transmission, and so I begin to repeat the phrases that we just constructed orally together, as they write them down in the booklet, as seen in figure 31, beginning in turn 52:

Energy excerpt 4 – transcript 5

52	6:30.6 - 7:55.0	Well done. Well done. So we can still say heat is transmitted from the high energy system. (Quincy suggests) Yeah, yeah, yeah. So now we're going to write this here. Write it here. Let's write this example of this person's arm. Heat is transmitted. From an an object of high energy. To an object of low energy, is transmitted. .....Does that make sense, from a s- Let's write a system because Ruslan is a system. The human body is a system, ... right, from a system of high energy because Ruslan is a high energy guy, haha (laughing theatrically), and a system of high energy. Because that's what we say, we don't say high temperature, right?	Teacher
53	7:56.3 - 7:59.2	(Looking up from writing) High energy, high heat energy. Figure 31	Kassim
54	7:59.4 - 8:05.4	Brilliant. To an...	Teacher
55	8:06.1 - 8:06.7	an object,	Ruslan
56	8:06.9 - 8:48.6	an object of lower energy, it's always relative. You must know boys temperature is relative in the universe. OK. It's always something relative to another. Mm hmm. All right. To an object of a lower temperature or lower energy, I'm sorry. Lower energy. Well done. Does that make sense to you? Then you write, for example, for example, Ruslan, Ruslan's arm, write the example of Ruslan's arm, what can we say about Ruslan's arm,	Teacher
57	8:49.4 - 8:51.8	for example, my friend's arm,	Quincy
58	8:52.0 - 9:13.6	for example, comma, my friend's arm sits on the table. (walks away to place the iPad on a stand) What can we say about Ruslan's arm? My friend's arm leans on the table.	Teacher
59	9:16.4 - 9:16.7	Maybe we could make a little diagram	Ruslan
60	9:18.4 - 9:25.3	you could make a little diagram ! (repeats, exclaiming; Quincy immediately looks up at the teacher and grimaces) That, is that what science people do? figure 32	Teacher
61	9:25.9 - 9:26.3	Yes. (Kassim looks up; Ruslan looks up and nods) figure 33	Kassim

Using the phrases that we stated orally, derived from over-writing the anchor text just now, I add the phrase "system of high energy" to try to connect with the work done early in the unit. Immediately, Kassim responds confidently to my prompts, "high heat energy" (turn 53), as can be seen from his expression in figure 31. I prompt for more phrases, and Quincy and Ruslan also contribute as they write. In turn 58, I echo Quincy's phrase, prompting for the next sentence, when Ruslan suddenly states, "Maybe we could make a little diagram" (turn 59).

I am quite amazed and exclaim "you could make a little diagram!" (turn 60) and Quincy simultaneously looks up at me from his writing, grimacing (figure 32). I continue with "That, is that what science people do?" and the other boys react immediately, as seen in figure 33, asserting that this is the case. Without further prompting, they immediately set to work on

drawing. I leave them to it, just as they had been doing the read-aloud without me in figure 29. I am still in wonder at this process, and eager to see what they can accomplish without interacting with me.



energy figure 31 – Epistemic work. review energy at 07min58. Students are writing sentences for the heat transmission example. Kassim : "(Looking up from writing) High energy, high heat energy" (turn 53). Ryu can be seen in the online call, writing as well.



energy figure 32 – Ruslan: Maybe we could make a little diagram (turn 59) Teacher: you could make a little diagram ! (repeats, exclaiming); Quincy immediately looks up at the teacher and grimaces) (turn 60



energy figure 33 – Teacher: That, is that what science people do? (turn 60) Yes. (Kassim looks up and says yes; Ruslan looks up and nods)



energy figure 34 – (teacher is moving elsewhere in the room; students chuckling at each other as they work) (turn 71)



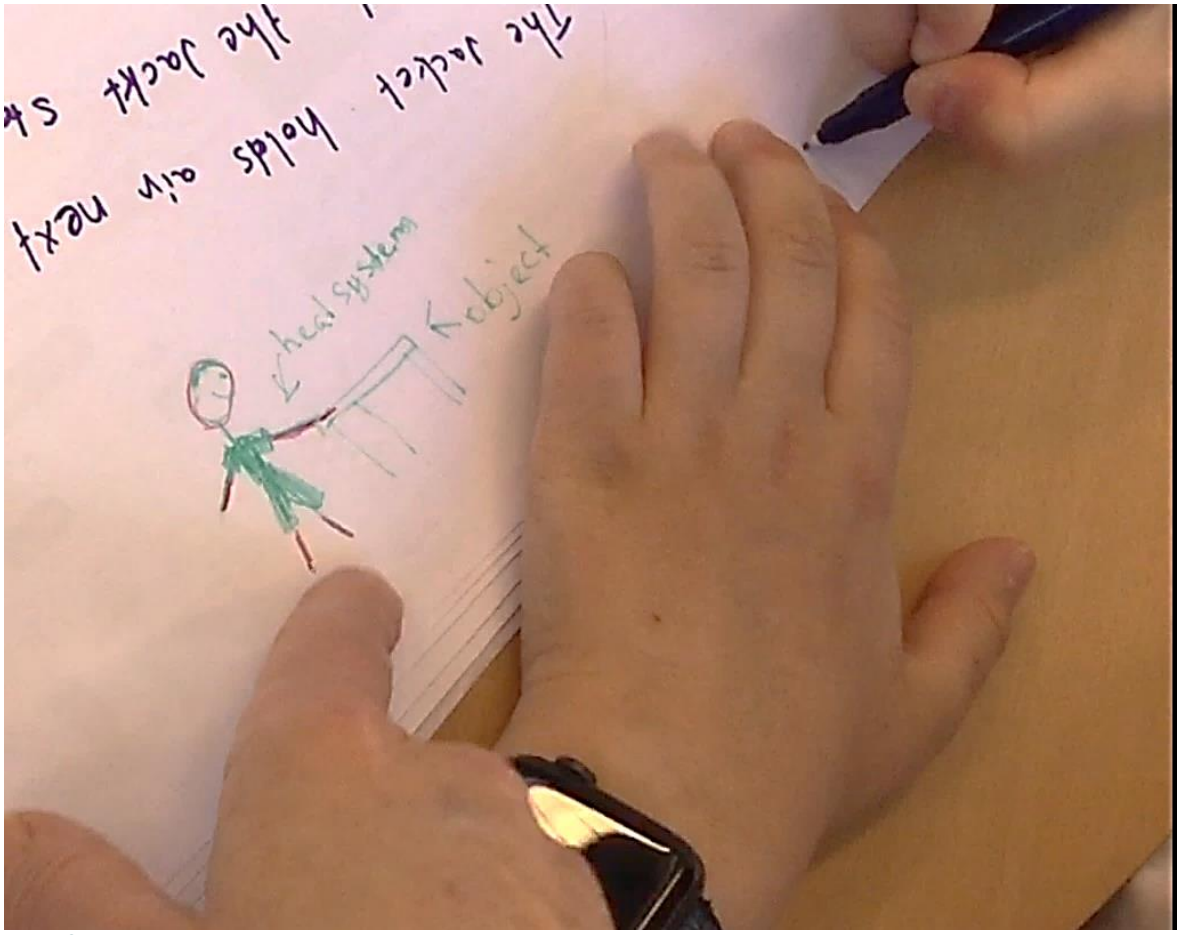
energy figure 35 – Ruslan: (stands up abruptly, pointing to his paper) Can I have a red to demonstrate that I'm kind of the heat is coming? (turn 80)

While I am elsewhere in the room, the students draw and interact with each other, as seen in figure 34. Ruslan shows his work to Ryu in the online call, while Quincy summarizes the idea about the arm to Ryu. Suddenly again, Ruslan stands up and states, " Can I have a red to demonstrate that I'm kind of the heat is coming?" (turn 80, figure 35). In figure 35, he is standing and placing his finger on a part of his drawing as he is speaking to me. Ruslan immediately takes one and begins to work with it on his drawing, while Quincy and Kassim continue as before with their own drawings.

They have now been working for about 5 minutes, and I decide to approach the table again and so pick up the iPad from its stand. On his drawing, Ruslan has carefully pencilled in red on the arms and legs of his stick figure, as well as the contour of the head. As seen in figure 36, he has labelled, with an arrow, the table as *object* and the arrow to the red arm on the table is initially labelled *heat sisstem*, although in this screenshot it is already corrected. The students appear to be quite engrossed in their semiotic work, though, so I try to prompt a meta-talk with one of my signals, "So here we have" and pointing:

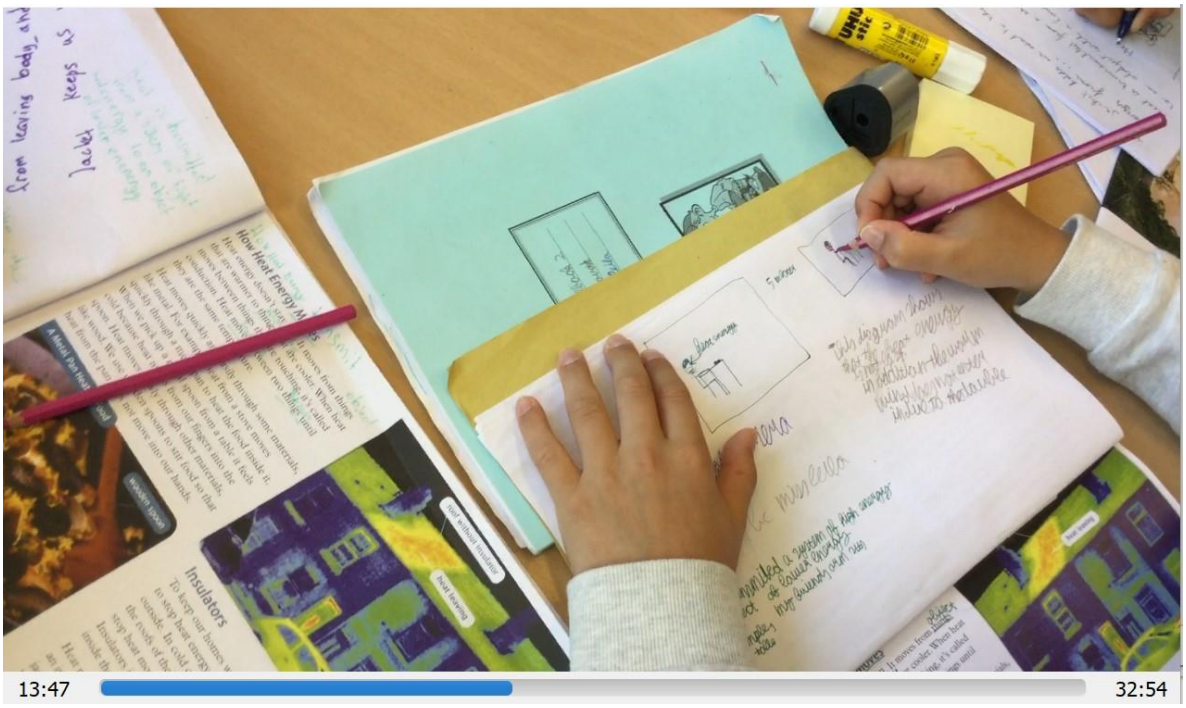
Energy excerpt 5 – transcript 5

93	13:26.6 - 13:34.1	good (in Russian). So here we have. (pointing to Ruslan's booklet as he is drawing) Here's the person with the red arms because the heat is. ...(pause)..figure 36	Teacher
94	13:36.8 - 13:37.7	*Quincy*: all around, all around us *Ruslan simultaneously*: I'm going to make a little key	Quincy and Ruslan
95	13:37.7 - 13:49.5	Well done. Well done. And you're making a diagram. Because, why? Why are we making a diagram, so... (prompting anyone to speak in general) figure 37	Teacher
96	13:49.5 - 13:58.4	so we understand better what we want to say, and we can see how is it, figure 38	Kassim
97	13:58.6 - 13:59.0	Mm-Hmm.	Teacher
98	13:59.5 - 14:14.4	if It's only some blah blah, we will only know, but there will not be an example. So in our head, it will be more difficult to understand (gesturing to his head while looking at Quincy). figure 38	Kassim



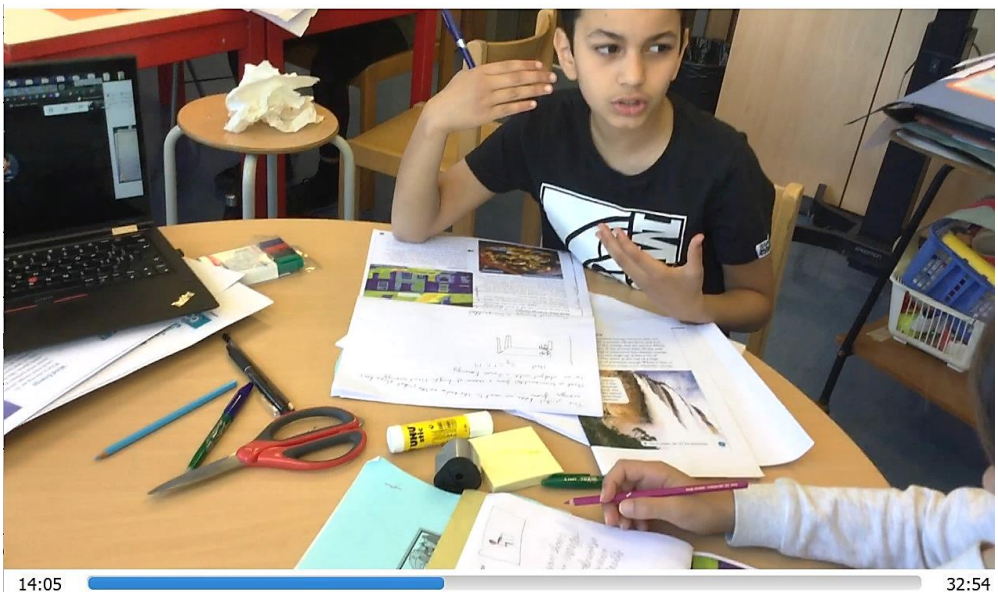
energy figure 36 – Teacher: So here we have. (pointing to Ruslan's booklet as he is drawing) Here's the person with the red arms because the heat is...(turn 93) Quincy: all around, all around us Ruslan simultaneously: I'm going to make a little key (turn 94)

Still pointing to Ruslan's diagram (figure 36), I start another prompt: "Here's the person with the red arms because the heat is...(pause)" (turn 93) and Quincy fills in smoothly with "all around, all around us" (turn 94). Ruslan, however, states his intention to make a key. Although my iPad is pointing to Ruslan's paper, I also see that Quincy has now taken up one of the red pencils and begun to apply colour to his diagram as seen in figure 37. In retrospect, I consider his phrase "all around, all around us" as indicating his moment of inner speech becoming externalized concurrently with his drawing, not merely as a response to my prompt. His diagram has two panels at this point, while Ruslan has the one panel. I note that this spoken phrase coincides with the moment he takes up the red pencil and begins to apply it first to his second panel, as seen in figure 37. I will return to this point below when Quincy narrates his diagram panels.

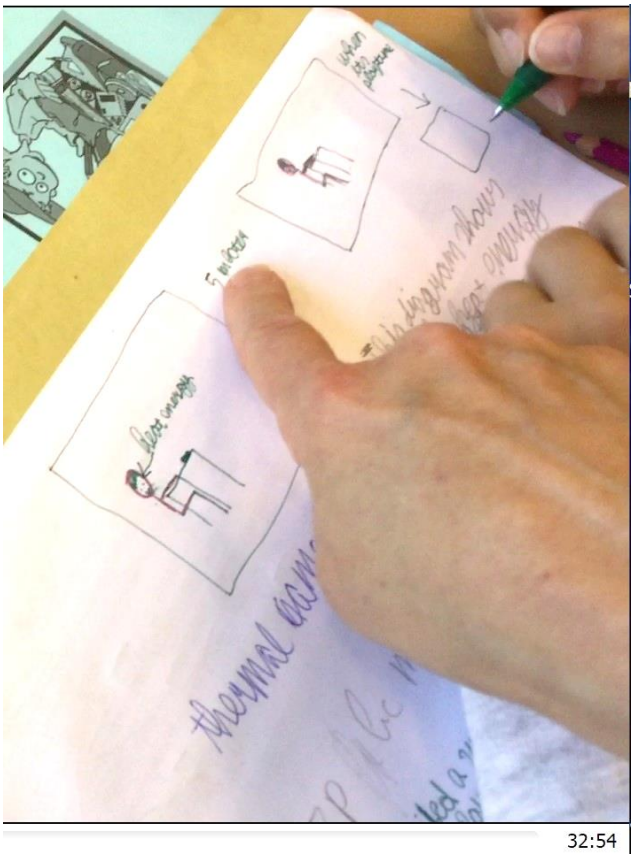


energy figure 37 – Teacher: Well done. Well done. And you're making a diagram. Because, why? Why are we making a diagram, so... (prompting anyone to speak in general) (turn 95) (Teacher focusing camera on Quincy who is now adding red colour to the second panel of his diagram)

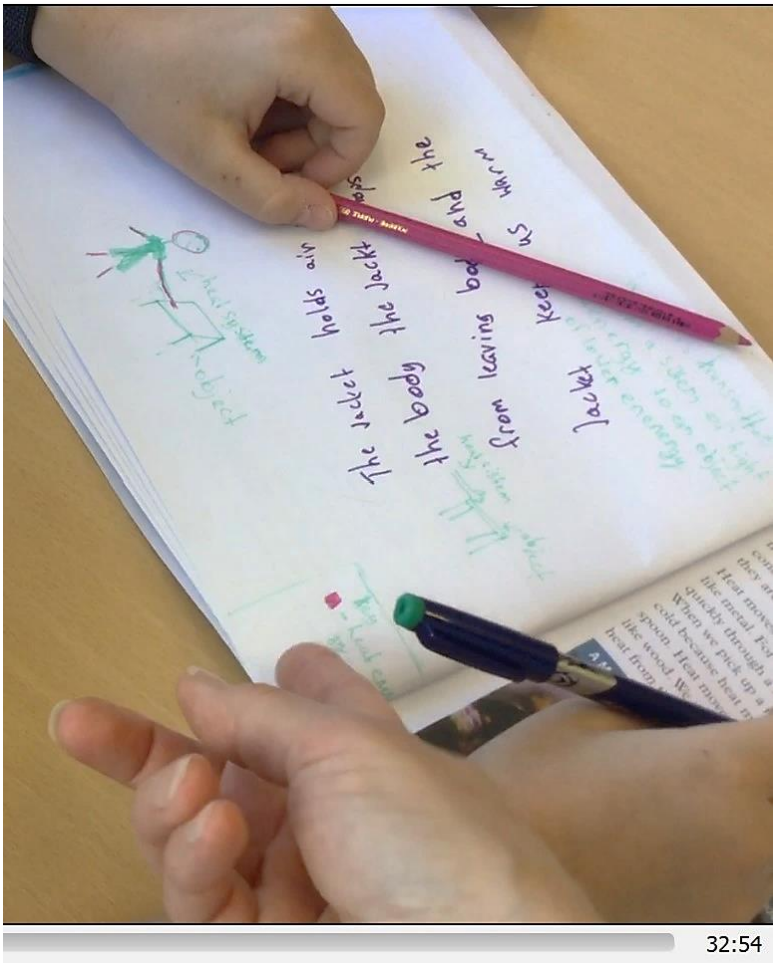
However, I am more focused on Ruslan's statement about the key, with "Well done. Well done. And you're making a diagram. Because, why? Why are we making a diagram, so..." I state this to signal encouragement here, because I want him to recollect all our previous work with keys in the concept maps, and less as an evaluation at that moment. Also affect. I continue with a prompt to meta-talk about the act of constructing this representation, since Ruslan initiated the act and the others joined in readily and are engaging at length. I quickly reformulate to state we. Kassim replies smoothly with a clearly and carefully spoken reasoning: "so we understand better what we want to say, and we can see how is it," (turn 96, figure 38). He elaborates, looking at Quincy, "if It's only some blah blah, we will only know, but there will not be an example. So in our head, it will be more difficult to understand. " (turn 98)



energy figure 38 – Kassim: so we understand better what we want to say, and we can see how is it, (gesturing to his head and looking at Quincy as he speaks)(turn 96) Teacher: Mm-Hmm. (turn 97) Kassim: if It's only some blah blah. We will only know, but there will not be an example. So in our head, it will be more difficult to understand. (turn 98)



energy figure 39 – Teacher: I see your point. And what did you do? (pointing to Quincy's diagram, where he has written a time expression) You wrote what? What does that say? Quincy: Five minutes later. Teacher: What is this ? This is a … Ruslan: protses (in Russian) Quincy *interjects*: process



energy figure 40 – Teacher: ...what a scientist, you are showing and you're putting a (now pointing to Ruslan's diagram key)-- key. (word spoken simultaneously with Ruslan) (turn 105)

Rather than inviting the other directly to respond to Kassim's insightful meta-talk, I instead turn to comment on Quincy's work, hoping to prompt some similar meta-talk from him around his own drawing. I have just seen a noteworthy element in it and say "and what did you do? (pointing to Quincy's diagram where he has written a time expression) You wrote what? What does that say?" (turn 101 figure 39) I am pointing to the time expression that he has written between the two panels, which he now reads out. I then prompt him with "What is this? This is ... " and Ruslan answers "protses" (in Russian) and Quincy interjects "process".

This time, I make an evaluative but also affective comment, "A-one. A-one ,what a scientist, what a scientist, you are showing and you're putting a (now pointing to Ruslan's diagram key)-- key. (word spoken simultaneously with Ruslan)" (turn 105, figure 40) at the same time pointing to Ruslan's diagram and the key, in figure 40. I try to work on what I perceive to be Ruslan's evident desire to

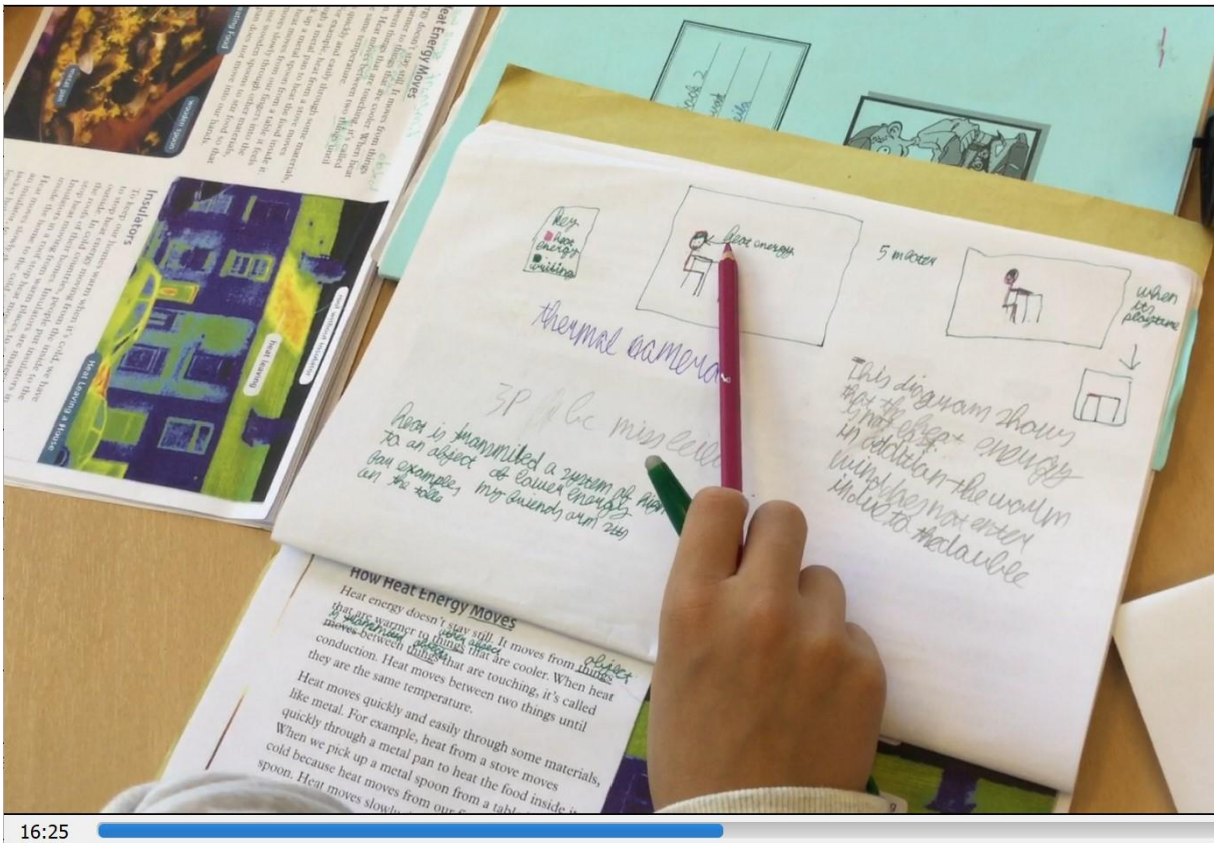
contribute to the meta-talk happening at the table among us, while also showing that I am noticing and crediting his epistemic work equally with the others, and explicitly connecting with his earlier comment on making a key (turn 94).

During this time, I am still standing by the table next to Quincy, holding the iPad and pointing it at the work on the table. When I conclude an exchange with Kassim, Quincy begins to explain his work, without any prompting, using the same signal *so here we have*, that I used just now in turn 93 and moving his red pencil to the first panel, as seen in figure 41:

Energy excerpt 6 – Transcript 5

116	16:21.2 - 16:26.0	So here we have Ruslan sitting on the table. (pointing to his diagram, the first panel, with the red pencil, as he is speaking) figure 41	Quincy
117	16:26.6 - 16:28.1	At the, you mean at the table	Teacher
118	16:28.1 - 16:36.4	At the table, Yes. And there he has heat energy, five minutes later (pointing to his second panel). The table's a bit warm. Then it's playtime, (pointing to the time expression)	Quincy
119	16:37.4 - 16:37.5	the	Teacher
120	16:38.1 - 16:42.5	he's gone and there's a bit of energy over there. (pointing to the third panel)	Quincy
121	16:47.2 - 17:34.7	Are you a scientist? I can see that, this is my evidence, evidence. figure 42You are a science person. You represented the concept of energy, because, as Kassim said, the blah blah helps a little bit, but the best is a series of diagrams and you did it by yourself. I didn't ask you to make this process. You Ruslan first said what figure 43, Let's make a diagram because Ruslan is a young scientist. And then you started to make a process because you realized just from this. Did it help, Quincy, that we had these? (pointing to the project posters on the WB, with his diagrams glued on, see figure 34) This one here? Did that help	Teacher
122	17:35.0 - 17:39.6	Yep. Yes. I learned it from that diagram.	Quincy
123	17:41.4 - 17:48.4	*Teacher* The process of … *Quincy*: coal *Teacher* …formation. Wow.	Teacher

In the sequence of turns shown in excerpt 6, he clearly and calmly presents his sequence of panels. He refers to the red colour by saying "here he has heat energy" and indicating it with the pencil in each panel; he states the time expressions and narrates each panel.



energy figure 41 – Epistemic work. **Rich Point**. Quincy: So here we have Ruslan sitting on the table. (pointing to his diagram, the first panel, with the red pencil, as he is speaking) (turn 116) Teacher: At the, you mean at the table (turn 117) Quincy: At the table, Yes. And there he has heat energy, five minutes later (pointing to his second panel). The table's a bit warm. Then it's playtime, (pointing to the time expression) (turn 118) Teacher: the ... Quincy: he's gone and there's a bit of energy over there. (pointing to the third panel) (turn 120).

Quincy concludes by looking up at me as a signal (figure 42), and I point the iPad at him while I again make evaluative but also affective comments in referring to the representational work in turn 121. I try to recognize the epistemic work of each student at the table (Ryu has not contributed here unfortunately) by crediting Ruslan with starting the work (figure 44), Kassim with his explanation about the uses of the diagram in understanding the concept, and Quincy with his series of panels detailing the process. In another flash, because I am standing next to his poster, it occurs to me to point to Quincy's coal diagram (seen behind him on his poster, in figure 33) now glued on this poster, and ask, "Did it help, Quincy, that we had these?" He turns around to look at it briefly, and calmly states, "Yep. Yes. I learned it from that diagram". I check again by prompting, "The process of ..." and he states, "coal".

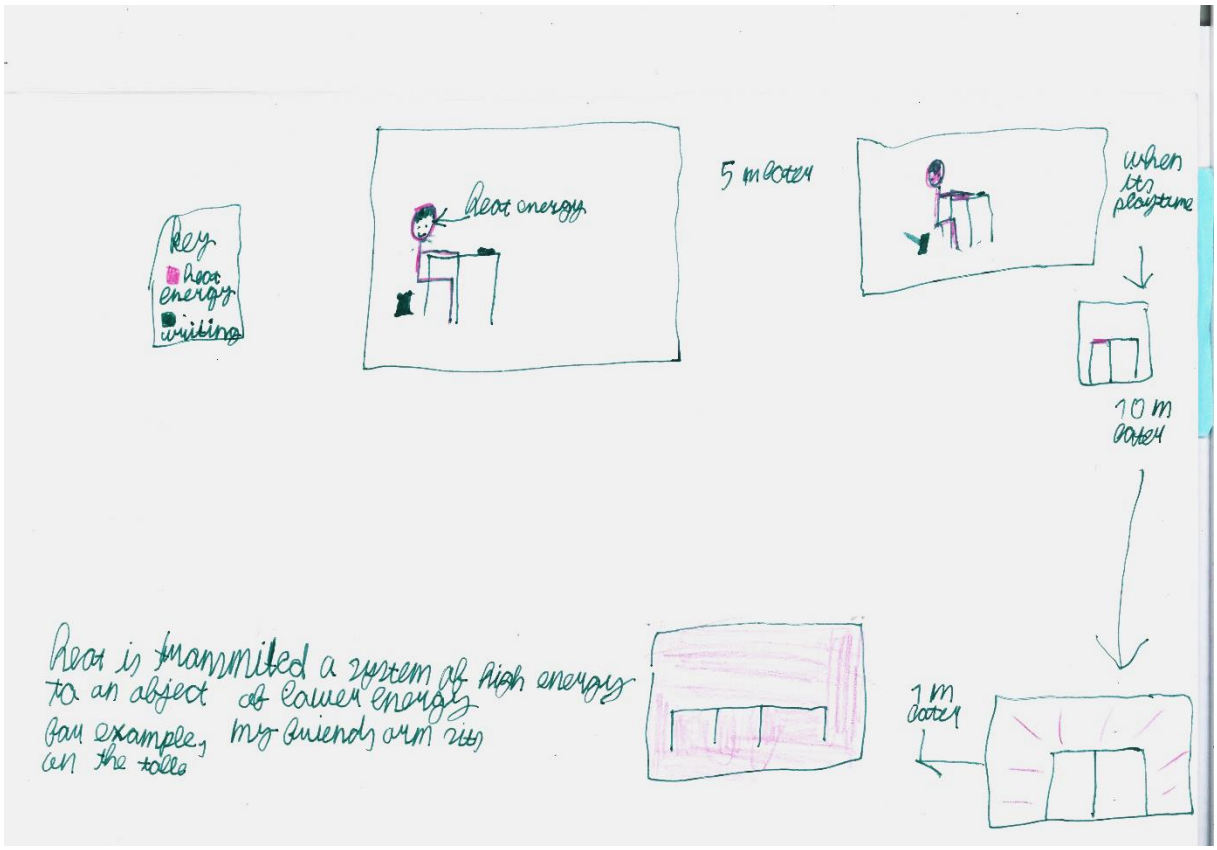


energy figure 42 – Teacher: Are you a scientist? I can see that, this is my evidence, evidence. You are a science person. You represented the concept of energy, because, as Kassim said, the blah blah helps a little bit, but the best is a series of diagrams and you did it by yourself… (turn 121)

Quincy and the others seem quite serene and are still engaging with their own diagrams. I have the impression that they wish to reflect within themselves, so I do not pursue the work with my thoughts about whether they were connecting with earlier Rich Points in the unit.

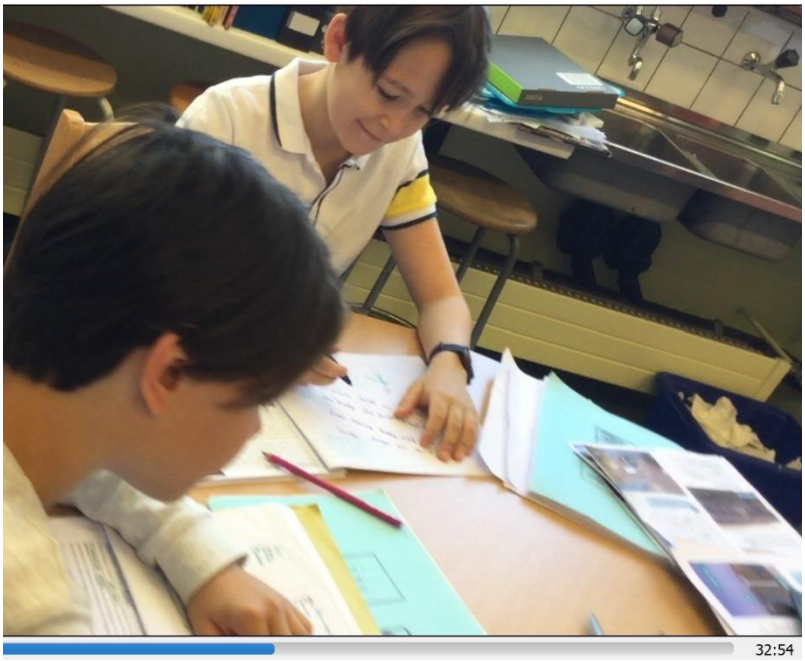
Figure 41 shows Quincy's diagram at the point that he chooses to present it; however, during the remainder of the lesson, he continues to work on it, eventually constructing two additional panels to complete the process, as seen in figure 43. He continues to use arrows and apply colour, as well as insert time expressions. Kassim continues to write more, as seen in figure 45, carefully pronouncing each word as he writes it. Ruslan adds detail to his existing drawing. After a time following the interaction described above, we continue with more reading aloud and discussing other examples of heat transfer.

With this Rich Point, I conclude my narrative presentation of the data in this final iteration; the Outcomes section and figure 4-6 delineate the cumulative results and the final revisions to the design, shown in bold.

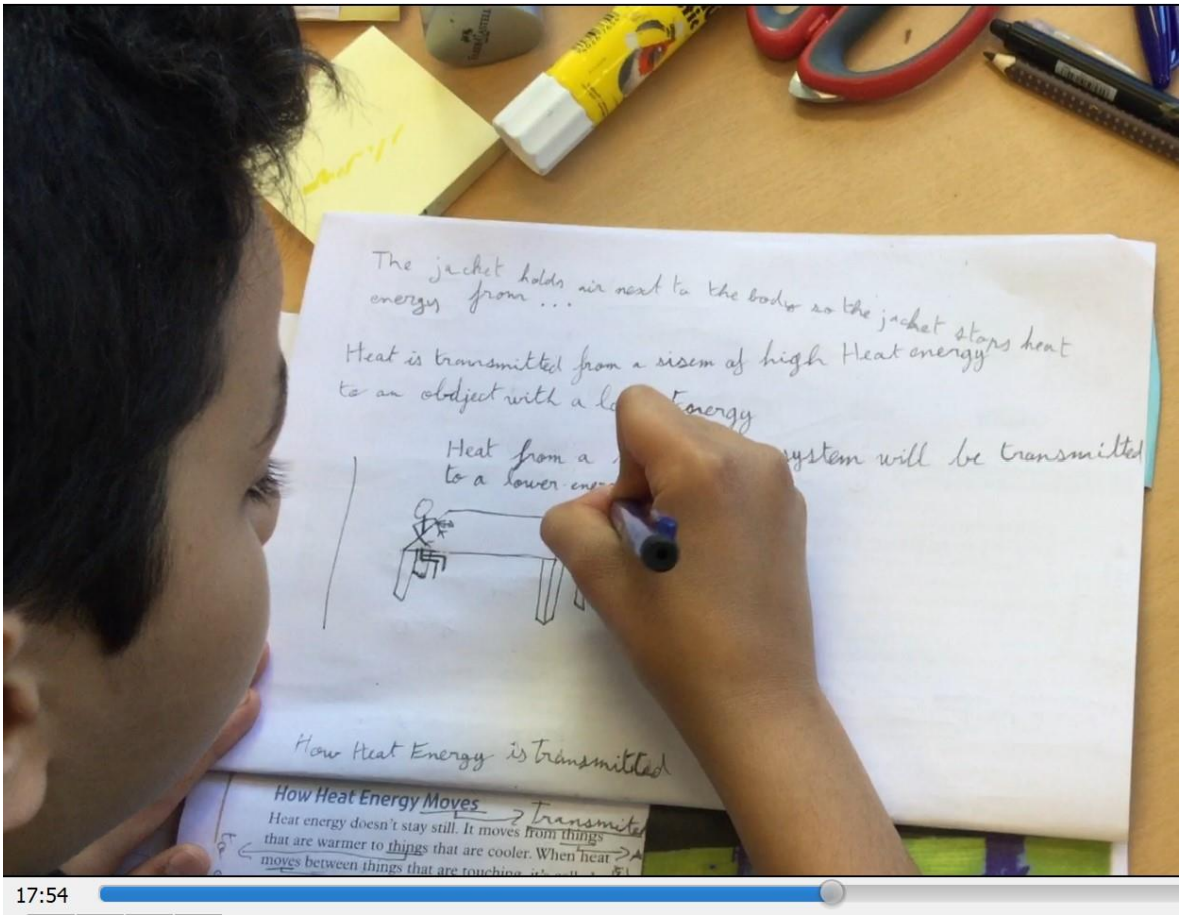


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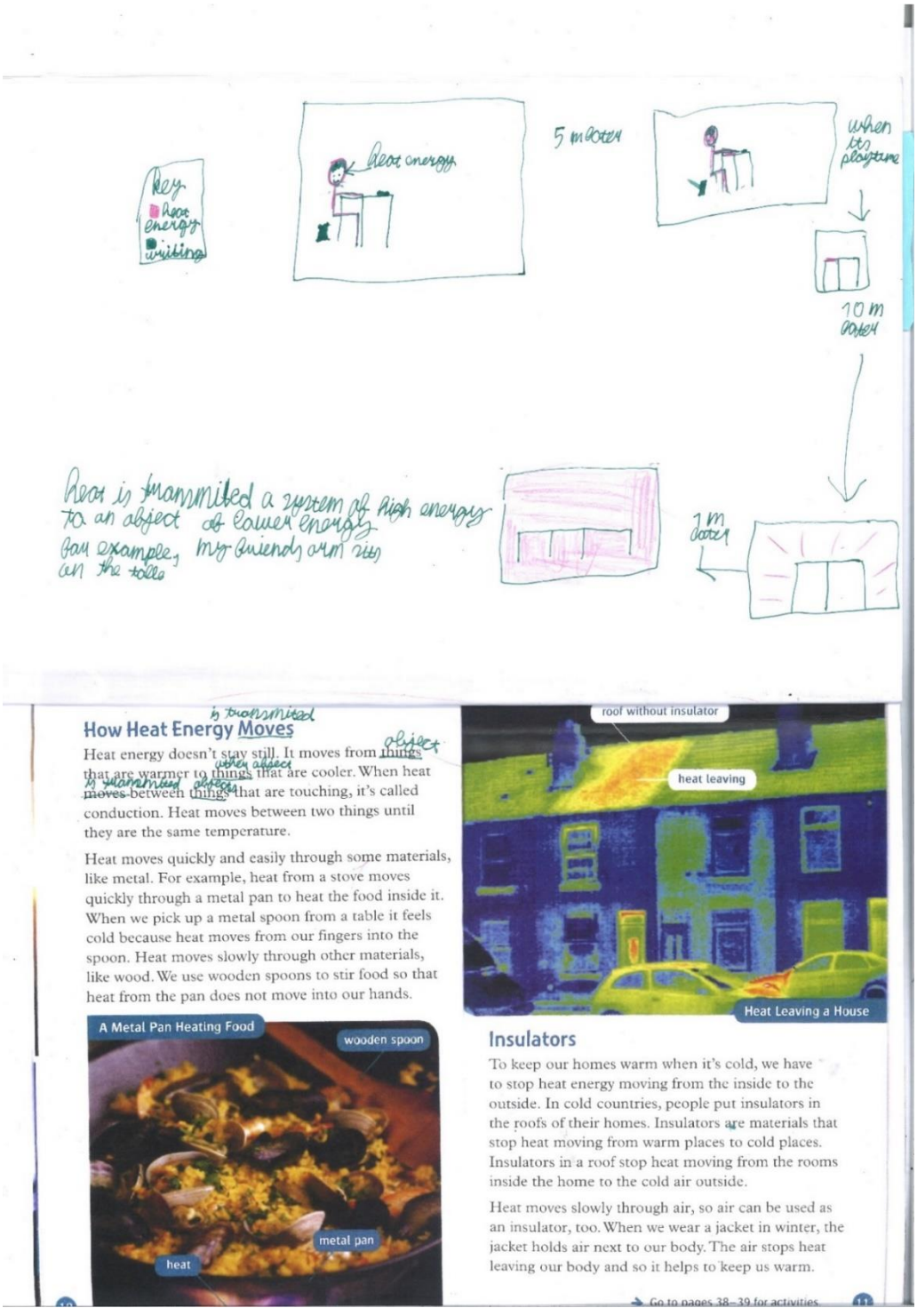
energy figure 43 – Epistemic work. Quincy's diagram, (detail from figure 46) with two panels added later in the lesson (compare figure 41) , with more time expressions and red pencil applied. Arrows suggest the sequence of the process. His use of the red colour as representing heat energy dispersing in rays in the fourth panel harks back to the athlete diagrams at the start of the unit.



energy figure 44 – Teacher: ...I didn't ask you to make this process. You, Ruslan, first said what, Let's make a diagram, because Ruslan is a young scientist... (turn 121)



energy figure 45 – Epistemic work. Kassim is writing the text box for his diagram panel and pronouncing the words as he writes them.



energy figure 46 Epistemic work. Quincy's complete notebook page, with his over-writing and independent diagram work.

5 Discussion

In this chapter, I present the discussion which follows the conclusion of the intervention phase in the DBR process, reported in chapter 4. Intermediate levels of analysis were conducted during the intervention process, in which I applied non-linear, abductive, iterative and recursive analysis to determine patterns of practice in the classroom interaction, based on microethnographic perspectives (Green, et al., 2020). Through this phase in the DBR process, I thereby collected observations and tested process conjectures, and so informed the next cycle of iteration; hence, chapter 4 contains detailed analysis situated in the context of each iteration. That analysis is set out in sections 4.2.1, 4.3.1, 4.4.1 and 4.5.1, and summarized in figure 4-3, figure 4-4, figure 4-5 and figure 4-6.

I now apply retrospective (Bakker, 2018) and inductive (Erickson, 2012) analysis to these Intermediate Outcomes. This level of analysis considers the features and signposts that emerged through the cycles of iterating the design. The Rich Points used to sequence the Design Narrative constitute the salient and surprising events of each iteration providing those signposts. In this chapter, I present the inductive analysis through which I determined the Design Features (DFs) and Enactment Processes (EPs) characterizing the interaction during which the Rich Points emerged. This analysis enables me to describe and explain the features of the learning trajectory for this intervention: I derive new insights into the learning process and discuss the revision of the Design Principles (DPs) and Conjecture Map (CM) for the design. In so doing, I also revise the High-level Conjecture (HLC) and the Outcomes, and arrive at a new characterization of the learning that took place in this intervention, and the means designed to support that learning.

This DBR study set out to explore the application of a set of DPs that I derived from research and pilot projects (section 3.3) in order to test a HLC on student progression along an EL – AL continuum through appropriation of academic literacies and disciplinary practices (Bloome, Carvalho and Ryu, 2018) in school science topics. Drawing on sociocultural theory and situative perspectives viewing learning as changes in participation over time, mediated by artifacts (Wertsch, 1985; Sawyer and Greeno, 2008; Greeno and Engeström, 2014), I

designed disciplinary literacies activities anchored by text to foster language learning as participation in academic literacies for knowledge construction (Säljö, 1998; Gee, 2004; Paavola and Hakkarainen, 2005).

Through implementation of the knowledge construction metaphor suggested by Paavola and Hakkarainen (2005), I developed and tested a design with such activities, enacted through a process of object-oriented collaboration with conceptual and material artifacts across four iterations each exploring a different topic. I drew on a wide conceptualization of *text* as encompassing semiotic resources as cultural tools (e.g. Wells, 1999; Gee and Green, 1998), and *words* as included in a broader semiotic perspective of meaning making through representations and sign-making (Lemke, 1990; Kress, et al., 2001; Prain and Tytler, 2012). Wells (1999) explicates Vygotsky's theory of mediation of social activity through artifacts and signs as tools, stating that participation in discourse allows the child to internalize the social functions encountered in interactions with others. Hence, the context influences knowledge construction, which is therefore situated and dialogic. The context is built by the participants around "the artifacts that are made and improved through the students' and teacher's participation in the activity" (Wells, 1999, p. 123), which forms the basis of the intervention reported in this study.

In this intervention, I participated as teacher, in collaboration with the students in building the context of the knowledge construction and the mediating discourse practices in a small group setting. The study seeks to describe and explain the everyday practices of the participants, defined as a local culture, to present the emic or insider point of view on the construction of these everyday practices (Kelly, 2023). This study therefore draws on microethnographic and discourse analytic approaches to identify social processes of knowledge construction, conducted through multiple levels of analysis (Green, et al., 2020).

Discourse moves were enacted around material artifacts in the form of anchor texts, as well as representations, as suggested by Tytler et al.'s (2020) work on reasoning through drawing, i.e. representation construction, as leading to student progression in disciplinary literacies. In this study, I view artifacts as including both texts and other material objects, as well as conceptual artifacts such as discourse moves around the texts, following (Paavola and Hakkarainen, 2005; 2014; 2021). Conceptual and material artifacts are viewed as

improvable objects in this study (Wells, 1999): findings show that discourse moves become objects of discussion by the participants during this intervention. Progression took place through students enacting mediating processes connecting knowledge construction with discourse moves around text and representations, namely, *meta-talk*, *languaging* and *epistemic work*, across four iterations of design testing. Figure 5-1 presents the learning progression for student learning in this study, constructed through the process of inductive analysis, which I now delineate. This is followed by figures 5-2 and 5-3, which in turn focus more narrowly on the key features of the learning progression, leading to a reformulation of the Learning Outcomes and Design Outcomes for the study, shown in figure 5-5. Figure 5-4 will present these outcomes as emerging through the construction of a local culture of practices, leading me to suggest a new variation in the application of DBR methods in education, with particular relevance for research drawing on the knowledge construction metaphor and investigation of learning through joint collaboration on knowledge objects.

In figure 5-1, column 1 shows the student interaction around their anchor text and their own generated text for Iteration I, *Farming*. Each successive column indicates the subsequent iterations. Two sets of arrows represent progression: in reading aloud, in blue, and in reasoning aloud in orange. These colours refer to the Map of findings for Iteration I, figure 4-2, and so on for each iteration in chapter 4, where I presented the intermediate key findings, repeated here in Column 1. In figure 5-1, these columns regroup the intermediate findings presented in chapter 4: the progression in reading aloud and reasoning aloud is shown, together with the interaction characterizing each stage in the progression. Thus, in column 1, the interaction on the anchor text involves learning to notice words and features, and learning to enact annotations; the lower box with the student generated text, shows students noticing, telling, imitating and transcribing symbols and using colours as codes, in sign-making that is imitating or *reproducing* text and representations from the anchor text. This is the entry point of activity in object-oriented collaboration in this study. It is orchestrated by teacher-initiated activity, as shown by the pale colours of the progression arrows.

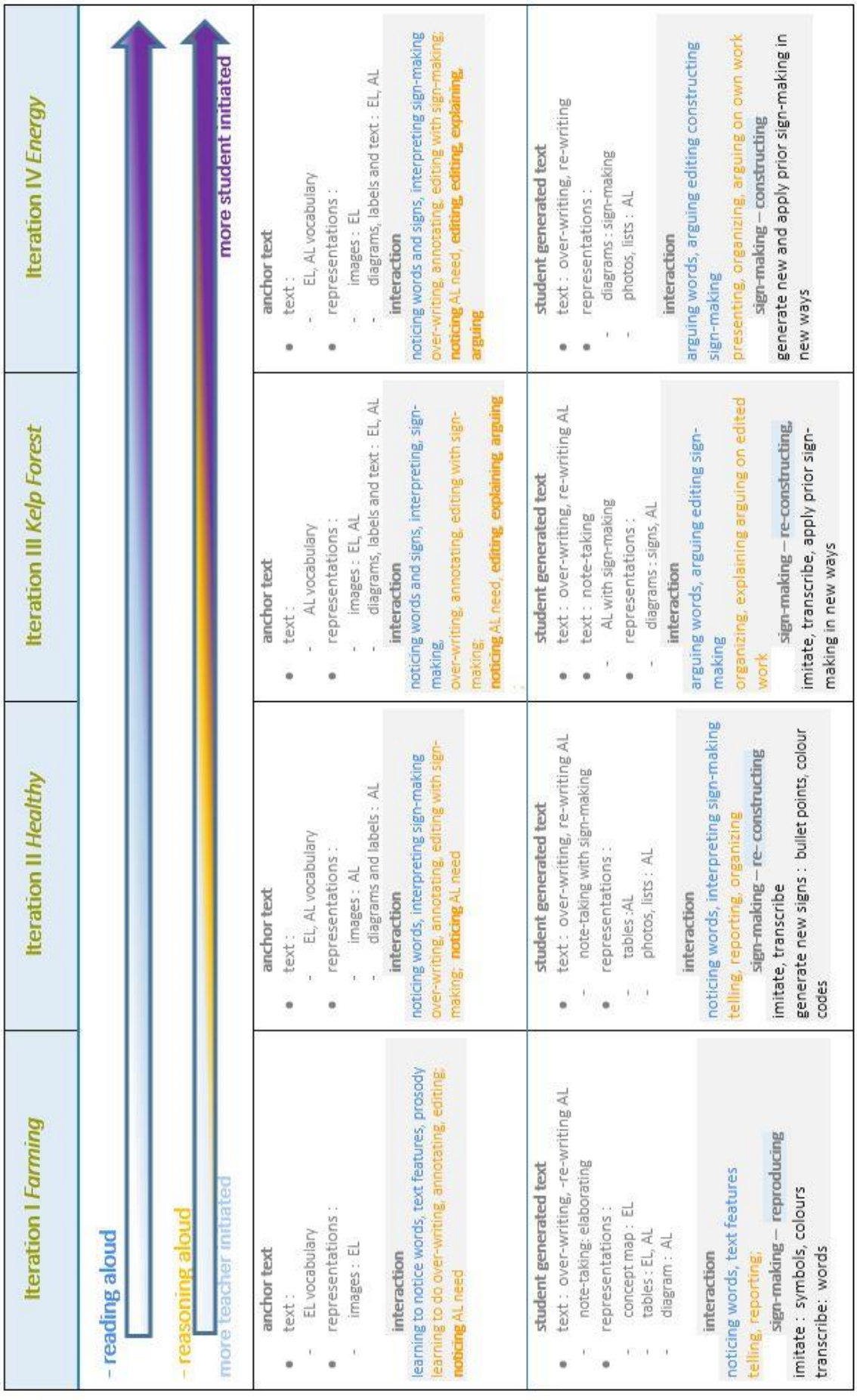


Figure 5-1 Learning Progression for student learning as mastery in using semiotic tools for epistemic work mediated by interaction around artifacts

Hence, this point is identified as beginning to establish intersubjectivity, and the student's beginning to internalize the semiotic mechanisms of sign-making, through this disciplinary activity (Wertsch, 1985). In this study, I am drawing on the notion of "calibrating our categories", achieved through this semiotic mechanism (Wertsch and Addison-Stone, 1985, p. 166), as discussed in the Intermediate Outcomes of the Iterations.

In column 2, Iteration II *Healthy*, the activity involves more elaborate forms of noticing, including interpreting sign-making on anchor texts, reflected in more annotation and *re-constructing* representations, including instances of students generating own new signs as they do so. The progression arrows indicate a stronger blue colour for more student reading aloud, and more orange for more incidences of reasoning around texts.

In column 3, Iteration III *Kelp Forest*, a clear change occurs in student-initiated action: it is reading aloud and *reasoning aloud on edits* of their own sign-making, *re-constructing* text and representations applying their sign-making in new ways.

In column 4, Iteration IV *Energy*, the progression arrows indicate nearly all student initiated read-alouds and reasoning aloud on their own work. Students are now *constructing* their representations, generating new signs and applying their own prior sign-making in new ways, while reasoning aloud on these processes.

Hence, these iterations mark levels of intersubjectivity in recognizing and utilizing sign forms: students are engaging in the process of acculturation to disciplinary sign forms and practices as suggested by Wertsch and Addison-Stone (1985). In columns 1 and 2, students are beginning to reason aloud concerning the representations, and are imitating and transcribing them in social processes which are still, however, preceding the students' full understanding through internalization. In column 3, students are showing internalization of the semiotic mechanisms by consistently suggesting reasoning-aloud points and edits on anchor text and their own work in extended sequences of talk, as well as by initiating their own representation work at an individual level, in addition to the collective work on representations as joint improvable objects. In column 4, students have fully internalized

the semiotic mechanisms practiced in this setting, so that the setting now fully constitutes a local culture of recognized sign-making practices.

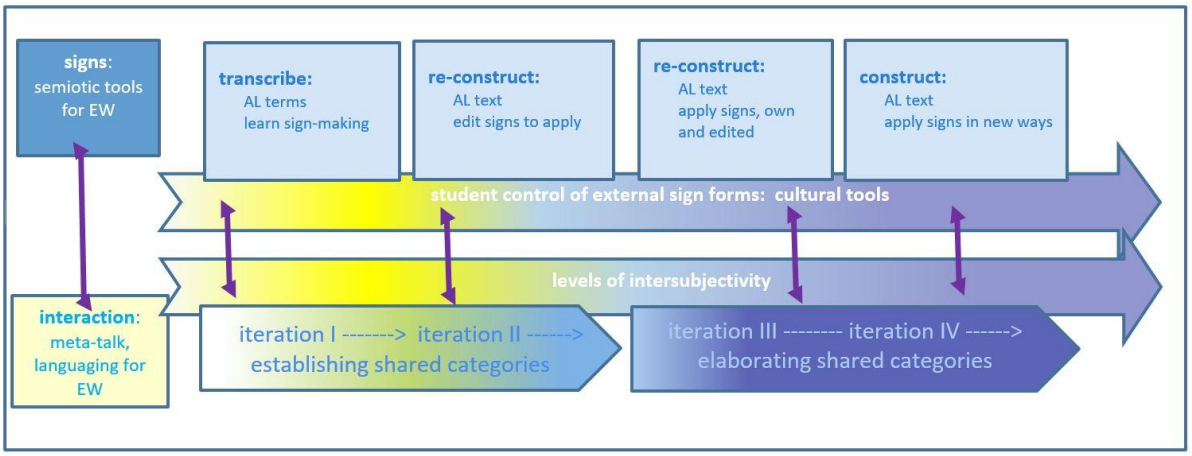


Figure 5-2 – Student progression in control of external sign forms, through interaction around signs as text and representation, across time, shown through levels of intersubjectivity

The changes in levels of intersubjectivity are presented in figure 5-2, shown as the bottom arrow which is in turn divided into sections showing the iterations I *Farming* and II *Healthy*, followed by Iterations III *Kelp Forest* and IV *Energy*. This is explained by the vertical connection to the forms of sign-making: Iteration I and II are about establishing shared categories (Mortimer and Wertsch, 2003), practiced on the social plane through transcribing and re-constructing, mediated by meta-talk and languaging, as discussed in sections 4.2.1 (*Farming*) and 4.3.1 (*Healthy*). The yellow colour on the arrows indicates that the learner is still working on the social plane, and as yet enacting the discourse moves more at an individual level: the learner's focus is on linguistic patterns and register, and he is working to establish the connection of words as concepts. This point is shown on figure 5-4 with the arrow on the left of the figure representing literacies as linguistic activity. I return to this figure further below.

Continuing with figure 5-2, I noted in section 4.4.1 (*Kelp Forest*)that new sign-making coincided with new kinds of meta-talk around it, during this iteration. This reciprocal process is shown by the purple vertical arrows, and summarized on the left: sign-making and discourse moves are working together. The blue colour of the arrows indicates the collective work of elaborating shared categories of understanding or intersubjectivity in sign making . I noted during the *Kelp Forest* analysis that reasoning aloud was taking place in

more lengthy exchanges around the sign-making in the form of edits such as over-writes and annotations on representations. These were noticed and initiated by the students, who had progressed from the word level as register choice for the disciplinary genre in Iteration I *Farming*, to signs as concepts in *Kelp Forest* and Iteration IV *Energy*. I discussed the mediating means of signs at length in the Outcomes and Analysis section 4.5.1 *Energy*, where I pointed out that meta-talk directed at noticing gaps in meaning, in text based discussion, served as the means to create the focus of joint attention on sign-forms and concepts (Scott, 1998). This constitutes the bridge from intermental functioning on the social plane to intramental functioning, through the gradually forming habit of epistemic work on sign-making (Wertsch, 1985).

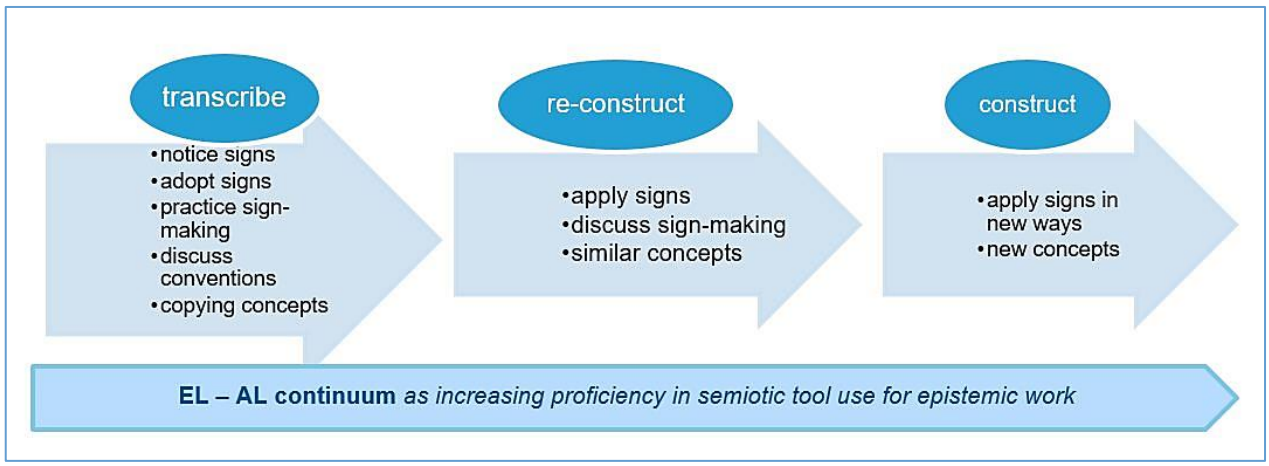


Figure 5-3 Learning Progression in learners' appropriation of disciplinary discourse practices, conceptualized as increasing proficiency towards mastery in uses of cultural tools

As I noted in section 4.5.1 *Energy*, through epistemic work with editing and authoring *text* considered as representations as well as words, established in Iterations I and II, the students gained the habits of mind to work at the conceptual level in Iterations III and IV, having established our cultural practices for epistemic work through increasing complexity in semiotic tool use. Figure 5-3 therefore focuses on the essence of the learning trajectory and learning outcomes in this intervention, namely increasing proficiency in sign-making for epistemic work in school science topics. This takes place in the social activity of the group: through enacting the processes of sign-making mediated by meta-talk in a reciprocal way, what begins as *transcribing* or imitating, through interaction taking place mostly on the social plane, develops into *re-constructing* as text and representations are edited and *improved* according to the developing understandings of the participants concerning disciplinary practices. Finally, the participants are fully aware of the significance of sign

forms in epistemic work, *constructing* their own representations through fully internalized semiotic mechanisms. Learning progression in academic literacies in this study is therefore defined through a trajectory signposting changes in participation: individuals participate more proficiently in literacies practices that have structure and meaning which are constructed by the individuals in situated activity (Greeno and Gresalfi, 2008; Greeno and Engeström, 2014). In this intervention, the learning trajectory consists of students' increasing proficiency toward mastery in using semiotic tools for epistemic work mediated by interaction around artifacts, i.e. improvable objects (Wells, 1999), including material and conceptual artifacts (Paavola andHakkarainen, 2005).



Figure 5-4 Learning Progression as participation and learner construction of a maturing local culture of practices

I now turn to a characterization of the local culture developed by the participants in this intervention, as schematized in figure 5-4, through a discussion of views of literacies contributing to this local culture. In sections 1.2 and 2.2.2, I reviewed perspectives on literacies as linguistic practice (Colombi and Schleppegrell, 2002; Gibbons, 2003; Fang and Schleppegrell, 2010) and views of literacies as social practices (Gee, 2004; Greeno and Gresalfi, 2008; Bloome, Carvalho and Ryu, 2018). These perspectives have in common the concern of presenting students with opportunities to engage in instructional activities that help them practice and acquire the literacy skills for developing and sharing knowledge, i.e.

advanced literacy skills as defined by Colombi and Schleppegrell (2002). These authors emphasize the concern for equity for all students in engaging in meaningful instructional experiences which provide access to knowledge *about* school texts, as well as the knowledge contained *in* them. I discussed this point in section 1.2, where I identified teaching the use of language in science as key for ELLs' participation in disciplinary literacies of science: I cited Bravo and Cervetti (2014), who referred to explicit instruction in academic English and science knowledge as a social justice imperative.

However, the two perspectives on literacies differ in their respective instructional approaches, emphasizing different views of language and the individual, according to Colombi and Schleppegrell (2002). These authors consider that the view of literacy as social activity involves meaning construction by individuals through joint activity, using the tools of their culture, citing Vygotsky (p. 6). They state that these tools are material, social and semiotic resources, which is how the notion of cultural tools has been used throughout this study, (e.g. Tytler, et al., 2020; Wertsch, 1997; Kelly, 2023). Colombi and Schleppegrell analyze the social view of literacies as foregrounding social activity for creating contexts for participation through social practices, and argue that this relegates language itself to the background. Instead, they suggest that language should be foregrounded through a view of literacy as linguistic activity, which "highlights the way that language as a semiotic tool interacts with social contexts in making meaning" (p. 8). The goal is to develop new ways of thinking through new ways of using language, through a focus on grammatical and lexical choices and therefore leading to"new forms of consciousness in students" (p. 9).

However, I argue here that the key is centering these literacies activities on *epistemic work* developed as cultural practices over time, as symbolized by the students reading, discoursing and drawing signs, thinking individually and as a group, in the center image of the cultural arrow, figure 5-4. In my study. this entails not only providing access to knowledge about texts valued in schools, but also the opportunities for epistemic agency in constructing those texts, through the social practices of the disciplinary literacies.

In my intervention, I thus attempt to find common ground in these literacies views, as shown in figure 5-4, where I represent both as dynamically active and interactive in the learning progression of the participants. I review Gee's (2004) discussion of language in the

science classroom, and situated meaning, noted in section 2.2.3. Gee states that "meaning in language is tied to people's experiences of situated action in the material and social world" (p. 25). He goes on to state that children need to expand the social language of science through reading lessons on expanded texts, "placed in the midst of practice and discussion" (p. 36).

Therefore, literacies as social practice can be designed and shown to foreground language use, only through different mechanisms, which I present in figure 5-4, with the orange arrow on the right. Furthermore, I incorporate the view of science-as-practice suggested by Lehrer and Schauble (2015), who I noted state that participants work in concerted activities as a "community of practice", where they are learning ways of talking about phenomena and uses of text. My schematic of literacies as linguistic activity and literacies as social activity contributing to build a local culture of knowledge construction therefore indicates that *both* mechanisms are employed, although at *different times* in the learning progression, as indicated by the placement of these arrows.

In this study, I show that I orchestrated activities around text which included discourse moves on grammatical and lexical choices: I defined these as *meta-talk* and *languaging*. However, these activities were enacted first on the social plane, and then also on the individual plane, through an evolving semiotic mechanism (Wertsch, 1985), namely sign-making for *epistemic work*. Hence, in figure 5-4, I show that my intervention incorporates activities that explore genre and choices in linguistic patterns, dynamically interacting with social practices of knowledge construction, where the students are developing the semiotic tools of this epistemic work over time, as their emerging local culture.

This dual contribution of the social and linguistic mechanisms is possible, I suggest, through the employment of the knowledge construction metaphor to design the EPs in this intervention. Paavola and Hakkarainen (2004) propose this metaphor as a way of implementing joint collaboration on knowledge objects, material and conceptual, taking place trialogically: not only social, dialogic interaction, not only individual work, but also joint work on knowledge objects which are in the process of being defined.

Organizing activities around shared objects takes place over time, and hence I have drawn the central diagonal arrow in my schematic, to indicate the passage of time, where the lengthy development of the shared knowledge objects results in a shared history of cultural practices. In the iterations, this is seen in changes in participation of the learners, in the EPs. They are not only *performing* the processes with more proficiency, they are implementing the EPs through the discourse moves to *author* concepts, through reasoning and representation work, jointly determined and individually carried out.

Therefore, turning to figure 5-5 below, as a consequence of my retrospective analysis, I have revised the DPs, item 4, to add knowledge construction practices as taking place in literacy and science contexts, and item 5a, discourse moves foster a local culture, not only a sense of identity in the practices.

The Design and Process conjectures are rewritten to incorporate the discourse moves as involving reasoning aloud, work on knowledge objects, and authoring tasks contributing to define identity and culture. The EPs, for Observable Interactions, are rewritten to specify how the discourse moves are employed.

The Intervention HLC and Outcomes are thereby rewritten: it is conjectured that the design for knowledge and use of the EL – AL continuum in fact involves appropriating practices for students representing and reasoning about phenomena and processes in school science topics, leading to revised Learning Outcomes and Design Outcomes. The students in this study showed progression in individual and collaborative work for knowledge goals decided as a group; furthermore, as seen in Iterations III and IV, each participant seized on opportunities to enact uses of semiotic tools in a highly personal way. I therefore argue that the design in this study ensures equity in developing literacy skills, as shown by these diverse students' participation.

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Figure 5-5 Revised Conjecture Map following retrospective analysis of the DBR intervention

High-Level Conjecture :

Students' knowledge and-use of the Everyday Language <---> Academic Language continuum requires their appropriation of disciplinary discourse practices, including

- **representing**
- **reasoning**

about phenomena and processes in school science topics.

Design principles

- are heuristic guidelines
- define the intervention: instruction is designed through application of these principles
- provide a means-end relation

Design Features:

(Embodiment of the design)

Physical Artifacts

TOOLS:

- paper notebooks
- tablets, chromebooks
- whiteboard, personal and classroom (WB)

MATERIALS :

- anchor texts
- worksheets
- worked examples
- internet: images, information

Activity Structures : (main events)

- performing read-alouds of anchor texts
- presenting own artifacts
- attending to read-alouds and presentations
- writing:
  - new words in AL
  - study questions
  - words in representations
  - worksheets
  - idea generation tasks
- worked examples jointly constructed
- constructing representations
- note-taking in digital notebooks using interactive features
- editing: comparing, modifying
- peer- and self-assessment

Discursive Practices

- norms for reading and writing tasks
- discussion: authoritative <--> dialogic patterns established
- daily opportunities for experiencing AL in disciplinary ways
- making connections to
  - prior knowledge
  - newly/recently used signs and terms in AL

Design conjectures:

articulate the Processes that the Design Features should engender

1. making learning visible through multimodal tools will mediate students' to cognitively challenging tasks in ***epistemic work***
2. performing and attending to *read-alouds* will help students to
   a. engage with content
   b. experience science discourse
   c. **engage in reasoning aloud**
3. authoring artifacts through ***epistemic work*** will help students to explore uses of AL in **knowledge construction in the discipline**
4. problematizing AL through ***meta-talk*** and ***languaging*** work will help students to explore the connection of words and concepts for ***epistemic work***
5. contributing to activity design **at task, lesson or project level** will help students to **define their identity** and the **features** of **the local culture**

Conceptual Framework :

1. Situative view of learning: learning in activity over time
2. Social practices: ways that people are initiated into the frames of reference of the community, through
   - language
   - participation in cultural practices
3. Situated activity is mediated by artifacts:
   - material: equipment and devices
   - semiotic: language, notation, representation
4. Science discourse: orchestrated by apprenticeship in practices through
   - a words to concepts continuum
   - representation construction
   - conceptual link-making strategies
5. Literacy and science integrated through:
   - hands-on activities
   - vocabulary, reading and writing
6. Science concepts form the basis of talk, anchored by texts
7. Different modes of teacher-student interaction: dialogic or authoritative

Designing instruction with:

1. a variety of modalities will stimulate and engage
2. science anchor texts will provide students with
   - read-aloud tasks
   - challenging content and concepts
   - models for disciplinary literacies
   - context for language activities
3. daily reading and writing, and connection making between these, will foster habits of mind for the discipline
4. integrated literacy and science will provide students with meaningful contexts for
   - language tasks
   - representation tasks
   - **knowledge construction practices**
5. teacher orchestration of discourse for
   - purposeful shifts in interactions
   - dialogic < --> authoritative
   - connection-making

   a. will help foster **a local culture**
   b. will help promote agency in students,
   c. will help students to enact AL in disciplinary ways

Note: revised elements in **bold**

Enactment Processes
(Mediating Processes)

- state the basic characteristics of the intervention
- result from Design Features (DFs)
- mediate learning outcomes

Participant Artifacts

1. shared writing: AL anchor texts
   a. annotated through *over-writing*
   b. annotating: notes and visuals
   c. *re-writing* jointly and individually
2. authoring own digital texts
3. sketches: note-taking
4. completing and editing worksheets
5. representation construction: concept maps, diagrams, symbols
6. shared writing: a word wall

Observable Interactions

7. performing read-alouds and presentations: ***epistemic work***
8. attending to read-alouds and presentations
9. discussion around:
   a. text-based questions: ***meta-talk***
   b. editing moves using ***meta-talk*** and ***languaging*** work
   c. note-taking moves using ***languaging*** for ***epistemic work***
   d. presenting notes: ***epistemic work***
   e. giving peer feedback on notes and edits: ***meta-talk*** and ***epistemic work***
   f. reflecting on own and other's edits: ***meta-talk***

Participant Experiences

10. increasing initiative in task design
11. sense of **agency**, authority
12. accumulation of visible authored **cultural** artifacts
13. participation in and construction of a local culture, identity
14. engagement with and **definition of the lesson content**

Process conjectures:

articulate why the Enactment Processes should yield certain Outcomes: *if* we engage in these processes, *then* we will achieve / yield autonomy in uses of AL

For Participant Artifacts: the process of

1. producing written ***epistemic work*** (not merely as procedural tasks) will help students achieve increased sense of mastery of AL
2. employing multimodal tools will help students
   a. to persist with ***epistemic work***
   b. to feel greater control of the epistemic process
3. representation construction will help students to
   a. engage in science disciplinary practices
   b. engage in epistemic practices with more agency
   c. use the representations as conceptual resources and tools during ***meta-talk*** and ***epistemic work***

For Observable Interactions: the process of

4. modelling of disciplinary practices of writing and discussion will help students to achieve uses of AL with more autonomy
5. modelling of language uses in disciplinary practices through ***meta-talk*** will help students achieve increasing agency in their uses of AL
6. using artifacts as tools for visible thinking will help students achieve the habits of mind for increased autonomy in AL for ***epistemic work***
7. engaging in *meta-talk* will help students carry out *epistemic work*, by enabling their thinking to become visible as ***knowledge object***

For Participant Experiences: the process of

8. ***meta-talk*** in disciplinary practices will foster student agency as they engage in *knowledge construction*: ***epistemic work***
9. building a local culture of students editing and authoring text and representations will help them achieve epistemic agency and authority
10. **enacting and defining cultural practices** will foster a sense of identity as a member of the **local culture**
11. increasing agency in task design will help students achieve habits of study for lifelong learning
12. experiencing **epistemic agency** will help students achieve the means for deep conceptual learning

Outcomes

revised

Learning outcomes

Participants'

- self-directed and goal oriented use of the EL – AL continuum to carry out
  - disciplinary discourse practices
  - knowledge construction
- enables them to construct an identity as a participant and author in the local culture of epistemic work practices
- with explicit knowledge of the practices of that culture

Design outcomes

Designers of learning environments are informed of

- a tested set of Design Principles,
- refined across four iterations,
- informing design decisions and enactment processes for a learning progression in academic literacies and disciplinary practices

Hence, through the DBR process, carried out across four iterations, analysed through recursive, abductive and inductive methods, I am able to present a Revised Conjecture Map for this intervention, incorporating new knowledge of the learning and the means supporting that learning, as suggested by the revised HLC.

In my study, therefore, working with language in the content classroom entails not only providing access to knowledge about texts valued in schools, but also the opportunities for epistemic agency in constructing those texts, through the social practices of the disciplinary literacies. Through participation in the processes of the design, in increased levels of proficiency, students become self-directed and goal oriented in enacting the EPs: they explicitly state their identity and membership in this new culture of practices, by explicating the significance of the practices and therefore their membership in this fully developed local culture.

6 Conclusion

In this study, I set out to report on a design-based research (DBR) intervention to investigate a learning environment fostering ELLs' learning of academic literacies and disciplinary practices in middle school science, in a small-group setting. DBR processes are appropriate for investigating a complex learning environment through cycles of activity, so as to systematically study the forms of learning within the context designed to support them. By iteratively testing a learning design, researchers arrive at not only a description of what is happening, but an understanding of the underlying reasons or conditions for the learning events and phenomena being investigated. A core assumption in this study is the situativity of learning, where the learner and the social environment are inseparable; hence, DBR aims to advance a situated theory, or theory-in-context to produce a set of knowledge claims to guide instructional decision-making, by also communicating the particulars of the context.

I therefore employed DBR methods and processes to investigate the overarching research question, *How can a learning environment be constructed in order to support ELL students appropriating academic literacies and disciplinary practices?* To operationalize this question in the format suggested by DBR practice, I reformulated this question as a High-level Conjecture (e.g. Bakker, 2018; Sandoval, 2014) namely, *Students' knowledge and use of the Everyday Language (EL) and Academic Language (AL) continuum requires their appropriation of disciplinary discourse practices, including representing and reasoning about phenomena and processes in school science topics*. I devised DPs drawing on research as well as prior empirical work and applied these to construct a Conjecture Map setting out Design Features (DFs) and Enactment Processes (EPs) conjectured to mediate this learning outcome. The resulting design involved applying the knowledge construction metaphor, with students enacting mediating processes connecting knowledge construction with discourse moves around text and representations as improvable objects. I conjectured the students would appropriate academic literacies and disciplinary practices through joint collaboration on knowledge objects, mediated by discourse moves that I termed *meta-talk*, *languaging* and *epistemic work*. The process of conjecture mapping was essential for clarifying the DFs and

EPs so as to conjecture a means-end relation for how these elements worked to attain the desired learning objectives.

I employed microethnographic discourse analytic methods in a longitudinal application of my design, collecting data from multiple sources, across four iterations of the design, so as to explain and account for the effects of the design on the learners' academic literacies and disciplinary practices. By maintaining the same DFs and EPs across the iterations, it was possible to conduct a retrospective analysis applying analytic induction and thereby plausibly test the design conjectures, so as to determine the salient features of the design leading to the learning outcomes.

Through this analytic process, I showed that the essential DFs and EPs led to the students' learning of academic literacies. Furthermore, the iterative process of implementation enabled me to reliably identify key elements of the design, through the analysis of the conditions surrounding critical i.e. surprising events which signposted the students' learning progression. I termed these critical events Rich Points, and used the episodes during which these occurred to construct a Design Narrative of the intervention, concurrently describing and explaining the participant interaction around knowledge objects, defined as text, representations and practices for their construction. The resulting knowledge of the changes in participation and the conditions during which these occurred enabled me to revise the Conjecture Map and the HLC, as well as refine the DPs.

I reformulated the DPs to define disciplinary practices as knowledge construction, and the processes of increased participation in knowledge construction as leading to a local culture, defined by and built by the participants. I revised the design conjectures to reformulate engaging in disciplinary practices as epistemic work, through moves mediating reasoning aloud, including meta-talk and languaging. Furthermore, for the process conjectures which articulate the mediation process leading to the learning outcomes, I revised the conjectures to incorporate the findings on the effect of joint collaboration on knowledge objects: it consists in participants enacting and defining their individual and joint activity for knowledge construction as cultural practices, and thereby the construction of their local culture.

Hence, the Outcomes for the study were also revised. The initial formulation conjectured the investigation learning outcomes in terms of appropriation of academic vocabulary and disciplinary practices, which learners would carry out with more agency. Through the iterations of enacting the DFs and EPs, I found that focusing interaction around knowledge objects fostered a progression in epistemic agency, through which the ELLs constructed an identity as participants in a local culture of epistemic practices, which they helped define and construct, showing explicit knowledge of the features and practices of this culture. I therefore revised the HLC as involving *representing and reasoning* around knowledge objects, as these practices include a wider understanding of academic literacies.

In DBR processes, design knowledge contributes to a local theory-in-context, which I initially formulated in terms of having principles available for adapting and constructing materials and enacting methods for generative student work in academic literacies. Through the study, I derived new design knowledge through producing a set of tested DPs informing design decisions and EPs for a learning progression in academic literacies and disciplinary practices. This design knowledge enables me to define learning as changes in student participation over time, through opportunities for appropriation and mastery of sign-making and semiotic resources for knowledge construction in school science. Therefore, the unexpected series of Rich Points signposted a learning progression in student learning which I am now able to define as increasing proficiency of participation in a maturing culture of academic literacies for knowledge construction, of which the students were the defining agents.

The significance and implications of the findings

The implications of the findings from the study point to a reformulation of progression in academic literacies for ELLs in middle school settings. This involves situating literacies along a progression of practices: the entry point involves employing a linguistic view of literacies, with an individual, cognitive exploration of genre and register. However, through an emphasis on text-based activity, treating text in a wider sense as sign-making and representations, processes of reading aloud and reasoning aloud on text as improvable knowledge objects provided conditions for epistemic work, enacted through languaging and meta-talk, so as to foster student agency in literacies as a social activity.

As a result, designing for student progression is not about ensuring their mastery of *performance* of the DFs and EPs in any new topic, through a focus on *individual learning outcomes*. It is equally about the learning process, and the dual outcomes of knowledge about the learning environment, and design knowledge to support that learning. This study presents an emerging local history of practices, fostering epistemic agency and authority in the participants, so that they come to define the practices they are engaging in as their local culture, emerging out of their local history as active members of this culture.

Thus, the diverse students in this multilingual setting were able to develop agency in disciplinary practices and define their own identities as epistemic agents, each in his own way: equity is not only about access to knowledge through an understanding of the text which represents it, but also about participation in epistemic work to construct that text as a cultural practice. In this study, the students progressed to mastery in the situated semiotic systems they had constructed, and stated explicitly the significance of their practices as knowledge construction in school science.

The contributions of the study

This study contributes to research on academic literacies and disciplinary practices, by providing tested, actionable DPs and design suggestions for practitioners working in similar settings, who wish to explore similar learning progressions and design for similar learning outcomes. I show in detail the process of defining DPs, through the dual sources of theory and empirical work; other practitioners may also carry out a similar process according to their goals, having defined their focus in literacies, and their setting, to ensure ecological validity.

Furthermore, the study innovates in reporting on all stages of iteration: I demonstrate the process of intermediate analysis applied to the Design Narrative, to test conjectures, revise the DPs and EPs, and signpost the intermediate outcomes for retrospective analysis. The reporting in the Design Narrative is enhanced by innovative features of transcription, through hyperlinking the narrative, the transcripts and the screenshots for ease of analysis. Additionally, camera work is discussed as a tool during interaction.

My findings also contribute to research confirming the usefulness of DBR and designing across time and in cycles of activity. By reporting fully on key events and features of each iteration, it becomes possible to reliably account for the pathways and mechanisms for the changes in participation across time. This reporting ensures trustworthiness and reliability in the findings. I emphasize the usefulness of constructing a Conjecture Map, in preparing an intervention: it resembles a schematic for constructing daily teaching plans, as it includes desired goals to be achieved by the enactment processes using the materials and participation structures suited to the age group of the participants. Hence, conjecture mapping as a planning strategy has been applied across many contexts by teams of teachers and researchers, as I discussed in chapter 3.

I have shown that conjecture mapping enables the researcher to clearly define the starting point of the intervention and formulate the conjectures to be tested, which in turn enables a focus on the surprising events pointing to the usefulness of the design for achieving the desired outcomes. At the end of the intervention, the Conjecture Map is then revised, enabling a clear formulation of the learning progression and the means supporting that learning. This provides actionable design knowledge for other practitioners, part of the dual aims of DBR, together with desired learning outcomes for the participants.

However, this study also provides a surprising contribution to knowledge about the DBR process itself. I showed that cycles of iteration in the DBR process need not be enacted only for refining a design to "iron out wrinkles"; it is about fostering a local, cultural history, constructed by the participants. In my intervention, the same DFs are gradually taken up by the participants and appropriated, so that *the design matures*. This takes place through the internalization of the practices first enacted in the social plane and which, through the opportunities afforded by the cycles of activity, became transformed in the mental plane of the participants. This transformation is then seen in the agency of the participants, as they individually and collectively act to define the semiotic practices of this local culture.

Limitations

This study was conducted in a small-group setting, with ELLs who were already at a communicative level of English and were competent learners in academic settings in their

respective countries of origin. The study therefore did not address literacies of individuals with limited experience in school-based literacies or in English language learning. It also did not address adaptations for students with special learning needs.

The study shows that quality in DBR for educational research is based on a thorough understanding of the ecology of the setting and the participants, in order to design for effective enactment processes and desirable learning outcomes, since the participants are to be considered as agents of change (Barab, 2022). In order to ensure a responsiveness to the real agency and learning goals of the intended participants, I have shown that actionable design principles must be clarified to guide an effective intervention: these are formulated based on both theory and empirical knowledge, which provides a bridge between theory and real world learning contexts, ensuring reliability and trustworthiness.

Future work

Future work may involve expanding the setting to include a whole class, but also across classes, namely the subject class and the literacy class (e.g. a pull-out setting for specific learner needs such as the setting in this study), through collaborative design teams, including teachers and researchers. The DPs that I developed and refined in this study may be applied and tested in larger groups, and with different age groups. It would be interesting to explore the adaptations that students with particular learning needs may employ, as these may constitute variations in the semiotic tools and mechanisms already employed in this intervention.

Most importantly, I consider that the revised Conjecture Map and DPs may be implemented in other language contexts. The definitions of academic literacies as semiotic sign-making for knowledge construction in individual and joint collaboration encompass the idea of sign-making in other languages, as it involves principles of practice. I have shown how DPs may be applied situatively in designing for a learning progression in this study, and therefore feel confident that this process is possible in other contexts as a development of discourse-in-use.

References

Aguiar, O. G., Mortimer, E. F. and Scott, P., 2010. Learning From and Responding to Students' Questions: The Authoritative and Dialogic Tension. *Journal of Research in Science Teaching,* 47(2), pp. 174-193.

Alzen, J. L. et al., 2023. Characterizing relationships between collective enterprise and student epistemic agency in science: A comparative case study. *Journal of Research in Science Teaching,* 60(7), pp. 1520-1550.

Anthony, R. J., Tippett, C. D. and Yore, L. D., 2010. Pacific CRYSTAL project: Explicit literacy instruction embedded in middle school science classrooms. *Research in Science Education,* 40(1), pp. 45-64.

August, D. B.-M. L., Cardenas-Hagan, E. and Francis, D. J., 2009. The impact of an instructional intervention on the science and language learning of middle grade English language learners. *Journal of Research on Educational Effectiveness,* 2(4), pp. 345-376.

August, D. et al., 2014. Helping ELLs meet the Common Core State Standards for literacy in science: The impact of an instructional intervention focused on academic language. *Journal of Research on Educational Effectiveness,* 7(1), pp. 54-82.

Baker, W. D., 2019. Transforming Classroom Discourse as a Resource for Learning: Adapting interactional ethnography for teaching and learning. In: E. Manalo, ed. *Deeper Learning, Dialogic Learning, and Critical Thinking.* London: Routledge, pp. 105-120.

Baker, W. D., Green, J. L. and Skukauskaitė, A., 2008. Video-enabled ethnographic research: A microethnographic perspective. In: J. Walford, ed. *How to do Educational Ethnography.* London: Tufnell Press, pp. 77-114.

Bakker, A., 2018. *Design Research in Education: A Practical Guide for Early Career Researchers.* New York: Routledge.

Bakker, A., 2019. Design principles in design research: A commentary. In: A. Bikner-Ahsbahs and M. Peters, eds. *Unterrichtsentwicklung macht Schule: Forschung und Innovation im Fachunterricht.* Wiesbaden: Springer VS, pp. 177-192.

Barab, S., 2014. Design-Based Research: A Methodological Toolkit for Engineering Change. In: K. Sawyer, ed. *The Cambridge Handbook of the Learning Sciences (Cambridge Handbooks in Psychology).* Cambridge: Cambridge University Press, pp. 151-170.

Barab, S., 2022. Design-Based Research: A Methodological Toolkit for Engineering Change. In: R. K. Sawyer, ed. *The Cambridge Handbook of the Learning Sciences.* Cambridge: Cambridge University Press, pp. 177-195.

Barab, S. A. and Duffy, T., 2012. From Practice Fields to Communities of Practice. In: S. Land and D. Jonassen, eds. *Theoretical Foundations of Learning Environments.* 2 ed. NY: Routledge, pp. 29-65.

Beck, I. L., McKeown, M. G. and Kucan, L., 2013. *Bringing Words to Life: Robust Vocabulary Instruction.* 2 ed. New Yok: Guilford Press.

Bell, P., Hoadley, C. M. and Linn, M. C., 2004. Design-Based Rearch in Education. In: M. C. Linn, E. A. Davis and P. Bell, eds. *Internet Environments for Science Education.* Mahwah, NJ: Lawrence Erlbaum, pp. 73-85.

Berland, L. K. et al., 2016. Epistemologies in practice: Making scientific practices meaningful for students. *Journal of Research in Science Teaching,* 53(7), pp. 1082-1112.

Bezemer, J. and Kress, G., 2020. Semiotic work in the science classroom. *Cultural Studies of Science Education,* Volume 15, pp. 71-74.

Bezemer, J. and Mavers, D., 2011. Multimodal transcription as academic practice: a social semiotic perspective. *International Journal of Social Research Methodology,* 14(3), pp. 191-206.

Bishop, J. P., 2021. Responsiveness and intellectual work: Features of mathematics classroom discourse related to student achievement. *Journal of the Learning Sciences,* 30(3), pp. 466-508.

Bladon, R., 2010. *Oxford Read and Discover Level 4 All About Ocean Life.* Oxford: Oxford University Press.

Bloome, D. and Beauchemin, F., 2018. Classroom Ethnography. In: H. Callan, ed. *The International Encyclopedia of Anthropology..* Hoboken, NJ: John Wiley and Sons, Ltd., pp. 1-9.

Bloome, D., Carvalho, G. T. and Ryu, S., 2018. Researching Academic Literacies. In: A. Phakiti, P. De Costa, L. Plonsky and S. Starfield, eds. *The Palgrave Handbook of Applied Linguistics Research Methodology.* London: Palgrave Macmillan, pp. 887-902.

Bloome, D. and Clark, C., 2012. Discourse-in-Use. In: J. L. Green, G. Camilli and P. Elmore, eds. *Handbook of complementary methods in education research.* 3 ed. NY: Routledge, pp. 227-241.

Bloome, D. et al., 2004. *Discourse analysis and the study of classroom language and literacy events: A microethnographic perspective.* NY: Routledge.

Boelens, R., De Wever, B. and McKenney, S., 2020. Conjecture mapping to support vocationally educated adult learners in open-ended tasks. *Journal of the Learning Sciences,* 29(3), pp. 430-470.

Boyd, M. P., 2012. Planning and realigning a lesson in response to student contributions. *The Elementary School Journal,* 113(1), pp. 25-51.

Boyd, M. and Rubin, D., 2006. How Contingent Questioning Promotes Extended Student Talk: A Function of Display Questions. *Journal of Literacy Research,* 38(2), pp. 141-169.

Bransford, J. D. and Schwartz, D. L., 1999. Chapter 3: Rethinking transfer: A simple proposal with multiple implications. *Review of research in education,* 24(1), pp. 61-100.

Bravo, M. A. and Cervetti, G. N., 2014. Attending to the Language and Literacy Needs of English Learners in Science. *Equity and Excellence in Education,* 47(2), pp. 230-245.

Britannica School, 2022. *Energy Pyramid.* [Online]
Available at: https://school.eb.com/levels/middle/article/energy-pyramid/611153
[Accessed 20 09 2022].

Brown, A. L., 1992. Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. *The Journal of the Learning Sciences,* 2(2), pp. 141-178.

Brown, A. L. and Campione, J. C., 1994. Guided discovery in a community of learners. In: K. E. McGilly, ed. *Classroom lessons: Integrating cognitive theory and classroom practice.* Cambridge MA: The MIT Press, pp. 229-270.

Brozo, W. G., et al., 2013. Content area reading and disciplinary literacy: A case for the radical center. *Journal of Adolescent & Adult Literacy,* 56(5), pp. 353-357.

Bybee, R. W., 2009. *The BSCS 5E Instructional Model and 21st Century Skills,* Washington, DC: The National Academies Board on Science Education.

Carlone, H., Mercier, A. and Metger, S., 2021. The Production of Epistemic Culture and Agency during a First-Grade Engineering Design Unit in an Urban Emergent School. *Journal of Pre-College Engineering Education Research,* 11(1), pp. 172-191.

Casteel, C. P. and Isom, B. A., 1994. Reciprocal processes in science and literacy learning. *The Reading Teacher,* 47(7), pp. 538-545.

Center for Biodiversity & Conservation, AMNH, 2020. *Kelp Forest food web.* [Online] Available at: http://cbc.amnh.org/crisis/foodweb.html
[Accessed 25 02 2020].

Cervetti, G. N. et al., 2012. The Impact of an Integrated Approach to Science and Literacy in Elementary School Classrooms. *Journal of Research in Science Teaching,* 49(5), pp. 631-658.

Cervetti, G. N., Fitzgerald, M. S., Hiebert, E. H. and Hebert, M., 2023. Meta-Analysis Examining the Impact of Vocabulary Instruction on Vocabulary Knowledge and Skill. *Reading Psychology,* 44(6), pp. 672-709.

Cervetti, G. N., Jaynes, C. A. and Hiebert, E. H., 2008. Increasing opportunities to acquire knowledge through reading. In: E. H. Hiebert, ed. *Reading More, Reading Better.* New York: Guilford Press, pp. 79-100.

Cervetti, G. N. and Pearson, P. D., 2018. Reading and understanding science texts. In: A. A. Bailey, C. A. Maher and L. C. Wilkinson, eds. *Language, Literacy, and Learning in the STEM Disciplines How Language Counts for English Learners.* NY: Routledge, pp. 79-100.

Cervetti, G. N., Pearson, P. D., Bravo, M. A. and Barber, J., 2006. Reading and writing in the service of inquiry-based science. In: R. Douglas, M. P. Klentschy, K. Worth and W. Binder, eds. *Linking Science & Literacy in the K-8 Classroom.* Arlington, VA: NSTA Press, pp. 221-244.

Cherbow, K. and McNeill, K. L., 2022. Planning for student-driven discussions: A revelatory case of curricular sensemaking for epistemic agency,. *Journal of the Learning Sciences,* 31(3), pp. 408-457.

Chin, C. and Osborne, J., 2008. Students' questions: a potential resource for teaching and learning science. *Studies in science education,* 44(1), pp. 1-39.

Chinn, C. A. and Iordanou, K., 2023. Theories of learning. In: N. G. Lederman, D. L. Zeidler and J. S. Lederman, eds. *Handbook of Reasearch on Science Education vol. III.* NY: Routledge, pp. 89-102.

Cirkony, C., Tytler, R. and Hubber, P., 2022. Designing and delivering representation-focused science lessons in a digital learning environment. *Educational technology research and development ,* Volume 70, pp. 881-908.

Clarke, D. and Chan, M. C. E., 2019. The Uses of Video in Classroom Research: window, lens or mirror. In: L. Xu, G. Aranda, W. Widjaja and D. Clarke, eds. *Video-based Research in Education, Cross-disciplinary Perspectives.* London: Routledge, pp. 5-18.

Cobb, P. and Bowers, J., 1999. Cognitive and Situated Learning Perspectives in Theory and Practice. *Educational Researcher,* 28(2), pp. 4-15.

Cobb, P. et al., 2003. Design experiments in educational research. *Educational researcher,* 32(1), pp. 9-13.

Cobb, P. and Whitenack, J. W., 1996. A method for conducting longitudinal analyses of classroom videorecordings and transcripts. *Educational studies in mathematics,* 30(3), pp. 213-228.

Cochran-Smith, M. and Lytle, S. L., 1999. The Teacher Research Movement: A Decade Later. *Educational Researcher,* 28(7), pp. 15-25.

Cohen, L., Manion, L. and Morrison, K., 2017. *Planning educational research. Research methods in education.* 8 ed. London: Routledge.

Col, J., 2025. *Enchanted Learning, LLC..* [Online]
Available at: https://www.enchantedlearning.com/home.shtml
[Accessed 01 05 2025].

Collins, A., Joseph, D. and Bielaczyc, K., 2004. Design Research: Theoretical and Methodological Issues. *The Journal of the Learning Sciences,* 13(1), pp. 15-42.

Colombi, M. C. and Schleppegrell, M. J., 2002. Theory and practice in the development of advanced literacy. In: M. J. Schleppegrell and M. C. Colombi, eds. *Developing Advanced Literacy in First and Second Languages: Meaning with power.* NY: Routledge, pp. 1-19.

Condie, C. and Ippolito, J., 2016. Exploring Elementary Teachers' Experiences of Teaching Disciplinary Literacy. *Massachusetts Reading Association Primer,* 44(2), pp. 6-14.

Coyle, D., 2020. Exploring the Potential of a Pluriliteracies Approach. In: K. Bower, D. Coyle, R. Cross and G. N. Chambers, eds. *Curriculum Integrated Language Teaching: CLIL in Practice.* Cambridge: Cambridge University Press, pp. 187-204.

Coyle, D., et al. 2018. Knowledge ecology for conceptual growth: teachers as active agents in developing a pluriliteracies approach to teaching for learning (PTL). *International Journal of Bilingual Education and Bilingualism,* 21(3), pp. 349-365.

Coyle, D., Hood, P. and Marsh, D., 2010. *CLIL Content and Language Integrated Learning.* Cambridge: Cambridge University Press.

Coyle, D. and Meyer, O., 2021. *Beyond CLIL: Pluriliteracies Teaching for Deeper Learning.* Cambridge: Cambridge University Press.

Crosson, A. C., et al., 2019. Key Elements of Robust Vocabulary Instruction for Emergent Bilingual Adolescents. *Language, Speech, and Hearing Services in Schools,* 50(October), pp. 493-505.

Damşa , C. et al., 2010. Shared Epistemic Agency: An Empirical Study of an Emergent Construct. *The Journal of the Learning Sciences,* 19(2), pp. 143-186.

Damşa, C., 2014. The multi-layered nature of small-group learning: Productive interactions in object-oriented collaboration. *International Journal of Computer-Supported Collaborative Learning,* 9(3), pp. 247-281.

Damşa, C. and Muukkonen, H., 2020. Conceptualising pedagogical designs for learning through object-oriented collaboration in higher education. *Research Papers in Education,* 35(1), pp. 82-104.

Danish, J. A. and Gresalfi, M., 2018. Cognitive and Sociocultural Perspectives on Learning: Tensions and Synergy in the Learning Sciences. In: F. Fischer, C. E. Hmelo-Silver, S. R. Goldman and P. Reimann, eds. *International Handbook of the Learning Sciences.* NY: Routledge, pp. 34-43.

Data Research and Development Center, 2007. *Guidelines for Video Research in Education,* Chicago, IL: NORC at the University of Chicago.

Derry, S. J. et al., 2010. Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *Journal of the Learning Sciences,* 19(1), pp. 3-53.

diSessa, A. A., 2004. Metarepresentation: Native Competence and Targets for Instruction. *Cognition and Instruction,* 22(3), pp. 293-331.

diSessa, A. A. and Cobb, P., 2004. Ontological Innovation and the Role of Theory in Design Experiments. *The Journal of the Learning Sciences,* 13(1), pp. 77-103.

Dohn, N. B. and Spence, N., 2024. A situated perspective on the usefulness of design principles. In: I. F. Christensen, et al. eds. *Creating Design Knowledge in Educational Innovation.* NY: Routledge, pp. 24-36.

Driver, R. et al., 1994. Constructing Scientific Knowledge in the Classroom. *Educational Researcher,* 23(7), pp. 5-12.

Duke, N. K. and Cartwright, K. B., 2021. The Science of Reading Progresses: Communicating Advances Beyond the Simple View of Reading. *Reading Research Quarterly,* 56(S1), pp. S25-S44.

Duke, N. K. and Pearson, P. D., 2008/2009. Effective practices for developing reading comprehension. *The Journal of Education,* 189(1/2), pp. 107-122.

Duke, N. K., Pearson, P. D., Strachan, S. and Billman, A., 2011. Essential elements of fostering and teaching reading comprehension. In: S. J. Samuels and A. Farstrup, eds. *What research has to say about reading instruction, 4e.* Newark, DE: International Reading Association, pp. 51-93.

Duschl, R., 2008. Science education in three-part harmony: Balancing conceptual, epistemic, and social learning goals. *Review of research in education,* 32(1), pp. 268-291.

Edelson, D. C., 2002. Design Research: What We Learn When We Engage in Design. *Journal of the Learning Sciences,* 11(1), pp. 105-121.

Eerikäinen, L. M., 2015. *Notebooking with iPads – ELLs in science class and beyond.* Aberdeen: MEd dissertation, University of Aberdeen.

Emerson, R. M., Fretz, R. I. and Shaw, L. L., 2011. *Writing ethnographic fieldnotes.* 2nd ed. ed. Chicago, IL: University of Chicago Press.

Enchanted Learning, 1996. *Food Chain Trophic Levels.* [Online]
Available at: https://www.enchantedlearning.com/subjects/foodchain/trophiclevels/
[Accessed 15 01 2020].

Encyclopædia Britannica, 2020. *Thermodynamics - The first law of thermodynamics.* [Online]
Available at: https://www.britannica.com/science/thermodynamics/The-first-law-of-thermodynamics
[Accessed 19 02 2023].

Encyclopædia Britannica, 2022. *Energy Pyramid - Britannica School.* [Online]
Available at: https://school.eb.com/levels/middle/article/energy-pyramid/611153
[Accessed 20 09 2022].

Engeström, Y., 2022. Learning in Activity. In: R. K. Sawyer, ed. *The Cambridge Handbook of the Learning Sciences.* Cambridge: Cambridge Universits Press, pp. 134-155.

Engle, R. A., 2006. Framing Interactions to Foster Generative Learning: A Situative Explanation of Transferin a Community of Learners Classroom. *The Journal of the Learning Sciences,* 15(4), pp. 451-498.

Engle, R. A. and Conant, F. R., 2002. Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom. *Cognition and Instruction,* 20(4), pp. 399-483.

Engle, R. A., Lam, D. P., Meyer, X. S. and Nix, S. E., 2012. How Does Expansive Framing Promote Transfer? Several Proposed Explanations and a Research Agenda for Investigating Them. *Educational Psychologist,* 47(3), pp. 215-231.

Erickson, F., 1995. Ethnographic microanalysis. In: S. L. McKay and N. H. Hornberger, eds. *Sociolinguistics and Language Teaching.* Cambridge: Cambridge University Press, pp. 283-306.

Erickson, F., 2006. Definition and Analysis of Data from Videotape: Some Research Procedures and Their Rationales. In: J. L. Green, G. Camilli and P. B. Elmore, eds. *Handbook of complementary methods in education research.* Washington DC: Lawrence Erlbaum Publishers, pp. 177-191.

Erickson, F., 2012. Qualitative Research Methods for Science Education. In: B. J. Fraser, K. Tobin and C. McRobbie, eds. *Second International Handbook of Science Education.* s.l.:Springer, pp. 1451-1469.

Fang, Z. and Schleppegrell, M. J., 2010. Disciplinary Literacies Across Content Areas: Supporting Secondary Reading Through Functional Language Analysis. *Journal of Adolescent & Adult Literacy,* 53(7), pp. 587-597.

Fang, Z., Schleppegrell, M. J. and Cox, B. E., 2006. Understanding the Language Demands of Schooling: Nouns in Academic Registers. *Journal of Literacy Research,* 38(3), pp. 247-273.

Ferguson, J., et al., 2019. Video Research: Purposeful selection from rich data. In: L. Xu, G. Aranda, W. Widjaja and D. Clarke, eds. *Video-based Research in Education. Crosss-disciplinary Perspectives.* NY: Routledge, pp. 124-139.

Fiorella, L. and Kuhlmann, S., 2019. Creating Drawings Enhances Learning by Teaching. *Journal of Educational Psychology,* 112(4), pp. 811-822.

Fiorella, L. and Mayer, R. E., 2015. *Learning as a Generative Activity: Eight Learning Strategies that Promote Understanding.* Cambridge: Cambridge University Press.

Ford, M. J. and Forman, E., 2006. Redefining Disciplinary Learning in Classroom Contexts. *Review of Research in Education,* 30(1), pp. 1-32.

Galloway, E. P., McClain, J. B. and Uccelli, P., 2020. Broadening the lens on the science of reading: A multifaceted perspective on the role of academic language in text understanding. *Reading Research Quarterly,* Volume 55, pp. S331-S345.

Gee, J. P., 2004. Language in the Science Classroom: Academic Social Languages as the Heart of School-Based Literacy. In: E. W. Saul, ed. *Crossing borders in literacy and science instruction: Perspectives on theory and practice.* Arlington, VA: NSTA Press, pp. 13-32.

Gee, J. P., 2005. Language in the Science Classroom: Academic Social Languages as the Heart of School-Based Literacy. In: R. Yerrick and W. Roth, eds. *Establishing Scientific Classroom Discourse Communities: Multiple voices of teaching and learning research.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc., pp. 19-44.

Gee, J. P., 2008. What is Academic Language. In: A. S. Rosebery and B. Warren, eds. *Teaching Science to English Language Learners: Building on Students' Strengths.* s.l.:NSTA, pp. 57-70.

Gee, J. P. and Green, J. L., 1998. Discourse analysis, learning, and social practice: A methodological study. *Review of Research in Education,* 23(1), pp. 119-169.

Gibbons, P., 2003. Mediating language learning: Teacher interactions with ESL students in a content-based classroom. *TESOL Quarterly,* 37(2), pp. 247-273.

Gibbons, P., 2007. Mediating Academic Language Learning Through Classroom Discourse. In: J. Cummins and C. Davison, eds. *International Handbook of English Language Teaching. Springer International Handbooks of Education, vol 15.* Boston MA: Springer, pp. 701-718.

Gilbert, J. K., 2013. Representations and Models: Aspects of Scientific Literacy.. In: R. Tytler, V. Prain, P. Hubber & B. Waldrip, eds. *Constructing Representations to Learn in Science.* Rotterdam: Sense Publishers, pp. 193-198.

Goldman, S. R., 2018. Discourse of Learning and the Learning of Discourse. *Discourse Processes,* 55(5-6), pp. 434-453.

Goodwin, C., 2000. Action and embodiment within situated human interaction. *Journal of Pragmatics,* 32(10), pp. 1489-1522.

Google for Education, 2023. *Jamboard.* [Online]
Available at: https://jamboard.google.com/
[Accessed 2023].

Grabe, W. and Stoller, F. L., 2020. *Teaching and Researching Reading.* 3 ed. NY: Routledge.

Gravemeijer, K. and Cobb, P., 2013. Design Research from the Learning Design Perspective. In: T. Plomp and N. Nieveen, eds. *Educational design research Part A.* Enschede, NL: Netherlands Institute for Curriculum Development (SLO), pp. 73-111.

Gravemeijer, K. and Prediger, S., 2019. Topic-Specific Design Research: An Introduction. In: G. Kaiser and N. Presmeg, eds. *Compendium for Early Career Researchers in Mathematics Education.* Cham: Springer, pp. 33-57.

Green, J. L., et al., 2007. Epistemological issues in the analysis of video records: Interactional ethnography as a logic of inquiry. In: R. Goldman, R. Pea, B. Barron and S. J. Derry, eds. *Video research in the learning sciences.* NY: Routledge, pp. 115-132.

Green, J. L. et al., 2020. Studying the over-time construction of knowledge in educational settings: A microethnographic discourse analysis approach. *Review of Research in Education,* 44(1), pp. 161-194.

Green, J. and Bloome, D., 2013. Video Documentation and Analysis in Literacy Research. In: C. A. Chapelle, ed. *Encyclopedia of Applied Linguistics.* Oxford: Blackwell Publishing Ltd, pp. 1-6.

Green, J. L. and Castanheira, M. L., 2012. Exploring classroom life and student learning: An interactional ethnographic approach. In: B. Kaur, ed. *Understanding Teaching and Learning.* Rotterdam: Brill Sense Publishers, Inc., pp. 53-66.

Green, J. L. and Chian, M. M., 2018. Triangulation. In: B. B. Frey, ed. *The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation.* Thousand Oaks CA: SAGE Publications, Inc., pp. 1718-1720.

Green, J. L., Skukauskaitė, A. and Baker, W. D., 2012. Ethnography as Epistemology. In: J. Arthur, M. Waring, R. Coe and L. V. Hedges, eds. *Research Methods and Methodologies in Education.* London: Sage, pp. 309-321.

Greeno, J. G., 2005. Learning in Activity. In: R. K. Sawyer, ed. *The Cambridge Handbook of the Learning Sciences.* Cambridge: Cambridge University Press, pp. 79-96.

Greeno, J. G., 2011. A Situative Perspective on Cognition and Learning in Interaction. In: T. Koschmann, ed. *Theories of Learning and Studies of Instructional Practice.* Dordrecht: Springer, pp. 41-71.

Greeno, J. G. et al., 1999. *Considering Conceptual Growth as Change in Discourse Practices.* NY, Routledge, pp. 1-6.

Greeno, J. G., Collins, A. M. and Resnick, L. B., 1996. Cognition and learning. In: D. Berliner and R. Calfee, eds. *Handbook of Educational Psychology.* NY: Macmillam, pp. 15-46.

Greeno, J. G. and Engeström, Y., 2014. Learning in Activity. In: R. K. Sawyer, ed. *The Cambridge Handbook of the Learning Sciences (Cambridge Handbooks in Psychology).* Cambridge: Cambridge University Press, pp. 128-148.

Greeno, J. G. and Gresalfi, M. S., 2008. Opportunities to Learn in Practice and Identity. In: P. E. Moss, et al. eds. *Assessment, Equity, and Opportunity to Learn (Learning in Doing: Social, Cognitive and Computational Perspectives).* NY: Cambridge University Press, pp. 170-199.

Gumperz, J. J., 1992. Contextualization and understanding. In: A. Duranti, ed. *Rethinking context: Language as an interactive phenomenon*. Cambridge: Cambridge University Press.

Gumperz, J. J., 2001. Interactional Sociolinguistics: A Personal Perspective. In: D. Schiffrin, D. Tannen and H. E. Hamilton, eds. *The Handbook of Discourse Analysis.* NY: Blackwell Publishers Ltd., pp. 215-228.

Hammer, D., Elby, A., Scherr, R. E. and Redish, E. E., 2005. Resources, framing, and transfer. In: J. P. Mestre, ed. *Transfer of Learning from a Modern Multidisciplinary Perspective.* Greenwich, CT: Information Age Publishing, pp. 89-119.

Hammer, D., Goldberg, F. and Fargason, S., 2012. Responsive teaching and the beginnings of energy in a third grade classroom. *Review of science, mathematics and ICT education,* 6(1), pp. 51-72.

Hammersley, M. and Atkinson, P., 2019. *Ethnography: Principles in practice.* 4 ed. London: Routledge.

Hand, B. and Prain, V., 2002. Teachers implementing writing-to-learn strategies in junior secondary science: A case study. *Science Education,* 86(6), pp. 737-755.

Haug, B. S. and Ødegaard, M., 2014. From words to concepts: Focusing on word knowledge when teaching for conceptual understanding within an inquiry-based science setting. *Research in Science Education*, 44(5), pp. 777-800.

Heisey, N. and Kucan, L., 2010. Introducing science concepts to primary students through read-alouds: Interactions and multiple texts make the difference. *The Reading Teacher,* 63(8), pp. 666-676.

Heller, R. and Greenleaf, C., 2007. *Literacy instruction in the content areas: Getting to the core of middle and high school improvement.,* Washington, DC: Alliance for Excellent Education.

Hennessy, S., et al., 2021. An analysis of the forms of teacher-student dialogue that are the most productive for learning. *Language and Education,* 37(2), p. 186–211.

Hickey, D. and Lam, D., 2018. Evolving and Emerging Perspectives on the Transfer of Learning. In: *The Oxford Handbook of Educational Psychology, online edition.* s.l.:Oxford Academic.

Hickey, D. T., Chartrand, G. T. and Andrews, C. D., 2020. Expansive framing as pragmatic theory for online and hybrid instructional design. *Educational Technology Research and Development,* Volume 68, pp. 751-782.

Hoadley, C., 2012. What is a Community of Practice and How Can We Support It?. In: S. Land and D. Jonassen, eds. *Theoretical Foundations of Learning Environments.* New York(NY): Routledge, pp. 287-300.

Horizon 2023 Framework Programme of the European Union, 2024. *General Data Protection Regulation (GDPR) Compliance Guidelines.* [Online]
Available at: https://gdpr.eu/
[Accessed 26 10 2024].

Hubber, P., Tytler, R. and Haslam, F., 2010. Teaching and Learning about Force with a Representational Focus: Pedagogy and Teacher Change. *Research in Science Education,* Volume 40, pp. 5-28.

Hynd-Shanahan, C., 2013. What Does It Take? The challenge of disciplinary literacy. *Journal of Adolescent and Adult Literacy,* 57(2), pp. 93-98.

Ippolito, J. et al., 2017. Planting seeds: to grow science disciplinary literacy skills we must layer basic and intermediate literacy skills across K-12. *Massachusetts Reading Association Primer,* 45(2), pp. 14-23.

Irby, B. J. et al., 2018. Implementation of Research-based ESL Strategies with Lower Grade Middle School ELLs in the Science Classroom: Findings from an Experimental Study. *The Electronic Journal for English as a Second Language,* 22(1), pp. 1-26.

Jaber, L. Z. and Hammer, D., 2016. Engaging in Science: A Feeling for the Discipline. *Journal of the Learning Sciences,* 25(2), pp. 156-202.

Kachur, R. & Prendergast, C., 1997. A closer look at authentic interaction: Profiles of teacher-student talk in two classrooms. In: M. Nystrand, A. K. R. Gamoran & C. Prendergast, eds. *Opening Dialogue.* New York: Teachers College Press, pp. 75-88.

Kali, Y. and Hoadley, C., 2021. Design-Based Research Methods in CSCL: Calibrating our Epistemologies and Ontologies. In: U. Cress, C. Rosé, A. Wise and J. Oshima, eds. *International Handbook of Computer-Supported Collaborative Learning.* Cham: Springer, pp. 479-496.

Kelly, G. J., 2014. Analyzing classroom activities: Theoretical and methodological considerations. In: C. e. a. Bruguière, ed. *Topics and trends in current science education.* Dordrecht: Springer, pp. 353-368.

Kelly, G. J., 2017. Learning Science: Discourse Practices. In: S. Wortham, D. Kim and S. May, eds. *Discourse and Education.* Cham: Springer, pp. 223-237.

Kelly, G. J., 2023. Qualitative research as culture and practice. In: N. G. Lederman, D. L. Zeidler and L. J. S., eds. *Handbook of Research on Science Education, Volume III.* NY: Routledge, pp. 60-86.

Kelly, G. J., Brown, B. and Jiménez-Aleixandre, M. P., 2023. Discourse Practices in Science Learning. In: N. G. Lederman, D. L. Zeidler and J. S. Lederman, eds. *Handbook of Research on Science Education.* New York: Routledge, pp. 413-446.

Kelly, G. J. and Green, L. J., 2018. Framing Issues of Theory and Methods for the Study of Science and Engineering Education. In: G. J. Kelly and L. J. Green, eds. *Theory and Methods for Sociocultural Research in Science and Engineering Education.* New York: Routledge, pp. 1-28.

Kelly, G. J. and Licona, P., 2018. Epistemic Practices and Science Education. In: M. R. Matthews, ed. *History, Philosophy and Science Teaching. New Perspectives.* Cham: Springer, pp. 139-165.

Kennedy, B. L. and Thornberg, R., 2018. Deduction, Induction, and Abduction. In: U. Flick, ed. *The SAGE Handbook of Qualitative Data Collection.* London: Sage Publications, Inc., pp. 49-64.

Kennedy, M. M., 2007. Defining a Literature. *Educational Researcher,* 36(3), pp. 139-147.

Keys, C. W., 1999. Revitalizing instruction in scientific genres: Connecting knowledge production with writing to learn in science. *Science Education,* 83(2), pp. 115-130.

Kim, M.-Y. and Bloome, D., 2021. When Thinking Becomes a Topic of Classroom Conversations: Languaging Thinking Practices in a High School English Classroom. *Research in the Teaching of English,* 56(2), pp. 177-199.

Klentschy, M. P., 2006. Science Education in a No Child Left Behind, Standards-Based World. In: R. Douglas, M. P. Klentschy, K. Worth and W. Binder, eds. *Linking Science & Literacy in the K-8 Classroom.* Arlington, VA: NSTA Press, pp. 373-389.

Klentschy, M. P., 2010. *Using science notebooks in middle school.* Arlington, VA: NSTA Press.

Knain, E. et al., 2017. Representing to learn in science education: Theoretical framework and analytical approaches. *Acta Didactica Norge,* 11(3), pp. 1-22.

Kress, G., et al., 2001. *Multimodal Teaching and Learning. The rhetorics of the science classroom.* London: Continuum.

Lantolf, J. P., 2000. Second language learning as a mediated process. *Language Teaching,* 33(2), pp. 79-96.

Lapp, D., Fisher, D. and Grant, M., 2008. “You can read this text—I'll show you how”: Interactive comprehension instruction. *Journal of Adolescent & Adult Literacy,* 51(5), pp. 372-383.

Laufer, B., 2016. The Three "I"s of Second Language Vocabulary Learning. Input, Instruction, Involvement. In: E. Hinkel, ed. *Handbook of Research in Second Language Teaching and Learning vol. III.* New York: Routledge, pp. 343-354.

Laufer, B., 2017. Form word parts to full texts: Searching for effective methods of vocabulary learning. *Language Teaching Research,* 2(1), pp. 5-11.

Lea, M. R., 2015. Academic Literacies in Theory and Practice. In: B. Street and S. May, eds. *Literacies and Language Education. Encyclopedia of Language and Education.* Cham: Springer, pp. 1-12.

Lee, O. et al., 2019. Science and language integration with English learners: A conceptual framework guiding instructional materials development. *Science Education,* 103(2), pp. 317-337.

Lehrer, R. and Schauble, L., 2015. The Development of Scientific Thinking. In: L. Liben and U. Müller, eds. *Handbook of child psychology and developmental science: Cognitive processes 7e.* Hoboken NJ: John Wiley & Sons, Inc, pp. 671-714.

Lehrer, R. and Schauble, L., 2019. Learning to Play the Modeling Game. In: A. Upmeier zu Belzen, D. Krüger and J. van Driel, eds. *Towards a Competence-Based View on Models and Modeling in Science Education. Models and Modeling in Science Education, vol 12..* Cham: Springer, pp. 221-236.

Lemke, J. L., 1990. *Talking Science: Language, Learning and Values.* Norwood, NJ: Ablex Publishing Corporation.

Lennox, S., 2013. Interactive read-alouds—An avenue for enhancing children's language for thinking and understanding: A review of recent research. *Early Childhood Education Journal,* 41(5), pp. 381-389.

Li, J.-T., et al., 2021. The effects of four instructional strategies on English learners' English reading comprehension: A meta-analysis. *Language Teaching Research,* 28(1), pp. 231-252.

Li, W., 2018. Translanguaging as a Practical Theory of Language. *Applied Linguistics,* 39(1), pp. 9-30.

Linn, M. C., Bell, P. and Davis, E. A., 2004. Specific Design Principles: Elaborating the Scaffolded Integration Framework. In: M. C. Linn, P. Bell and E. A. Davis, eds. *Internet environments for science education.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc., pp. 315-340.

Littleton, K., Twiner, A. and Gillen, J., 2010. Instruction as orchestration: multimodal connection building with the interactive whiteboard. *Pedagogies: An International Journal,* 5(2), pp. 130-141.

Lobato, J., 2008. Research Methods for Alternative Approaches to Transfer. Implications for design experiments. In: A. E. Kelly, R. A. Lesh and J. Y. Baek, eds. *Handbook of design research methods in education: Innovations in science, technology, engineering, and mathematics learning and teaching.* NY: Routledge, pp. 167-194.

Magnusson, S. J. and Palincsar, A. S., 2004. Learning from text designed to model scientific thinking in inquiry-based instruction. In: E. W. Saul, ed. *Crossing borders in literacy and science instruction: Perspectives on theory and practice.* Arlington, VA: NSTA Press, pp. 316-339.

Marchessault, J. K. and Larwin, K. H., 2014. The Potential Impact of Structured Read-Aloud on Middle School Reading Achievement. *International Journal of Evaluation and Research in Education (IJERE),* 3(3), pp. 187-196.

McKenna, M. C. and Robinson, R. D., 1990. Content literacy: A definition and implications. *Journal of Reading,* 34(3), pp. 184-186.

McKenney, S. and Reeves, T. C., 2014. Educational design research. In: J. M. Spector, M. D. Merrill, J. Elen and M. Bishop, eds. *Handbook of research on educational communications and technology.* New York, NY: Springer, pp. 131-140.

McKenney, S. and Reeves, T. C., 2018. About educational design research. In: S. McKenney and T. C. Reeves, eds. *Conducting Educational Design Research, 2e.* London: Routledge, pp. 6-33.

McKeown, M. G., 2019. Effective Vocabulary Instruction Fosters Knowing Words, Using Words, and Understanding How Words Work. *Language, Speech, and Hearing Services in Schools,* 50(October), pp. 466-476.

McTigue, E. M. and Flowers, A. C., 211. Science visual literacy: Learners' perceptions and knowledge of diagrams. *The Reading Teacher,* 64(8), pp. 578-589.

Mercer, N., 1995. *The Guided Construction of Knowledge: Talk amongst teachers and learners.* Clevedon, UK: Multilingual Matters Ltd.

Mercer, N., 2004. Sociocultural discourse analysis: analysing classroom talk as a social mode of thinking. *Journal of applied linguistics,* 1(2), pp. 137-168.

Mercer, N., 2008. The Seeds of Time: Why Classroom Dialogue Needs a Temporal Analysis. *The Journal of the Learning Sciences,* 17(1), pp. 33-59.

Mercer, N., 2010. The analysis of classroom talk: Methods and methodologies. *British Journal of Educational Psychology,* 80(1), pp. 1-14.

Mercer, N., Hennessy, S. and Warwick, P., 2019. Dialogue, thinking together and digital technology in the classroom: Some educational implications of a continuing line of inquiry. *International Journal of Educational Research,* Volume 97, pp. 187-199.

Mercer, N. and Howe, C., 2012. Explaining the dialogic processes of teaching and learning: The value and. *Learning, Culture and Social Interaction,* 1(1), pp. 12-21.

Meyer, O. and Coyle, D., 2017. Pluriliteracies Teaching for Learning: conceptualizing progression for deeper learning in literacies development. *European Journal of Applied Linguistics,* 5(2), pp. 199-222.

Michaels, S. and O'Connor, C., 2015. Conceptualizing Talk Moves as Tools: Professional Development Approaches for Academically Productive Discussions. In: C. Asterhan, S. Clarke and L. Resnick, eds. *Socializing Intelligence Through Academic Talk and Dialogue.* Washington DC: American Educational Research Association, pp. 347-362.

Miller, E. et al., 2018. Addressing the epistemic elephant in the room: Epistemic agency and the next generation science standards. *Journal of Research in Science Teaching,* 55(7), pp. 1053-1075.

Miro, 2025. *Miro: Jamboard Alternative.* [Online]
Available at: https://miro.com/compare/jamboard-alternative/
[Accessed 30 1 2025].

Moje, E. B., 2008. Foregrounding the disciplines in secondary literacy teaching and learning: A call for change. *Journal of Adolescent & Adult Literacy,* 52(2), pp. 96-107.

Mondada, L., 2011. Understanding as an embodied, situated and sequential achievement in interaction. *Journal of Pragmatics,* Volume 43, pp. 542-552.

Moore, J. and Schleppegrell, M., 2014. Using a functional linguistics metalanguage to support academic language development in the English Language Arts. *The Role of Metalanguage in Supporting Academic Language Development,* Volume 26, pp. 92-105.

Moore, J., Schleppegrell, M. J. and Palincsar, A. S., 2018. Discovering Disciplinary Linguistic Knowledge With English Learners and Their Teachers: Applying Systemic Functional Linguistics Concepts Through Design-Based Research. *TESOL Quarterly,* 52(4), pp. 1022-1049.

Mortimer, E. F. and Wertsch, J. V., 2003. The Architecture and Dynamics of Intersubjectivity in Science Classrooms. *Mind, Culture and Activity,* 10(3), pp. 230-244.

Myhill, D. and Newman, R., 2016. Metatalk: Enabling metalinguistic discussion about writing. *International Journal of Educational Research,* 80(177-187).

Myhill, D. and Newman, R., 2019. Writing Talk: Developing metalinguistic understanding through dialogic teaching. In: N. Mercer, R. Wegerif and L. Major, eds. *The Routledge Handbook of Research on Dialogic Education.* NY: Routledge, pp. 360-372.

Myhill, D., Newman, R. and Watson, A., 2020. Going meta: Dialogic talk in the writing classroom. *Australian Journal of Language and Literacy,* 43(1), pp. 5-16.

Nagy, W. E. and Townsend, D., 2012. Words as tools: Learning academic vocabulary as language acquisition. *Reading Research Quarterly,* 47(1), pp. 91-108.

Nasir, S. N. et al., 2020. Learning pathways: How learning is culturally organized. In: S. N. Nasir, C. D. Lee, R. Pea and M. M. de Royston, eds. *Handbook of the cultural foundations of learning.* New York: Routledge, pp. 195-211.

National Academies of Sciences, Engineering, and Medicine, 2017. *Promoting the Educational Success of Children and Youth Learning English: Promising Futures,* Washington, DC: The National Academies Press.

Nation, P., 2020. The Different Aspects of Vocabulary Knowledge. In: S. Webb, ed. *The Routledge Handbook of Vocabulary Studies.* London: Routledge, pp. 15-28.

Norris, S. P. and Phillips, L. M., 2003. How Literacy in Its Fundamental Sense Is Central to Scientific Literacy. *Science Education,* 87(2), pp. 224-240.

O'Connor, C. and Michaels, S., 1993. Aligning academic task and participation status through revoicing: Analysis of a classroom discourse strategy. *Anthropology & Education Quarterly,* 24(4), pp. 318-335.

O'Connor, M. C. and Michaels, S., 1996. Shifting participant frameworks: orchestrating thinking practices in group discussion. In: D. Hicks, ed. *Discourse, Learning and Schooling.* NY: Cambridge University Press, pp. 63-103.

Oliveira, A. W. and Weinburgh, M. H., 2019. Using Commmunication Models to Teach ELLs Science. In: L. C. d. Oliveira, . K. M. Obenchain, R. H. Kenney and A. W. Oliveira, eds. *Teaching the Content Areas to English Language Learners in Secondary Schools.* Cham: Springer, pp. 247-261.

One Punch Manga Online, 2019. *One Punch Man ワンパンマン chapter 179 - One Punch Manga Online.* [Online]
Available at: https://1punchman-manga.com/manga/one-punch-man-chapter-179/
[Accessed 23 02 2023].

Osborne, J., 2002. Science without literacy: A ship without a sail?. *Cambridge Journal of Education,* 32(2), pp. 203-218.

Osborne, J., 2014. Teaching scientific practices: Meeting the challenge of change. *Journal of Science Teacher Education,* 25(2), pp. 177-196.

Oxford University Press, 2022. *Oxford Read and Discover.* [Online]
Available at: https://www.oxfordreadingclub.com/books/seriesDetail?cid=COLCORD
[Accessed 6 May 2022].

Paavola, S., Engeström, R. and Hakkarainen, K., 2012. The trialogical approach as a new form of mediation. In: A. Moen, A. I. Mørch and S. Paavola, eds. *Collaborative Knowledge Creation: Prctices, Tools Concepts.* Rotterdam: Sense Publishers, pp. 1-14.

Paavola, S. and Hakkarainen, K., 2005. The Knowledge Creation Metaphor – An Emergent Epistemological Approach to Learning. *Science & Education,* Volume 14, p. 535–557.

Paavola, S. and Hakkarainen, K., 2009. *From meaning making to joint construction of knowledge practices and artefacts – A trialogical approach to CSCL.* Rhodos, International Society of the Learning Sciences, pp. 83-92.

Paavola, S. and Hakkarainen, K., 2014. Trialogical Approach for Knowledge Creation. In: S. Tan, H. So and J. Yeo, eds. *Knowledge Creation in Education, Education Innovation Series.* Singapore: Springer Science+Business Media, pp. 53-73.

Paavola, S. and Hakkarainen, K., 2021. Trialogical Learning and Object-Oriented Collaboration. In: U. Cress, C. Rosé, A. Wise and O. J., eds. *International Handbook of Computer-Supported Collaborative Learning. Computer-Supported Collaborative Learning Series, vol 19.* Cham: Springer, pp. 241-259.

Paavola, S. et al., 2011. The roles and uses of design principles for developing the trialogical approach on learning. *Research in Learning Technology,* 19(3), pp. 233-246.

Paavola, S., Lipponen, L. and Hakkarainen, K., 2004. Models of Innovative Knowledge Communities and Three Metaphors of Learning. *Review of Educational Research,* 74(4), pp. 557-576.

Palincsar, A. S. and Magnusson, S. J., 2001. The interplay of first-hand and second-hand investigations to model and support the development of scientific knowledge and reasoning. In: S. M. Carver and D. Klahr, eds. *Cognition and instruction: Twenty-five years of progress. Papers presented at the 30th Carnegie Mellon Symposium on Cognition..* Mahwah, NJ: Lawrence Erlbaum Associates, pp. 151-194.

Parr, J. M. and Wilkinson, I., 2016. Widening the theoretical lens on talk and writing pedagogy. *International Journal of Educational Research,* Volume 80, pp. 217-225.

Pearson, P. D. and Billman, A. K., 2016. Reading to learn science: A right that extends to every reader—Expert or novice. In: Z. Babaci-Wilhite, ed. *Human Rights in Language and STEM Education: Science, Technology, Engineering and Mathematics.* Rotterdam: Sense Publishers, pp. 17-34.

Pearson, P. D. and Cervetti, G. N., 2015. Fifty Years of Reading Comprehension Theory and Practice. In: P. D. Pearson and E. H. Hiebert, eds. *Research-Based Practices for Teaching Common COre Literacy.* NY: Teacher's College, Columbia University, pp. 1-24.

Penn, J., 2011. *How to Stay Healthy.* Oxford: Oxford University Press.

Pierson, A. E. and Clark, D. B., 2019. Sedimentation of Modeling Practices. *Science & Education,* 28(8), p. 897–925.

Pierson, A. E., Clark, D. B. and Brady, C. E., 2020. Scientific modeling and translanguaging: A multilingualandmultimodal approach to support science learning and engagement. *Science Education,* 105(4), pp. 776-813.

Pierson, A. E., Clark, D. B. and Kelly, G. J., 2019. Learning Progressions and Science Practices. Tensions in Prioritizing Content, Epistemic Practices, and Social Dimensions of Learning. *Science & Education,* Volume 28, pp. 833-841.

Plomp, T., 2013. Educational Design Research: An Introduction. In: T. Plomp and N. Nieveen, eds. *Educational Design Research - Part A.* Enschede, NL: Netherlands Institute for Curriculum Development (SLO), pp. 11-50.

Powell, A. B., Franciso, J. and Maher, C. A., 2003. An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. *Journal of Mathematical Behavior,* 22(4), pp. 405-435.

Powell, M. B. and Gadke, D. L., 2018. Improving oral reading fluency in middle-school students: A comparison of repeated reading and listening passage preview. *Psychology in the Schools,* 55(10), pp. 1274-1288.

Prain, V. and Hand, B., 2016. Learning Science Through Learning to Use Its Languages. In: B. Hand, M. McDermott and V. Prain, eds. *Using Multimodal Representations to Support Learning in the Science Classroom.* Cham: Springer International Publishing, pp. 1-10.

Prain, V. and Tytler, R., 2012. Learning Through Constructing Representations in Science: A framework of representational construction affordances. *International Journal of Science Education,* 34(17), p. 2751–2773.

Prain, V., Xu, L. & Speldewinde, C., 2023. Guiding Science and Mathematics Learning when Students Construct Representations. *Research in Science Education,* Volume 53, pp. 445-461.

Proctor, C. P. et al., 2020. Shared knowledge netween reading and writing among middle school adolescent readers. *The Elementary School Journal,* 120(3), pp. 507-527.

Raphael, T. E., Kirschner, B. W. and Englert, C. S., 1988. Expository Writing Program: Making Connections between Reading and Writing. *The Reading Teacher,* 41(8), pp. 790-795.

Reichertz, J., 2014. Induction, Deduction, Abduction. In: U. Flick, ed. *The Sage Handbook of Qualitative Data Analysis.* London: Sage Publications, Inc., pp. 123-135.

Reimann, P., 2011. Design-Based Research. In: L. Markauskaite, P. Freebody & J. Irwin, eds. *Methodological Choice and Design: Scholarship, Policy and Practice in Social and Educational Research.* Heidelberg: Springer, pp. 37-50.

Reinhardtsen, J., Carlsen, M. and Säljö, R., 2015. *Capturing learning in classroom interaction in mathematics: Methodological considerations,.* Prague, CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education.

Resnick, L. B., Asterhan, C. C., Clarke, S. N. and Schantz, F., 2018. Next generation research in dialogic learning. In: G. E. Hall, L. F. Quinn and D. M. Gollnick, eds. *The Wiley handbook of teaching and learning.* Hoboken NJ: John Wiley & Sons, Inc., pp. 323-338.

Resnick, L. B., Michaels, S. and O'Connor, M. C., 2010. How (well structured) talk builds the mind. In: D. Preiss and R. Sternberg, eds. *Innovations in educational psychology: perspectives on learning, teaching, and human development.* NY: Springer, pp. 163-194.

Rojas-Drummond, S., 2019. A dialogic approach to understanding and promoting literacy practices in the primary classroom. In: N. Mercer, R. Wegerif and L. Major, eds. *The Routledge International Handbook of Research on Dialogic Education.* NY: Routledge, pp. 306-319.

Romance, N. R. and Vitale, M. R., 1992. A curriculum strategy that expands time for in-depth elementary science instruction by using science-based reading strategies: Effects of a year-long study in grade four. *Journal of Research in Science Teaching,* 29(6), pp. 545-554.

Romance, N. R. and Vitale, M. R., 2006. Science IDEAS: Making the Case for Integrating Reading and Writing in Elementary Science as a Key Element in School Reform. In: R. Douglas, M. P. Klentschy, K. Worth and W. Binder, eds. *Linking Science & Literacy in the K-8 Classroom.* Arlington, VA: NSTA Press, pp. 391-406.

Rossman, G. B. and Rallis, S. F., 2017. Analyzing and Interpreting Data. In: *An Introduction to Qualitative Research: Learning in the Field.* 4 ed. Thousand Oaks, CA: Sage Publications Inc., pp. 227-263.

Rothstein, S., 2023. *Alternatives to Google Jamboard.* [Online]
Available at: https://www.edutopia.org/article/replacements-for-google-jamboard/
[Accessed 1 6 2024].

Ruiz-Primo, M. A., et al., 2001. On the Validity of Cognitive Interpretations of Scores From Alternative Concept-Mapping Techniques. *Educational Assessment,* 7(2), pp. 99-141.

Sadler, T. D., 2009. Situated learning in science education:. *Studies in Science Education,* 45(1), pp. 1-42.

Säljö, R., 1998. Thinking with and through artifacts. In: D. Faulkner, K. Littleton and M. Woodhead, eds. *Learning Relationships in the Classroom.* London: Routledge, pp. 54-66.

Sandel, T. L., 2015. Rich Points. In: K. Tracy, C. Ilke & T. Sandel, eds. *The International Encyclopedia of Language and Social Interaction.* NY: John Wiley & Sons, Inc., pp. 1-5.

Sandoval, W., 2014. Conjecture Mapping: An Approach to Systematic Educational Design Research. *Journal of the Learning Sciences,* 23(1), pp. 18-36.

Santoro, L. E. et al., 2016. Using read-alouds to help struggling readers access and comprehend complex, informational text. *Teaching Exceptional Children,* 48(6), pp. 282-292.

Saul, E. W., 2004. Introduction. In: e. W. Saul, ed. *Crossing Borders in Literacy and Science Instruction.* Arlington, VA: National Science Teachers Association, pp. 1-9.

Sawyer, R. K., 2022. An Introduction to the Leaarning Sciences. In: R. K. Sawyer, ed. *The Cambridge Companion of the Learning Sciences.* Cambridge: Cambridge University Press, pp. 1-24.

Sawyer, R. K. and Greeno, J. G., 2008. Situativity and learning. In: P. Robbins and M. Aydede, eds. *The Cambridge Handbook of Situated Cognition (Cambridge Handbooks in Psychology).* Cambridge: Cambridge University Press., pp. 347 - 367.

Scardamalia, M., 2002. Collective Cognitive Responsibility for the Advancement of Knowledge. In: B. Smith, ed. *Liberal Education in a Knowledge Society.* Chicago: Open Court, pp. 67-98.

Scardamalia, M. & Bereiter, C., 1991. Higher Levels of Agency for Children in Knowledge Building: A Challenge for the Design of New Knowledge Media. *The Journal of the Learning Sciences,* 1(1), pp. 37-68.

Scardamalia, M. and Bereiter, C., 2014. Knowledge Building and Knowledge Creation: Theory, Pedagogy, and Technology. In: R. K. Sawyer, ed. *The Cambridge Handbook of the Learning Sciences.* NY: Cambridge University Press, pp. 397-417.

Scardamalia, M. & Bereiter, C., 2021. Knowledge Building: Advancing the State of Community Knowledge. In: U. Cress, C. Rosé, A. F. Wise & J. Oshima, eds. *International Handbook of Computer-Supported Collaborative Learning.* Cham: Springer, pp. 261-279.

Schleppegrell, M. J., 2004. *The language of schooling: A functional linguistics perspective.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Schleppegrell, M. J., 2013. The Role of Metalanguage in Supporting Academic Language Development. *Language Learning,* 63(March), pp. 153-170.

Scott, P., 1998. Teacher Talk and Meaning Making in Science Classrooms: a Vygotskian Analysis and Review. *Studies in Science Education,* 32(1), pp. 45-80.

Scott, P., 2008. Talking a Way to Understanding in Science Classrooms. In: N. Mercer and S. Hodgkinson, eds. *Exploring Talk in School.* London: SAGE Publications Ltd., pp. 17-36.

Scott, P. H., Mortimer, E. F. and Aguiar, O. G., 2006. The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science education,* 90(4), pp. 605-631.

Sfard, A., 1998. On Two Metaphors for Learning and the Dangers of Choosing Just One. *Educational Researcher,* 27(2), pp. 4-13.

Sfard, A., 2006. Participationist discourse on mathemstics learning. In: J. Maasz and W. Schloeglmann, eds. *New Mathematics Education Research and Practice.* Rotterdam: Sense Publishers, pp. 153-170.

Sfard, A., 2014. Metaphors for Learning. In: R. Gunstone, ed. *Encyclopedia of Science Education.* Dordrecht: Springer, pp. 634-638.

Shanahan, C. and Shanahan, T., 2014. Does disciplinary literacy have a place i elementary school?. *The Reading Teacher,* 67(8), p. 636–639.

Shanahan, T., 2013. Best Practices in Writing about Text. In: S. Graham, C. A. MacArthur and J. Fitzgerald, eds. *Best Practices in Writing Instruction 2e.* NY: The Guilford Press, pp. 334-350.

Shanahan, T. & Shanahan, C., 2008. Teaching Disciplinary Literacy to Adolescents: Rethinking Content-Area Literacy. *Harvard Educational Review,* 78(1), pp. 40-59.

Shanahan, T. and Shanahan, C., 2012. What is disciplinary literacy and why does it matter?. *Topics in Language Disorders,* 32(1), pp. 7-18.

Shanahan, T. and Shanahan, C., 2017. Disciplianry literacy: just the FAQs. *Educational Leadership,* 74(5), pp. 18-22.

Sherin, B. L. and Chinn, C. A., 2022. Microgenetic Methods. In: R. K. Sawyer, ed. *The Cambridge Handbook of the Learning Sciences.* Cambridge: Cambridge University Press, p. 217–237.

Sidnell, J., 2014. The architecture of intersubjectivity revisited. In: N.J. Enfield, P. Kockelman and J. Sidnell, eds. *The Cambridge Handbook of Linguistic Anthropology.* Cambridge: Cambridge University Press, pp. 364-399.

Sikorski, T.-R. and Hammer, D., 2017. Looking for coherence in science curriculum. *Science Education,* Volume 101, pp. 929-943.

Skinner, K., 2022. Anchoring Analysis in Rich Points. In: A. Skukauskaitė and J. L. Green, eds. *Interactional Ethnography: Designing and Conducting Discourse-Based Ethnographic Research.* New York: Routledge, pp. 242-265.

Skukauskaitė, A. & Green, J. L., 2022. Ethnographic Spaces of Possibilities: Interactional Ethnography in Focus. In: A. Skukauskaite & J. L. Green, eds. *Interactional Ethnography: Designing and Conducting Discourse-Based Ethnographic Research.* New York: Routledge, pp. 1-18.

Smolkin, L. B. and Donovan, C. A., 2003. Supporting comprehension acquisition for emerging and struggling readers: The interactive information book read-aloud. *Exceptionality,* 11(1), pp. 25-38.

Spence, N., 2025. Creating design principles from research, experience and literature. In: I. F. Christensen, et al. eds. *Creating Design Knowledge in Educational Innovation. Theory, Methods and Practice.* NY: Routledge, pp. 110-122.

Spilsbury, L. and Spilsbury, R., 2011. *Oxford Read and Discover Level 6 Incredible Energy.* Oxford: Oxford University Press.

Stoller, F. L., Anderson, N. J., Grabe, W. and Komiyama, R., 2013. Instructional Enhancements to Improve Students' Reading Abilities. *English Teaching Forum,* 51(1), pp. 2-33.

Street, B. V., 2017. New Literacies, New Times: Developments in Literacy Studies. In: B. Street and S. May, eds. *Literacies and Language Education. Encyclopedia of Language and Education.* Cham: Springer, pp. 3-15.

Sutton, C. R., 1992. *Words, Science and Learning.* Buckingham: Open University Press.

Swain, M. and Lapkin, S., 2001. Focus on form through collaborative dialogue: Exploring task effects. In: M. Bygate, P. Skehan and M. Swain, eds. *Researching Pedagogic Tasks. Second Language Learning, Teaching and Testing.* NY: Routledge, pp. 99-118.

Tai, K. W., Li, W. and Loh, E. K. Y., 2025. Enhancing students' content and language development: Implications for researching multilingualism in CLIL classroom context. *Learning and Instruction,* 96(April), pp. 1-7.

Teachers Network, 2020. *Ocean food web activity.* [Online]
Available at: http://teachersnetwork.org/teachnet-lab/glasgold/food_chain/ocean%20food%20chain%20resources.htm
[Accessed 01 01 2020].

Thompson, J. et al., 2016. Rigor and Responsiveness in Classroom Activity. *Teachers College Record,* 118(May), pp. 1-58.

Thomson, A. and Martinet, A., 1980. *A Practical English Grammar.* 3 ed. Oxford: Oxford University Press.

Tippett, C. D., 2016. What recent research on diagrams suggests about learning with rather than learning from visual representations in science. *International Journal of Science Education,* 38(5), pp. 725-746.

Tools for Schools, I., 2023. *Book Creator - Love learning Book Creator app.* [Online]
Available at: https://bookcreator.com/
[Accessed 04 07 2023].

Tracy, S. J., 2013. *Qualitative Research Methods: Collecting Evidence, Crafting Analysis, Communicating Impact.* 1 ed. Hoboken NJ: Wiley Blackwell.

Tytler, R. and Hubber, P., 2016. Constructing Representations to Learn Science. In: B. Hand, M. McDermott and V. Prain, eds. *Using Multimodal Representations to Support Learning in the Science Classroom.* Cham: Springer, pp. 159-181.

Tytler, R. et al., 2020. Drawing to reason and learn in science. *Journal of Research in Science Teaching,* 57(2), pp. 209-231.

U.S.: Energy Information Administration, 2020. *Coal: Energy Kids.* [Online]
Available at: https://www.eia.gov/kids/energy-sources/coal/
[Accessed 2020].

Van den Akker, J., et al., 2006. *Educational Design Research.* London: Routledge.

van Lier, L., 2008. The ecology of language learning and sociocultural theory. In: A. Creese, P. Martin and N. H. Hornberger, eds. *Encyclopedia of Language and Education.* Boston, MA: Springer, pp. 53-65.

Van Zoest, L. R. et al., 2021. Conceptualizing important facets of teacher responses to student mathematical thinking. *International Journal of Mathematical Education in Science and Technology,* 53(10), pp. 2583-2608.

Varelas, M. and Pappas, C. C., 2006. Intertextuality in Read-Alouds of Integrated Science-Literacy Units in Urban Primary Classrooms: Opportunities for the Development of Thought and Language. *Cognition and Instruction,* 24(2), pp. 211-259.

Varelas, M. et al., 2014. How Science Texts and Hands-On Explorations Facilitate Meaning Making: Learning From Latina/o Third Graders. *Journal of Research in Science Teaching,* 51(10), p. 1246–1274.

Wallace, C., Hand, B. and Yang, E., 2004. The Science Writing Heuristic: Using Writing as a Tool for Learning in the Laboratory. In: E. W. Saul, ed. *Crossing Borders in Literacy and Science Instruction: perspectives on theory and practice.* Arlington, VA: NSTA Press, pp. 355-367.

Webb, N. M. et al., 2014. Engaging with others' mathematical ideas: Interrelationships among student participation, teachers' instructional practices, and learning. *International Journal of Educational Research,* Volume 63, pp. 79-93.

Webb, P. and Whitlow, J. W., 2019. Merging Cognitive and Sociocultural Approaches: Toward Better Understandings of the Processes of Developing Thinking and Reasoning. In: V. Prain and B. Hand, eds. *Theorizing the Future of Science Education Research.* Cham: Springer, pp. 11-28.

Webb, S., Yanagisawa, A. and Uchihara, T., 2020. How Effective Are Intentional Vocabulary-Learning Activities? A Meta-Analysis. *The Modern Language Journal,* 104(4), pp. 715-738.

Wellington, J. and Osborne, J., 2001. *Language and literacy in science education.* Buckingham, UK: Open University Press.

Wells, G. C., 1999. *Dialogic inquiry. Towards a sociocultural practice and theory of education.* Cambridge: Cambridge University Press.

Wertsch, J. V., 1985. Semiotic Mechanisms in Vygotsky's Genetic Law of Cultural Development. In: *Vygotsky and the social formation of mind Vygotsky's Genetic Law of Cultural Development.* Cambridge MA: Harvard University Press, pp. 158-183.

Wertsch, J. V., 1997. *Mind as Action.* Oxford: Oxford University Press.

Wertsch, J. V. & Addison-Stone, C., 1985. The concept of internalization in Vygotsky's account of the genesis of higher mental processes. In: J. V. Wertsch, ed. *Culture, Communication and Cognition: Vygotskyan Perspectives.* NY: Cambridge University Press, pp. 162-179.

Wertsch, J. V. and Kazak, S., 2005. Intersubjectivity through the mastery of semiotic means in teacher-student discourse. *Research and Clinical Center for Child Development Annual Report,* 27(3), pp. 1-11.

Wozniak, H., 2015. Conjecture mapping to optimize the educational design research process. *Australasian Journal of Educational Technology,* 31(5), pp. 597-612.

Wright, T. S. and Gotwals, A. W., 2017. Supporting disciplinary talk from the start of school: Teaching students to think and talk like scientists. *The Reading Teacher,* 71(2), pp. 189-197.

Yore, L. D., 2000. Enhancing Science Literacy for All Students With Embedded Reading Instruction and Writing-to-Learn Activities. *Journal of deaf studies and deaf education,* 5(1), pp. 105-122.

Yore, L. D., Bisanz, G. L. and Hand, B. M., 2003. Examining the literacy component of science literacy: 25 years of language arts and science research. *International journal of science education,* 25(6), pp. 689-725.

Yore, L. D. et al., 2004. New directions in language and science education research. *Reading Research Quarterly,* 39(3), pp. 347-352.

Appendix A

Transcripts

Notes on transcripts

The transcription processes applied in this study were used to prepare transcripts as artifacts, constructed through microethnographic research processes (Green and Bloome, 2013).

The transcripts include indications of gestures and pauses, as well as gaze direction and other interaction, which presents the situated meaning of the interaction from the insider perspective (Hammersley and Atkinson, 2019). Participants' ways of speaking and pronouncing are not changed; that is, utterances that appear to contain grammar and pronunciation mistakes are not corrected.

Multimodal transcription techniques (Bezemer and Mavers, 2011) are applied as follows

- yellow highlight denotes key discourse moves: meta-talk
- **Rich Points** are indicated in the Annotation column, and actively linked (i.e. hyperlinked) to the Design Narrative
- hyperlinks are provided to screenshots of the specific moment, which are shown in the Design Narrative as figures. These figures in also link back to the relevant transcript turn.
- blue highlights are used to indicate a sequence of interaction used as an excerpt in the Design Narrative, with a hyperlink to this point in the narrative.

Transcripts – Iteration I Farming

LIST OF TRANSCRIPTS – ITERATION I

I farming - transcript 1 – 2019-09-25 chapter 2 crops Meta-talk and languaging: noticing *humanities book words* Episode 3 401

I farming - transcript 2 – 2019-10-14 chapter 4 Meta-talk and languaging: overwriting and rewriting steps – edited, abridged. Episode 5 405

I farming - transcript 3 – 2019-10-14 chapter 4 Meta-talk and languaging: rewriting steps concluding segment of lesson. Episode 5 410

I farming - transcript 1 – 2019-09-25 chapter 2 crops Meta-talk and languaging: noticing *humanities book words* Episode 3

turn	Timespan	2019-09-25 chapter 2 crops – noticing *humanities book words* Episode 3 See notes on transcription conventions	Speaker	Annotations
1	0:00.2 - 0:00.8	Tell me that again (T adjusting the iPad to begin filming) excerpt 1	Teacher	meta-talk
2	0:02.4 - 0:13.8	is, you know, another word for the "water" like in "cool" is *temperate* and the "hot" is *tropical*.	Ruslan	meta-talk and EW Rich Point
3	0:16.7 - 0:22.3	hmm, so you really feel that, the, it should be, it should be…	Teacher	meta-talk
4	0:22.4 - 0:28.8	something, there's another humanity word for the "water". figure 7	Ruslan	meta-talk
5	0:29.1 - 0:32.7	Mm hmm. How did you get that feeling?	Teacher	meta-talk
6	0:34.2 - 0:37.1	'cause hmm there is 'cause there is a (pointing to the page and the sentence with his pen) figure 8	Ruslan	Rich Point
7	0:41.1 - 0:42.6	the word, "good" (pointing to the anchor text)	Teacher	
8	0:45.5 - 0:54.1	"Good", and um uh, from "hot" and "cold", I forget if I just there is like	Ruslan	
9	0:54.5 - 0:55.3	so many words.	Teacher	
10	0:55.5 - 0:59.5	Yeah, I think there's something for the "water".	Ruslan	meta-talk
11	1:01.6 - 1:03.9	There should be. There should be.	Teacher	
12	1:04.5 - 1:05.2	But there's no.	Ruslan	
13	1:05.5 - 1:48.2	Yes, there is. Yes, there is absolutely a great point. A great point. So now I'm just going to keep this here. (looking at the anchor text) I'm just going to keep this here for now good. I'm just going to keep this here for now, and we're going to look at this water. We're going to learn the word what the farmer says for water. The water says, the farmer says. *Irrigation*. Did you ever hear that?	Teacher	meta-talk
14	1:48.8 - 1:49.1	Yeah,	Ryu	
15	1:50.0 - 2:41.4	I think I did. Brilliant. So The water here here is a farmer (pointing to the illustration) he made he made this so that the plant can be properly you know the word properly, right, properly or appropriately. It's very close. Properly not "in lots of water", but *irrigate*. It sounds very complicated, but you could sense. OK, so. *Irrigation* can we write and *appropriate soil*	Teacher	epistemic work
16	2:43.1 - 2:44.2	a lot of words	Ryu	

17	2:44.8 - 3:48.6	could. Yes. So can you write this word, (speaking to Ruslan, going to the word wall) In our little word wall over there, so let's remove it. (erasing some words from the word wall) Let's remove some of these words, and let's put it this way. *Irrigation*. So now you can take a green pen here for our science words. There you go. You can take the paper, take the paper with you, You could take the paper. So did you notice what you noticed? Let's exchange.(speaking to Ryu and Quincy) Let's compare. Compare now. Move over here. Move closer to me. You know you can move your chair. Good. Now let's compare what they can find or compare. What did you find? *Irrigation*. (in Russian, what more). Let's read all the other important words. How about *suitable climate, suitable climate*	Teacher	meta-talk
18	3:49.6 - 4:02.8	and. In fact, it's like, no, no, it's not. You don't think so.	Ryu	
19	4:03.8 - 4:17.9	Yeah, OK, we in this in the *temperate* zone and in a *temperate climate*. Yeah, you need one or the other, but not both. The temperate zone is the place. The place on our planet,	Teacher	
20	4:18.8 - 4:19.3	no but I need a	Quincy	
21	4:20.5 - 4:26.4	Oh, I didn't see it. I didn't see. He has a point. He has a point.	Teacher	
22	4:29.7 - 4:31.0	Yeah, it was a very close.	Quincy	
23	4:31.0 - 5:01.8	I didn't quite see, I didn't quite see. All right. All right. What else? What else did you notice? (looking at students writing) Oh, can you write it grows? I think that um. hm. Brilliant, brilliant. What else should we write in our word wall? Do you want to write some more words you want to write over there? Well, here's the green pen.	Teacher	meta-talk
24	5:02.0 - 5:07.8	What is the word for it? I want a word for “a lot”, ”a lot”.	Quincy	meta-talk
25	5:08.8 - 5:10.4	A lot ? Is that not humanities?	Teacher	meta-talk
26	5:15.0 - 5:15.1	Can we	Ryu	
27	5:15.1 - 5:18.6	Please go ahead. (indicating Ryu) Oh, so you remember we talked about it?	Teacher	connection
28	5:19.2 - 5:19.4	Yeah.	Ryu	
29	5:20.5 - 5:28.5	Oh oh, lots. That doesn't sound like it is in this book does it. What do you think, Quincy?	Teacher	meta-talk
30	5:29.3 - 5:29.4	No,	Quincy	
31	5:29.7 - 5:41.9	not really. “A lot”. Yeah, I like a lot of different things in the cafeteria. Yeah, that's not the very humanities. What do you think it should be?	Teacher	meta-talk
32	5:46.5 - 5:46.6	It should be	Ryu	
33	5:46.6 - 5:53.1	We're just in lots of water. Oops. So this one here, are you talking about that? Lots of	Teacher	meta-talk
34	5:53.1 - 5:53.6	yeah and also.	Ryu	
35	5:56.2 - 6:03.3	What is another word for “lots of water” in the book it will be the	Teacher	meta-talk

36	6:03.3 - 6:04.0	the first	Ryu	
37	6:07.0 - 6:50.2	*abundant abundant*. Did you hear the word *abundant*? So now we're going to write that. Have one *appropriate* I'll help you *appropriate*. Now I'm going to write the word *abundant irrigation*. Good. *Rice needs to*, move your move your body over, move your move your body over	Teacher	languaging
38	6:50.3 - 6:50.8	*terraces irrigation*. excerpt 2	Ryu	meta-talk and EW
39	6:52.8 - 7:12.9	Yes, terraces, and so *rice needs abundant irrigation*. Do you hear how that sounds like a textbook that sounds like a textbook, doesn't it?	Teacher	connection and evaluation
40	7:13.3 - 7:13.8	Yeah.	Ryu	
41	7:15.3 - 7:36.8	*Abundant*. And the advantage is, children, it's the same word in French. Let me tell you then, *irrigation* (pronouncing in French)	Teacher	connection translanguaging
42	7:38.0 - 7:41.7	I hear a lot of time and then was going to French (the French lesson) I hear it a lot of times (speaking excitedly)	Ruslan	connection
43	7:44.6 - 7:45.2	*abondante* (pronouncing in French)	Teacher	translanguaging
44	7:47.4 - 7:48.2	I heared those.	Ruslan	
45	7:51.0 - 8:09.0	So this is the advantage, the book words are the same English and French most very, many times, very many times. Thank you. You are right, not 100 percent, but a lot.	Teacher	
46	8:10.3 - 8:11.4	And I think there is *humanities book words*	Ryu	epistemic work
47	8:15.6 - 8:30.6	correct, correct. We'll get to that. We'll get to that, let's stick to this, because now we've learned that we've used a lot of words. Do you think you've learned them?	Teacher	evaluation
48	8:30.9 - 8:31.5	Yes.	students	
49	8:31.8 - 8:39.1	And what makes you think you have really learned them? How do you feel about how do you feel about? Yes, (indicating student)	Teacher	epistemic work
50	8:41.3 - 8:58.6	because how we know it is, it's kind of like lots of letters but the book word, because we underline the word that's not a book word and we, the book word, we put above it.	Quincy	evaluation
51	8:59.6 - 9:00.0	Yeah. and also...	Ryu	
52	9:00.1 - 9:06.0	And so you feel so you feel calm, you feel that you feel confident that you	Teacher	epistemic work
53	9:06.8 - 9:12.9	because I know that it means a lot of water, well, in a word.	Quincy	meta-talk
54	9:15.3 - 9:19.0	Is that, does that make sense to you? Do you agree with that? Do you agree with that?	Teacher	invite epistemic work
55	9:19.3 - 9:31.5	Yeah. And also, you know, just like, you know, just like it seems like a lot of times to remember, we're also writing and we're correcting it to remember more.	Ruslan	epistemic work

56	9:34.0 - 10:38.6	Totally, boys. You really have it. You really have. This is it. This was it. This is what we're doing in this lesson. Yeah. And in your beautiful book creator, you're going to use these things because we're going to learn about farmers in different parts of the world .... You can go and see this today, and you can talk about it, you can read about it when you're going to read all of this. You will get it.	Teacher	meta-talk
57	10:40.6 - 10:40.8	Yes.	Ryu	
58	10:42.3 - 11:09.6	OK, so you see our goal, and I think you understand how we're working really, really well, I'm really impressed and really, really impressed. Great stuff. There's only one thing here is only one thing. Would you please these questions where it says the questions? You see how the example shows answer with a complete sentence. Can you please answer (in Russian: complete sentence) Yes, dear. (Ruslan wishes to speak)	Teacher	meta-talk
59	11:10.8 - 11:11.3	Can I ask you a question, What is the humanities word for "grow"	Ruslan	meta-talk
60	11:16.0 - 11:16.4	"where does wheat grow"	Teacher	
61	11:17.2 - 11:17.3	and also bananas	Ruslan	
62	11:17.3 - 11:39.2	brilliant, brilliant. We're going to use the word *production. Where does wheat production happen*	Teacher	meta-talk, languaging
63	11:39.8 - 11:39.9	or *produced*	Ruslan	languaging; epistemic work
64	11:41.0 - 11:58.4	*Where is wheat produced?* Brilliant. So please underline the word "grow" and then you can say, *where is wheat produced?* And let's do that	Teacher	meta-talk, languaging
65	12:01.5 - 12:01.7	*grows,* instead	Ryu	meta-talk
66	12:01.7 - 12:20.7	instead of where it says "grows", we're going to say where and then we can't we can't say, does, where is instead of does. We're going to find that in the humanities and science they don't use the word does so much. Yeah,	Teacher	
67	12:21.9 - 12:28.1	*produced in tropical climates*.	Ryu	languaging; epistemic work
68	12:28.6 - 12:52.1	Absolutely. Absolutely. OK. Maybe that's enough for now, because I think Ryu wants to show us his beautiful machine. (Ryu has brought his new laptop in to class) Do you want to log on to the machine? I will show you. I guess, yeah, yeah. So open it, please open your machine. Log on, please.	Teacher	

I farming - transcript 2 – 2019-10-14 chapter 4 Meta-talk and languaging: overwriting and rewriting steps – edited, abridged. Episode 5

turn	Timespan	2019-10-14 chapter 4 overwriting and rewriting steps – edited, abridged Episode 5	Speaker	annotations
40	7:47.5 - 8:28.5	otherwise and they and well done, well done children. So now, children, let's put some more. First of all, "lots of" we already know that. Please add some of the things that we know already to fix the silly, some of the silly words, please. And then we're going to add some more because obviously the word "cattle", It turns out and that's not what it's going to be in our green book (the social studies textbook) and here it will not be in our beautiful book. We're going to read a little later.	Teacher	meta-talk
41	8:30.8 - 8:31.0	"machines" excerpt 3	Ryu	meta-talk
42	8:31.0 - 8:33.6	First of all, "machines", (indicating student) go ahead, go ahead. Yeah.	Teacher	meta-talk
43	8:33.6 - 8:33.8	*equipment*	Ryu	meta-talk
44	8:33.8 - 9:57.2	Good, say, ... Ready. What other words, do we need to change to get closer to the social studies textbook? aah (noticing student glancing at the word wall) And one person is looking at the word wall , you are looking at the word wall. Huh. Hmm.... What is it supposed to be? "Machines",	Teacher	meta-talk
45	9:57.7 - 9:57.9	*equipment*	students	meta-talk
46	9:58.1 - 10:03.3	*equipment*? OK. OK. Anything else	Teacher	
47	10:04.7 - 10:05.5	I think I have one ideas	Ryu	meta-talk
48	10:05.8 - 10:06.4	What is it?	Teacher	
49	10:07.1 - 10:11.0	So you can maybe draw a picture to say.	Ryu	epistemic work
50	10:12.4 - 10:17.0	We could add more, add more illustrations, we could add more illustrations.	Teacher	
51	10:17.8 - 10:18.1	I wrote it,	Ryu	
52	10:18.1 - 10:34.2	Good, good, good, good. But first, yes, don't tell me that. (about drawing) Don't tell me about, tell me instead, please, what *word* (emphasizing) we should use. What other word you wrote. One more word instead of "make". Every time you see the word, "make", it's...	Teacher	
53	10:34.6 - 10:34.8	*produce*	students	meta-talk
54	10:34.8 - 11:03.7	In this case, it could be *produced*. Yes. We also *produce*. But then we can't say we also make milk into cheese. So, dear children. Over the word, "make", you're going to write the word *produce*. But now if we read the sentence, it doesn't sound so right. We drew it, OK. "We also produce milk into cheese." Does that sound right?	Teacher	meta-talk
55	11:04.6 - 11:04.7	No,	students	

56	11:05.0 - 11:55.4	not quite so, not quite, please, students, just like you did here. Remember, here we have already, figure 15 (holding up Quincy's whiteboard with sentence work, written in figure 11) I didn't erase because this is important. Here we had *how do fertilizers assist crops to grow?* Yeah, OK. *How is cotton produced* remember that. And *how is a sugar produced?* Remember that. So let's use this to help us fix this sentence. Can you please fix the sentence?	Teacher	meta-talk
57	11:56.0 - 11:56.4	Yes,	Ruslan	
58	11:56.5 - 12:39.8	....So now here is *how is cotton produced*" So you see. Here, the key point is children. This is different than "how do we produce cotton?" Do you see a key word that is missing here? We. The word we is not here with us or the farmer.	Teacher	meta-talk
59	12:39.9 - 12:43.1	How are we using cotton?	Quincy	
60	12:45.0 - 13:19.8	But not, this is the correct sentence, this is the correct sentence, *how is cotton produced*. We don't see the word "farmer" anymore. We don't want it. We don't see the word "we" anymore. We don't want it. We know it was the farmer, don't need to add that. So now look at this example, look at this example, see how you can fix about the milk. And the cheese and yogurt. See how you can do it. See,	Teacher	meta-talk
62	13:21.9 - 16:08.9	....Go back to chapter the chapter one, that had stuff that had this draft. This was a bad example. Go back to chapter one with the with the sugar cane. Remember the sugar cane example?	Teacher	meta-talk
63	16:10.5 - 16:11.3	Chapter two.	Ryu	
64	16:13.2 - 16:49.4	Now, sugar cane example. Find the Chapter two with the sugar cane example. Find the Chapter two with the sugar cane example. That's the introduction. Here	Teacher	
65	16:49.4 - 16:49.5	here it is	Quincy	
66	16:58.1 - 17:34.2	today we're going to learn the strategy. So what does it say? Repeat, say,	Teacher	
67	17:34.2 - 17:48.6	a lot of sugar is produced. a crop called sugar cane from from crop called sugar cane. Oh yeah. Yes. Yeah. Underline that.	Quincy	meta-talk
68	17:48.8 - 18:58.6	Yes, *is produced from* because you had underlined it was good. So how can you make that the same? How can you do the same work in Chapter four? And cheese. So what do you think when you stop? No, no, no. You're changing it too much. You rewrite this. And what what is that supposed to be, what word is that supposed to be? So you don't need that, don't need that, because that's not here. Just rewrite this. See if you can do it and then I'll help you. See if you can do it because we want, "is produced". write it here, you're trying to do it here, not over there, but here.	Teacher	meta-talk
69	19:10.0 - 19:10.3	So here,	Quincy	
70	19:10.3 - 22:44.3	... We're going to write. *Writing the humanities sentence*. (writing on the board) Please write this little title like this. Good. You put a little arrow. Put a little arrow like this, please. Good, and then you write this subtitle reading writing the humanities sentence, please. First of all we're going to write some steps. Now, I'm going to use this colour, step 1 you're going to write. Are you OK?	Teacher	meta-talk

71	22:48.2 - 22:48.4	do I write humanities writing	Quincy	
72	22:48.4 - 23:21.5	*writing the humanities sentence*, good, and you take a different colour. Now, it can be this, it can be purple, purple. Now you take a different colour and write , the step one here in the margin. There, so now you write, Step one	Teacher	
73	23:22.6 - 23:22.8	can I use this.	Ryu	
74	23:22.7 - 28:26.0	ah sure. OK, here. ... So now honey now I want you to write the first step, which is we we're going to write it like this. We can make this right. Please, can I please? Yes, it's wrong. But we have to learn how to do it so we make milk into. Let's write this sentence here. First of all, “we make milk into cheese”. Let's write this, please. … So then you skip a space. Can you write Step two here, you know, with the purple here, the purple pen, because then you skip a line and you write Step two. Good, step two step two. Yes, dear. Yes, they're beautiful, I really like those pens. So, step two. And here is where. We go like this. And you write use. You write it properly. Oh, no. See what I did. Can you please do this? step two . Yes. And this word for “you”. (writing the null symbol and indicating it) Does anyone know what this means?	Teacher	
75	28:28.0 - 28:28.5	Nothing.	Ryu	
76	28:29.4 - 28:37.6	That's right. It is the real, the real symbol for nothing. This means you don't nothing. That's right.	Teacher	
77	28:38.7 - 28:41.9	So you you write you write that next to the sentence.	Ryu	meta-talk
78	28:54.2 - 29:58.7	This side. No, I mean, I'm so I'm sorry. So here, where does the produce and goes underneath the word make? OK. Take a different colour to show it. Pick a different colour to really see how. So now what am I doing here, really? I have the word make here. Can you see, my honey? So I have the word make your I underlined it right? I underlined it because I'm going to change it. That's my step two, my step two. I'm going to underline and change. Yes. So I just put it here to show how I change this word. But I can also change with what I take away. I can take it away. That's another thing. Yes.	Teacher	
79	29:58.7 - 30:00.2	And also you can add	Ryu	meta-talk
80	30:00.2 - 30:57.2	and I can add a word, and that's what I want to do. You are right. You are right, in my step three. I am going to add. Good. Now you write step three here, please. So there is a more there's more and more, can we do it, please? Are you doing it? I can. All right. Is it OK? Did you do it? That's good. Now I'm going to start with, Milk.	Teacher	
81	31:12.9 - 31:14.5	Oh, dear. I'm sorry.	Teacher	
82	31:14.9 - 31:15.4	Yeah, underline *the milk* and bring it	Ryu	meta-talk
83	31:17.4 - 32:22.5	....so what did we have we had *Sugar is produced from sugar cane*, and you're going to put yellow on *is*.	Teacher	
84	32:25.0 - 32:26.9	Yellow. Yellow.	students	
85	32:26.9 - 32:40.8	Yeah. Oh, the yellow. You're going to put the yellow here on *is* and you're going to put it on -ED, and	Teacher	

86	32:42.4 - 32:43.4	I have a problem	Ruslan	
87	32:43.7 - 32:44.3	What is it?	Teacher	
88	32:45.1 - 32:48.2	I just erased it at one time were so.	Ruslan	
89	32:50.0 - 33:27.3	You're fine. There is no problem. It's because you're pressing too hard, too hard, and then you can go over it again with that. Yeah. All right. Well, it didn't go. So now you put the yellow, please. You can borrow a yellow right here or there it is. Hmm. Good, good. So how did we end up?	Teacher	
90	33:29.9 - 33:35.2	*cheese is produced from the milk*	all	
91	33:36.7 - 33:36.9	*from milk*,	students	
92	33:37.6 - 34:14.5	so it gets switched around then. Do you see how that happens? And not only that, we don't have the word “we” anymore. Did you see and we just write *cheese is produced* so we take that away completely. And we just write. *Cheese is produced from milk*. That's it, except that here *produced* instead of because “make” is sort of like today, make this the present tense here.	Teacher	
93	34:15.4 - 34:15.6	it's an ED which is past.	Ryu	meta-talk Rich Point
94	34:16.6 - 34:38.2	It's an ED which is past. It sort of past. Yeah. So that's why I put the yellow, right? do you agree. Not all over. Did you notice, honey? I didn't put it everywhere. Can you? Yeah. OK, so this didn't work out, either. Yeah. So boys, did you notice I only put on the ED.	Teacher	
95	34:39.0 - 34:39.3	Yeah. that's what I did.	Ryu	meta-talk
96	34:39.3 - 34:44.2	See, that's that's what you noticed. Very good. But you know what?	Teacher	
97	34:44.2 - 34:46.1	I just erased every single word.	Ruslan	
98	34:46.3 - 35:55.2	Well, but then you do it again. OK, so now can you please pay attention? I only put it on the -ED! Yes, good, you noticed. Well done, the *cheese is produced from milk*. full stop . Well done, that's, so now. Never mind him. So now. So now how about making another sentence? Now you try another one part again step one that one, let's try step one start right again, the words that one here. Mm-Hmm. And we'll do another example. We'll do another example.	Teacher	
105	40:51.4 - 40:51.7	Yes,	Quincy	
106	40:51.7 - 41:14.9	let's do another example. What about, what about? OK, so now you write another step one. Why, would you like the word yoghurt? Or do you like the word butter, word	Teacher	
107	41:15.4 - 41:15.5	butter butter?	variously	
108	41:15.5 - 41:56.6	butter? No. So we did it already, so “we make milk into butter”. Yeah, let's do that. Let's start with the sentence “we make milk into”. I know how to make it, but that's not what I want to know. I want to know if you can write step one here. All right. And this is good. One, two three. Step one is a regular sentence. Repeat	Teacher	
109	41:57.1 - 42:01.0	step one is the regular sentences.	all	

110	42:01.7 - 42:28.3	Step two is the important word. The second is the word, the book word and step three is rearranging. To make it a humanities sentence. Yes, we make milk into...(prompting)	Teacher	
111	42:28.8 - 42:29.2	butter.	Ryu	meta-talk
112	42:29.6 - 42:29.9	Butter.	Teacher	
113	42:39.8 - 42:41.2	Now, the important word	Ryu	meta-talk
114	42:45.6 - 45:51.2	two, the important word that we add or we take away, we're going to do. …. Now you put your example, your next example. Step one. Leave some. Leave some space, and then you write another step one, please. Did you put the yellow? Yes, I did. We put the yellow here. Very good. Very good. So now I think how do you feel? Are you getting it?	Teacher	

turn	Timespan	2019-10-14 chapter 4 rewriting steps concluding segment of lesson. Episode 5	Speaker	Annotations
1	0:03.3 - 1:10.3	So we wrote the example. “They milk the cattle with milking machines”. I changed the word “machines” into *equipment*. *They*, I take it away. figure 16 I keep *milk*, figure 17 but I put it into *milked*. Right. And then I reorganised my sentence a little bit because I have to reorganize now. I have to write *the cattle* first. *Are milked*. figure 18 So, *with the milking equipment*. Does that make sense? Do you see it? Do you see it?	Teacher	
2	1:21.8 - 1:21.9	we don't want to hear about the caf card (Ryu comments on extraneous noise)	Ryu	
3	1:21.9 - 2:13.1	No, no, not at the moment. Does this so do we did we put the words that you see are important? OK? This makes sense. Oh put the yellow on here ED “they milk the cow with milking machines”. We take that away. So the step two is what we switch out. The words, repeat	Teacher	
4	2:13.6 - 2:18.0	the step two, we switch out the words	all	
5	2:18.7 - 2:26.1	and put and put in the book words. And then the step three is what	Teacher	
6	2:26.6 - 2:28.9	to rewrite the sentence.	Ryu	meta-talk
7	2:31.0 - 2:49.0	to rewrite the sentence. We have just one more sec. One more second. Finish up here. Does this make sense, boys?	Teacher	
8	2:49.4 - 2:50.2	Yeah. Yeah.	students	
9	2:50.7 - 3:00.1	So if we read it out loud, we hear that it sounds a bit more different. What do you think?	Teacher	epistemic work
10	3:02.4 - 3:02.5	good	students	
11	3:04.6 - 3:17.6	*The cattle are milked with milking equipment.* figure 19 How does that sound? But. Finally, there's one word you're going to add.	Teacher	meta-talk
12	3:19.8 - 3:24.6	Wait now I remember that I've heard the word *equipment*	Quincy	connection
13	3:25.1 - 3:28.2	this, we did it in the other chapter when we learned about	Teacher	
14	3:29.3 - 3:29.8	no but I mean like	Quincy	
15	3:30.5 - 3:31.2	somewhere else,	Teacher	
16	3:31.5 - 3:32.6	somewhere else. Yeah.	Quincy	
17	3:34.6 - 3:35.0	Of course,	Teacher	

18	3:35.3 - 3:44.4	because now we need a sentence in like. I read it a lot. And now I think about where I did it before.	Quincy	connection
19	3:45.9 - 4:07.8	You are making connections. You are making connections. This is very important. Now what is the real title of this chapter? It is not “cattle”. In the humanities textbook, you will see the word. *livestock*,	Teacher	
20	4:10.4 - 4:10.6	oh yeah.	students	
21	4:11.2 - 4:19.2	How can you write the word *livestock* here so it can be	Teacher	
22	4:19.2 - 4:19.9	next to, next to “cattle”	Ryu	meta-talk
23	4:19.9 - 4:20.7	next to “cattle”	Teacher	
24	4:22.5 - 4:23.4	So can I put the	Ryu	meta-talk
25	4:23.4 - 5:09.8	you can do it. *Livestock* is the correct word. You will see, cattle, sometimes, but *livestock* is the real word. Good, good. All right. (bell rings) So now, children, please. You can put your your papers in the table, but just put the papers in the portfolio and the next one in the portfolio. This is where you or you can actually be, OK? Does this make sense?	Teacher	
26	5:10.9 - 5:11.2	Yes.	students	
27	5:12.6 - 5:33.6	I appreciate. I appreciate. Thank you. And tomorrow, Yeah, then thank you. Tomorrow, we'll have a better chance to work in the Book Creator. Sorry about that. We didn't have a chance today, but tomorrow. Thank you very much. Thank you, dear.	Teacher	

Transcripts – Iteration II Healthy

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II Healthy - transcript 1 – 2019-11-05 Healthy – Introduction page discussion and writing Episode 2

turn	Timespan	2019-11-05 healthy – introduction page discussion and writing, abridged and edited, Episode 2	Speaker	Annotations
19	7:54.3 - 9:04.2	.... Please write little captions. (holding up Ryu's page, figure 4, pointing to the first image) Every picture should have something (pausing and looking at each student in turn). And here, because it's about what, is this about exercise? So what can we write here? (placing finger on Dai's page and the image of swimming)	Teacher	epistemic work
20	9:05.2 - 9:06.1	Swimming	Ryu	
21	9:06.4 - 9:11.4	swimming, (emphasizing the ending) the activity The name of the activity, swimming What is this (pointing)	Teacher	
22	9:13.5 - 9:15.0	mountain biking	students	
23	9:15.7 - 9:16.3	mountain biking, What is this (pointing)	Teacher	
24	9:16.6 - 9:17.6	roller skating	Quincy	
25	9:18.1 - 10:04.9	roller blading (emphasizing) Hmm. Those are roller blades, not roller skates. I'll tell you the difference. And here, what is this? (pointing) You see, I wrote the word *nutrition*. (pointing to the word wall) I wrote down the word *nutrition*. Can you write the word *nutrition*? Sort of here? here on the side, please. (indicating the side of the page, then giving the page back to Quincy) Are you OK? (looking at Dai) (students begin to write, teacher looking at each student writing, in turn) Good (seeing they are done, signalling the next idea), and then underneath (pointing on Quincy's page). Please write the word *protein* figure 5	Teacher	
26	10:05.7 - 0:05.9	this one	Quincy	
27	10:06.4 - 0:57.6	Yes, because here is protein also. . .. So (pointing on Dai's page) you wrote swimming, mountain biking (emphasizing the ending) OK, so now I am going to write, (going to the word wall) I'm going to write OK, exercise, swimming, mountain biking, rollerblading rollerblading. Good. And then there we have *protein*.	Teacher	
28	11:01.2 -11:01.4	energy	Ryu	epistemic work
29	11:02.7 -11:27.5	good, and what are we going to write here (pointing on Quincy's page)? What is that? What do you think that so, good. Let's also write seafood (writing on the word wall)	Teacher	
30	11:29.8 -11:30.4	and fruit	Quincy	
31	11:30.7 -11:49.6	fruit, you know, as some fruit salad vegetables. Good, good. (sitting down again) So now we are captioning, we are putting captions on the illustrations. Repeat	Teacher	meta-talk
32	11:50.7 -11:56.1	captions on the illustration.	all	

33	11:57.0 -12:30.6	*Caption*, *illustration* are those book words. Totally. What's an illustration again? Any picture Any picture in a book This is an illustration. And this is an illustration. Any picture of any kind This is a little illustration. Any drawing, anything that is not a word. Anything that is not a word. Yes.	Teacher	meta-talk
34	12:31.0 -12:31.3	Yes.	Quincy	
35	12:33.6 -13:03.6	This is a little illustration. It is a symbol. Brilliant. OK. Please now take a different colour and write the word caption. Write the word. Just take. Yeah, well take that blue, take that blue and write the word caption. How about how about just here (taking Quincy's pen and writing a point on his paper) Caption. Sorry.	Teacher	epistemic work
36	13:04.0 -13:04.4	I don't know.	Ryu	
37	13:05.2 -14:18.6	.... Yeah, go ahead. Go ahead, go ahead. Go ahead. Good. So you wrote the word *caption* See, look, good. It's not working. Yes. Sure. It's sure it's working. Here's a blue. OK, good. Here's a blue. See, OK. Are you OK with that caption? And then here. (writing a point on Quincy's paper) Here, write *illustration*, please. here write *illustration*, *caption*, (showing the paper to Dai) honey, (speaking to Quincy) be sure that you write the *o* properly. How do you write the *o* you connect at the top? Yeah, otherwise it can look like an *a*. Right? (Dai looks at Ryu's paper as he writes)	Teacher	
38	14:19.7 -14:19.8	Yeah.	Quincy	
39	14:20.6 -14:22.9	So how do I write *illustration*? (gets up to write)	Teacher	meta-talk
40	14:29.0 -14:29.1	can I try (teacher gives him the pen)	Quincy	epistemic work
41	14:29.0 -15:10.8	Get up here and go underneath. (Quincy goes to the word wall, teacher indicates spot where to write and then sits) illustration, ill us tra tion (sounding out the word). T - t -t make the t bigger because we can't understand, r a tion. Wait for him, wait for us to finish talking about it (the students were starting to copy the word). Brilliant. Now, friends, the only tricky bit is the second vowel, he put an *o*. Oh, that is not a bad guess, dear	Teacher	meta-talk
42	15:10.8 -15:10.9	oh it's *a*	Quincy	
43	15:10.9 -15:42.2	no, honey, it's hard to guess that one, if children stop, wait for us to finish talking about that word, you did a great job. Yes, in this vowel (pointing to the word) is hard to guess what it is. You guessed a good guess. It's a *u*	Teacher	
44	15:44.0 -15:44.1	u	Quincy	
45	15:44.4 -16:38.3	it's going to be yeah, yeah, but we pronounce it dear. Could you put a little, good, brilliant, make the a a little better OK, so how do we do this? Why? Why can we write the u? It's because we pronounce it like an A. We say it illustration, in French, It's *illustration* (pronouncing in French). It's the exact same word, exact same. So the lucky bit is boys, is that all these book words you will find in French. Repeat	Teacher	meta-talk, translanguaging
46	16:38.8 -16:46.0	all these book words I will find in French.	all	
47	16:47.4 -17:19.6	Only I say it a little differently. Yes. So in French, it's easier to know some of the spelling because they say u when there's a u, they say u, they put the little mouth like this, you put their little mouth like this, like they're going to whistle (pouts, students also pout), *illustration* (pronouncing in French) Everybody,	Teacher	meta-talk, translanguaging

48	17:20.1 -17:20.8	*illustration* (in French)	all	meta-talk, translanguaging
49	17:24.8 -17:32.6	There you have it. You speak French. aha. repeat	Teacher	
50	17:32.6 -17:32.8	Je parle français. (speaking in French)	all	
51	17:37.3 -17:38.8	And also, Je parle français	Quincy	
52	17:40.1 -17:44.5	voilà bravo, so now we have, what,	Teacher	
53	17:44.5 -17:46.5	but I can speak a bit French	Quincy	
54	17:46.6 -18:55.4	brilliant. Je parle français *Illustration* (pronouncing in French). All right. So we did what, we put the captions on the illustrations. Please write the word *illustration* Can I see, please (taking Dai's page) Thank you. *illustration caption*, Oh, how do you spell swimming? .... Are you ready for chapter one? Oh, well, as ready as you're going to be, as ready as we're going to be,	Teacher	meta-talk, translanguaging
55	18:55.5 -18:56.0	I thought chapter 2.	Quincy	
56	18:56.8 -19:03.1	Yeah. Chapter two is after chapter one. So first reading chapter one, (handing the photocopy to each person)	Teacher	
57	19:04.0 -19:05.5	so *illustration*, yeah	Ryu	meta-talk
58	19:05.5 -19:14.9	you can read quietly, read quietly to yourself, we are waiting for one person,	Teacher	
59	19:16.0 -19:16.8	that's cool (looking at the page)	Quincy	
60	19:16.8 -19:22.4	Can you just be? Yes, brilliant. Can you read quietly to yourself while we are waiting?	Teacher	

Turn	Timespan	2019-11-14 healthy chapter 1, Episode 3	Speaker	Annotations
1	0:00.1 - 1:02.8	Another important book word that we should know. What's another important book word that we should know. Tell me another one, you found *disabilities*. What's another one? Yeah! What's wrong with that? I mean, we say it, but it's still a kind of book word. I agree. Good point. Good point. Because it's a topic word. Yeah. And we'll see it in other things. Yeah. Good. So put a very, very light, little, good job. Put a very light ombragé in French a little shading in when we just put a little bit of colour, the name is a shading in, can you say, shading in	Teacher	meta-talk
2	1:03.2 - 1:04.8	shading in	Lina and Dai	
3	1:05.2 - 1:07.7	If we put a lot of colour, that's colour.	Teacher	
4	1:08.9 - 1:24.8	But this is a shade because it's sort of like a shade. You know, you go like this. Look, you go like this (shading with the hand). You see a little shade. Yeah, OK, that's all. Well done. Well done. What else, dear? *Disabilities*, *exercise*.	Teacher	meta-talk
5	1:40.3 - 1:40.4	healthy	Lina	
6	1:40.4 - 1:47.4	All right. Healthy, healthy, let's highlight *healthy*, because that is the whole point. Repeat.	Teacher	
7	1:47.6 - 1:50.4	That's the whole point.	Lina and Dai	
8	1:51.1 - 3:40.6	That's the whole idea. That's the big idea. Well done. (clapping hands) The big idea. What's another one then? Because we had it here, we had it here in our beautiful word wall, healthy. We had some of these other things. But we put things in our beautiful concept map. You have your concept map, and we use some of the words from here. figure 7 What's another important book word on this page? That we didn't put here. What about *equipment*? (an AL word in the anchor text) What do you think? Do remember what is *equipment*? (Ryu, Ruslan and Quincy arrive) Hello, boys. Hello, boys, how are you? Nice to see you. Nice to see you ,... pause while students settle in.	Teacher	meta-talk
28	7:49.6 - 8:10.1	... OK. And what about *equipment*? (an AL word in the anchor text)We didn't put it in our concept map, but you see that if we had space in our concept map, which is too full now, we would put *equipment* someplace, right? Excerpt 1	Teacher	meta-talk
29	8:12.5 - 8:12.6	yeah	Ryu	
30	8:12.6 - 8:30.5	And then we would put *disabilities* someplace right? But our concept map is too full now. So what's another one? Do I need to, do I need to highlight "supermarket"?	Teacher	meta-talk
31	8:31.6 - 8:31.9	No,	Ryu	
32	8:32.2 - 8:35.9	no, no, no. That's an everyday word. That's an everyday word, right?	Teacher	meta-talk
33	8:36.8 - 8:36.9	yeah.	Ruslan	

34	8:36.9 - 8:53.6	Right. And do I need to highlight the "right food"? Do you know, now I was waiting for someone to tell me the "right food"? Is that science?	Teacher	meta-talk
35	8:54.5 - 8:54.8	No.	Ruslan	epistemic work
36	8:57.9 - 8:58.8	Why is it not science?	Teacher	epistemic work
37	9:00.8 - 9:02.1	Because "food" is everyday.	Ruslan	epistemic work
38	9:02.6 - 9:12.7	The *food* is an everyday word. What about if I say "the right"? "You need the right food" Does that sound, Lina, like a science thing to say? (trying to invite Lina to speak)	Teacher	meta-talk
39	9:14.1 - 9:21.5	Yes. No, right, is he in his right, it seems right, but "food" is not, is everyday.	Ruslan	meta-talk
40	9:24.6 - 9:26.2	What's the science word for "food"?	Teacher	meta-talk
41	9:34.2 - 9:35.4	*nutrition*.	all	meta-talk
42	9:40.6 - 9:40.9	so *nutrition*.	Ruslan	meta-talk
43	9:42.3 - 10:41.3	Yes. Now what about "the right"? You're used to hearing the word and do the right thing. It needs to be right for something. But now, actually, I need to tell you. You noticed from when you were talking in your concept map about DNA and age, remember I said, at my age, do you remember what I said about my age of and my age? What is the right nutrition for me? Do you remember that? Not really. Do you think I need the same food as you?	Teacher	connecting, epistemic work
44	10:42.6 - 0:42.9	No,	students	
45	10:43.0 -0:59.5	not at all. Remember that? Is that coming back to you? Remember Quincy when your what your wonderful mother said to you? She is a vegetarian, but you are not. Because why, what what did she say?	Teacher	connecting, epistemic work
46	11:00.0 -11:06.7	And she said that she didn't need to grow that much	Quincy	
47	11:07.4 -11:07.7	Right.	Teacher	
48	11:09.7 -11:11.0	So that's what she said.	Quincy	
49	11:11.3 -11:51.5	She doesn't need the same of food as you do, you see? Totally, totally do you see at the different times and different people needed different things. So then the "right food" is too vague, because it sounds like, you know, we don't really know what, what, what does, what's right. OK, so the right food, it sounds like, you know, like there's a bad food. Yeah, and that's a different thing. Remember about the french fries and the oily food? Yeah. That's simply unhealthy. That's unhealthy. Right?	Teacher	epistemic work
50	11:52.9 -11:53.0	can I ask a question.	Ruslan	
51	11:54.2 -11:54.9	Yes, dear.	Teacher	
52	11:55.4 -11:59.7	Do you know, was a woman?	Ruslan	connecting

53	12:01.6 -12:02.0	Yes.	Teacher	
54	12:02.5 -12:07.9	And making all going to be one hundred years old very interesting and we can read what she was doing.	Ruslan	
55	12:08.5 -12:09.6	Absolutely great	Teacher	
56	12:09.6 -12:14.5	cause she was eating that she was vegetarian or she was also eating meat.	Ruslan	
57	12:14.9 -12:15.9	We should study her diet.	Teacher	
58	12:17.4 -12:25.2	Her diet and also what exercise she was doing was something that...	Ruslan	epistemic work
59	12:26.8 -12:32.1	we should investigate. Did the science teacher say to you the word *investigate*?	Teacher	
60	12:33.1 -12:33.3	yeah	students	
61	12:33.3 -12:56.0	Aha. So investigate is the science, we go and see. You are a science person. You are saying. How is this happening? What are the factors? Did you hear the word *factor*?	Teacher	connecting, epistemic work
62	12:56.0 -12:56.3	yeah	students	
63	12:56.3 -13:34.2	What are what is influencing? What is causing? Yeah. What is making this happen? You are science young people. That's what scientists do, they say, Oh, so this wonderful old person? What did she do all her life? Totally, totally. That's what science people do, because look at the result. So what made this, right? So then the word is cause remember, cause, did you hear the teacher say to you cause and effect?	Teacher	epistemic work
64	13:34.5 -13:34.8	Yeah,	Ryu	
65	13:35.2 -14:15.4	right? So what causes this result? What causes it? And this is another reason why we're looking at these things, children. Because maybe you will grow up to be doing more science about this, because in the world, many of us are growing older and we want to be older but healthy, there's no point in being older if you are having a back pain. Yeah. What's the point? Right? Or if you have to take a lot of medication because this and because that. Yeah, do you agree?	Teacher	connecting
66	14:15.7 -14:15.8	yeah	students	
67	14:16.0 -14:27.1	I don't want to. I don't want to, me, I'm a lot older than you. I want to stay healthy. I'm reasonably healthy. And I take no medication. Nothing.	Teacher	
68	14:27.6 -14:31.2	Everybody wants to be healthy but longer	Ryu	epistemic work
69	14:31.6 -15:13.8	and live a better life. Remember, that's what you were saying. (in Russian, good life). Yeah. That was your critical question. What helps us have a long and happy life? That's why I keep your beautiful questions here. (pointing to the whiteboard) And your point that just now was a brilliant point, let us study that woman, what did she do? What did she eat? And we know now things that we can study because we made a concept map, right?	Teacher	connecting, epistemic work
70	15:17.3 -15:17.5	yeah	Ruslan	
71	15:17.5 -15:28.8	We could look and we can ask her, What did you know? Did you do this? Did you do that? Because now we identified, we identified the factors, repeat.	Teacher	

72	15:29.1 -15:33.4	We identified the factors.	all	
73	15:33.7 -15:47.3	So all of these are factors, things that act. Your life cycle, your feelings, your rest, your movement, these are factors, can you say	Teacher	epistemic work
74	15:47.6 -15:48.6	factors	students	
75	15:49.1 -15:51.2	factor acts repeat	Teacher	
76	15:51.2 -15:54.6	a factor acts	all	
77	15:55.2 -16:00.1	in to make the result, to make the results repeat	Teacher	
78	16:00.1 -16:02.3	to make the result	all	
79	16:03.0 -16:06.5	only we don't know how exactly.	Teacher	
80	16:07.0 -16:07.2	Yeah,	Ryu	
81	16:07.9 -17:49.0	... So in the life cycle, where is it? Look. So then. Life cycle is important because your mother said that she doesn't need the same food as you, so that's your clue right there. We don't need the same food. I don't need the same food as you.	Teacher	connecting
82	17:49.3 -18:20.4	Yeah. Because like when you're vegetarian, when you're a child it's it's no good because you just have a healthy food and you're not going to grow. So until 20, about 20 to 24 year olds. You eat the normal food, there's a protein in it. And then you can do things going right to stay healthy.	Ryu	epistemic work
83	18:21.9 -18:53.6	Yeah, yeah. So we know already you have an idea that there's some things you really, really need as a young person. So there are some things you really, really need, me, I need a lot less red meat. Yeah. Beef, you know, beef. Yeah, the red meat, OK? The food word is beef. Remember, we did the farm words. The beef comes from	Teacher	epistemic work
84	18:54.0 -18:54.4	the cow,	Ryu	
85	18:54.7 -18:58.5	no, cattle, livestock. can you say livestock,	Teacher	meta-talk
86	18:58.5 -18:59.2	livestock,	students	
87	18:59.3 -19:01.1	right? So not the cow, but the	Teacher	
88	19:01.5 -19:01.9	livestock. ...	students	
103	20:55.0 -21:27.8	...and some fish have bones in it, so you can think of them, so kids go, Oh, no little bones. But actually for nutrition, let's say children. I'm reviewing a little bit with this discussion, but instead of right food, let's keep the concept map just under, instead of right food. What do you what do we need to write because it says your body needs exercise and the right food,	Teacher	epistemic work
104	21:28.0 -21:29.2	right, nutrition,	Ryu	
105	21:30.1 -21:35.6	the right nutrition? It depends on your age. Remember,	Teacher	

106	21:36.2 -21:38.4	it's it depends,	Ryu	
107	21:38.4 -21:39.2	you know, depends.	Teacher	
108	21:42.1 -21:42.3	yeah	students	
109	21:42.3 -22:56.2	So now, please, children underline the word *right* with the green pen. You have a green thank you, the green pen and over here green pen pass her and has the green please. Thank you. So please underline the word *right food* because you will never see this in a text book. You will never see this in a science book. Here is a science book. You will never see it. The *right food*. You will never see it. You see, this is a nice book for middle school science. And it does not say the *right food*. It says. *Nutrition* and it says science words. So now the word *right* is not science we need to say *appropriate*. Did you hear the word?	Teacher	meta-talk
110	22:56.3 -22:56.5	Yes,	Ryu	
111	22:56.5 -22:57.4	appropriate.	Teacher	
112	23:00.1 -23:00.7	appropri -ate	Ryu	
113	23:01.2 -23:03.0	appropriate. Can you say	Teacher	
114	23:03.6 -23:04.6	appropriate	all	
115	23:06.8 -23:10.5	that is a book word. And	Teacher	
116	23:10.5 -23:12.0	that will be the	Ruslan	
117	23:12.6 -23:53.8	Yeah, it means the relevant (in Russian, what's needed) now exactly the right thing. So now I'm going to write it. Let me write it over here. Appropriate. I'm going to write the black word and then I'm going to help you here. Here, come up here and then you. Close, close, Honey, who wants to help. Who wants to help and write the book word? Who wants to give it a try to write the word appropriate?	Teacher	
118	23:55.1 -23:55.3	I am gonna try ...	Ruslan	
130	27:58.4 -28:36.0	...Good. Are you OK? You get it. Good. Good. OK, so there, appropriate nutrition. Let's just add one thing here. Appropriate nutrition for the life cycle, so just underneath can you write for the life cycle? So just underneath for the life cycle? So then you write here for here, just that here for.	Teacher	
131	28:36.8 -28:38.0	For the life cycle.	students	
132	28:42.3 -29:55.4	Because at different times in your life, you need different things. And you know this already from your life. ...,	Teacher	evaluating

turn	Timespan	2019-12-03 healthy ch 3 lesson second half, re-writing nutrition steps in the notebook, Episode 5	Speaker	Annotation
1	0:03.8 - 1:34.3	Good, so we're remembering our example from the sheep before we, well done, before we start, how we did it, how we need to do it today. figure 17 The topic is a little different, but the idea is really the same and you're looking in your other page, you are looking how you did it before. Well done. Well done. (PA announcement). OK. Are you doing that? Did you do it now, honey? How about if you put that yellow also? So use the yellow pencil to put the -ED. That's what sort of is the one of the big things with this way of writing the book. There's yellow. Very good. All right. Is it working? Is it working? Yes. Honey, can you put this in a different colour *produce*, right? Because that's step two of the book word, the book word is the.	Teacher	connecting
2	1:38.3 - 1:38.6	science word	Ryu	meta-talk
3	1:38.6 - 4:01.7	Yes, and we this is where we need to first remember or realize that the science word needs to go in instead of the everyday word, right? And then we're going to go with our example of today, our example of today. That's okay, don't worry, because we're not done yet. (sitting and observing students writing the example again in their notebook, figure 19) Don't worry, do you have the next here. Step three You forgot to write the steps three. (pointing to the exemplar on the laptop screen) Good you're you're writing the step three, *wool is produced from the fleece*, which you remembered perfectly. Just now. You remembered it just now. Good, you are doing that (gets up and goes to the board) and then I'm going to put that one step two step three here. (writing out the steps on the board) Well, and then I'm going to put that sentence. (changing pen colour) "Vitamins that help you to stay healthy", "fruit and vegetables have vitamins that help you to stay healthy". (reading the chapter again to select the sentence) Let me write that. (goes to write on the board) Let me just write, "fruit have vitamins that help you to stay healthy", voilà bon alors. Shall we do it together? So let's do it together if you like, if you like. Pardon	Teacher	connecting, meta-talk suggesting task
4	4:01.7 - 4:02.0	may I be excused.	Ryu	
5	4:02.9 - 4:09.4	Yes, honey. So here, "have", remember. Are you OK?	Teacher	
6	4:10.2 - 4:10.3	Yes.	Quincy	
7	4:10.9 - 4:15.6	"have", what what are we going to change with "have"? "Have" is going to be what	Teacher	meta-talk
8	4:15.6 - 4:15.7	*contain*	Dai	meta-talk
9	4:15.6 - 4:26.8	brilliant, *contain*. So then I go like that, right? (writing an arrow) I go like that and I use a different colour. And I write *contain*.	Teacher	meta-talk
10	4:29.7 - 4:30.0	Yes.	Quincy	

11	4:38.5 - 6:16.4	Then I'm going to underline the “help” and then I'm going to underline “healthy”. And then. I'm just going to write that here. I'm going to write *need* and then I'm going to write “help”. Because “help” is really wrong, it says it says in that website about, that's OK. That's what it says in the website about for parents, about children's health that the vitamins must. So I think the words or really the word “help” isn't really suitable for. Right, do we have it Do we have it *contains*, *need* and *health*. How are you doing? Did you do it? Well done. And you have two clearly different colours. Well done. Well done. All right. So now so now let me write the new sentence, fruit.	Teacher	meta-talk
12	6:18.9 - 6:20.8	Wait, “help” is wrong, right? excerpt 2	Quincy	meta-talk
13	6:21.2 - 6:44.4	That's right. “healthy”, instead of “healthy” we're going to write *health*, just the noun. Remember, we're going to start taking away the verbs and adjectives, and we turn everything into nouns, ideas, because science is ideas and facts. OK, so fruit.	Teacher	meta-talk
14	6:49.3 - 6:51.3	Instead of “helping to” something, *need*.	Quincy	meta-talk
15	6:57.9 - 8:17.9	Right. So now we had so we had . How was my colour code before, my colour code was like this, so *fruit contains vitamins that are needed*. let's write *health* and *growth*. *Health* and *Growth* in.	Teacher	meta-talk
16	8:19.6 - 8:26.3	I don't I don't think I wrote the continues growth.	Quincy	
17	8:28.4 - 9:05.2	So are you OK dear? OK And then I put the yellow. All right, then I put the yellow. Go ahead. So just copy from over there. And when we discuss this and we discuss it. A little bit more, we read it out loud a little bit more.	Teacher	meta-talk
18	9:54.2 - 10:20.6	Good. Good. So let's look at it. One person is still copying out. Well done. How do you feel about this sentence now? Let's read it out loud. *Fruit contains vitamins that are needed for health and growth.*	Teacher	meta-talk, epistemic work
19	10:21.6 - 10:26.4	I think it's good. It's a real science sentence.	Quincy	epistemic work Rich Point
20	10:28.3 - 10:29.4	How do you feel that?	Teacher	epistemic work
21	10:30.7 - 10:44.3	Well, because fruit, because it doesn't have have the word “have”, and “help”, it it has science words inside	Quincy	meta-talk, reasoning
22	10:46.5 - 10:48.2	and it doesn't say, “you”,	Teacher	
23	10:48.7 - 10:48.8	hmhm	Quincy	
24	10:49.1 - 11:16.2	because we know this. This is where the topic is people, we don't need to say, Oh, the child, in this, except if there's something specific for children, but it doesn't say, actually, actually, everybody needs these things. And we know the topic is humans, we're not talking about sharks. Or butterflies? Or.	Teacher	epistemic work
25	11:19.5 - 11:19.9	Dolphins	Ryu	
26	11:20.7 - 11:21.5	Lions.	Teacher	
27	11:24.0 - 11:26.0	I think I used all the vitamins	Quincy	

28	11:26.0 - 13:02.5	That's really great. That's really great. That's really good. So now, friends, let's find let's find one more example like this, let's find another example. How about the next sentence, *proteins help your muscles to grow*? Let's do another one, let's put it over here on the page. Let's put it here, and let's write that, please. Yeah. So please, let's do another very similar example, because it's all the time about this kind of thing. How do the nutrients help us? But we don't want to say just us all living organisms and needed nutrients. All the living organisms, this plant here (pointing to a plant in the room) needs things too, see. All right. So Ryu, what about you do the next one, then please? And what did I mention, *proteins help your muscles to grow*? So I'm going to write that here. Why don't you write it, honey?	Teacher	epistemic work, meta-talk
29	13:11.4 - 13:11.5	is this good	Ryu	
30	13:11.5 - 13:14.0	Oops. t-h here	Teacher	
31	13:14.6 - 13:14.7	oh	Ryu	
32	13:14.7 - 13:27.4	it's not heal*f*y but heal*th*y. Good, good. So let's do one more example, instead of *proteins help your muscles to grow*.	Teacher	meta-talk
33	13:29.5 - 13:29.8	OK. (goes to the board)	Ryu	
34	13:31.6 - 13:32.9	Please start with that one	Teacher	
35	13:34.0 - 13:34.3	proteins,	Ryu	languaging
36	13:34.6 - 15:43.0	proteins that help your muscles to grow. help your muscles. Good, how does muscles go? How do we do muscles? Mus-cles, yes, mus-close, your mus clause muscles to grow, good. Oh, not that, not that you are not the number ten, remember not 10. The mus- cles. So how's it going to be? What do we need to take away? Well, oh yeah, we take away. We're going to take away, grow and then we're going to take away help..... What are we going to say, dear? We're because remember, the zero, it means we take it away completely. What are we going to do instead of to *grow*? That's the verb. We're going to put the noun. And I just made you write it. Do you? Pardon	Teacher	meta-talk
37	15:44.2 - 15:44.6	grew.	Ryu	meta-talk
38	15:46.4 - 16:01.4	grew is the past, yesterday I grew, when I was little, I grew. But now I just grow sideways. voilà OK. So what's the noun? Remember, healthy and health.	Teacher	meta-talk
39	16:02.8 - 16:04.6	Grow and growth.	Ryu	meta-talk
40	16:04.9 - 16:26.9	Good! Well done. So let's put let's put it just a little bit further down, *growth*. So then we go down a little bit, then we write instead of to *grow*, we're going to write *growth*. Well done. And then how about *help*, then we're going to say instead of help	Teacher	meta-talk
41	16:27.3 - 16:27.9	*contain*	Dai	meta-talk
42	16:28.5 - 16:30.2	oh that's “have”	Ryu	meta-talk

43	16:30.3 - 16:41.1	That's right. That's right. You're trying, you're trying really hard. You are trying really hard. Yes. Let's see. What did we say? instead of *help* because	Teacher	
44	16:41.7 - 16:41.8	*need*	Dai	meta-talk
45	16:41.8 - 16:50.3	this is it. We can't choose (referring to nutrition). We have to have it. So we write the word *need*. Well done. Well done. And.	Teacher	
46	16:54.1 - 16:56.2	Oh, so then we underline it, it should be *need*	Ryu	meta-talk
47	17:02.7 - 17:11.7	yes. So then we write, then we take the yellow because we're going to say, Are	Teacher	
48	17:11.9 - 17:14.4	protein need your muscles to grow?	Ryu	meta-talk
49	17:14.8 - 18:19.1	*Proteins are needed*, right? Just like we wrote before we wrote before *fruit, or vitamins that are needed*. Fruit contains vitamins. So you wanted to use the word *contains* and we didn't get a chance because we didn't start with like meat contains, fish contains, the proteins that are needed, oh honey do you want to finish the correct the final sentence. (speaking to Ryu) Do you want to write it out on the board, please? so honey, Here you write, *are needed*. Remember how I did it before so then we write, *proteins are needed for growth*.	Teacher	meta-talk
50	18:20.7 - 18:20.8	so, are *needed* figure 20	Ryu	
51	18:29.6 - 19:12.1	Yes. So then we write, remember I it's sort of my little trick here is the *-ED*, right? Otherwise, I can't put the yellow right right and then I just write, *need* here. I write, need here. It's my little trick to make sure that there's, yes, you see, I have to work backwards. Very good. And then we write, *for growth*. Well done, well done. Does it make sense? Is it working for you?	Teacher	languaging, meta-talk
52	19:12.4 - 19:12.7	Yes. ...	Ryu	

Transcripts – Iteration III Kelp Forest

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III kelp forest - transcript 1 – animals unit transition lesson 1: review of "healthy" and new concept map, start of Episode 1

Turn	Timespan	2020-01-06 animals unit transition 1 review of "healthy" and new concept map start	Speaker	Annotations
1	0:00.1 - 0:08.9	(discussion has already begun) About why you need to stay healthy like food, drinks and rest	Quincy	connecting
2	0:11.2 - 0:15.6	And so first, we talked about it and then we wrote or how was it?	Teacher	meta-talk
3	0:17.1 - 0:19.2	First, we talked about it.	Quincy	meta-talk
4	0:19.3 - 0:20.5	Mm-Hmm. Mm-Hmm.	Teacher	
5	0:20.8 - 0:21.7	And then we wrote.	Quincy	meta-talk
6	0:21.8 - 0:23.1	Mm hmm.	Teacher	
7	0:23.3 - 0:26.9	And then you add more and more and more. . figure 1	Quincy	meta-talk
8	0:28.1 - 0:32.8	Do you remember? (to others) And then we added more and more and then we did this (pointing to the paper). Then we did what,	Teacher	meta-talk
9	0:34.3 - 0:36.0	the key	Quincy	meta-talk
10	0:36.2 - 1:15.2	The key, then we did the key. All right. So now, how about if we start, let's start, don't put this away (the old concept map). How about this, if we can take a new paper, I'm sorry, I'm sorry. Take a new paper, put it over, because that way you can still see the older one. Put the new paper on top. But the new paper Take a new paper. Please put the new paper on top, and the title of the new one is going to be what	Teacher	meta-talk
11	1:15.9 - 1:16.7	"endangered animals"	Quincy	
12	1:17.0 - 1:54.2	"endangered animals". OK, and now first, let's discuss a little bit. Let's discuss a little bit. Because what we have here, what we have here. Because in our old one, we have learned that we had the main idea, the main word. The main idea, which is an idea, healthy, is an idea. And what are these, the major…	Teacher	connecting, meta-talk
13	1:55.0 - 1:56.0	categories	all	
14	1:56.3 - 2:15.6	Brilliant. So I would like now, If we write OK, concept map endangered animals and then are we going to repeat that here in the middle, are we going to repeat it? Maybe not. What is the main idea?	Teacher	meta-talk
15	2:16.9 - 2:17.5	"Danger",	Ruslan	

16	2:18.2 - 2:27.1	danger or animals? What do you think? I'm sorry. (seeing Dai's hand) What did you want to say?	Teacher	
17	2:27.4 - 2:29.7	I think will be "animals".	Dai	reasoning
18	2:30.0 - 4:19.8	Let's start like this. Let's start like this. I like what you just said. I like, I'm going to, it. And you you'll see what you what you think, please children let's let's make, let's do, let's follow this suggestion. ..... concept map, shall we write Endangered animals or just animals	Teacher	
19	4:19.9 - 4:20.0	endangered	students	
20	4:21.0 - 4:49.1	all right then. And trying to erase and then you, now that we are used to doing the color code. Tell you what, tell you what. Maybe it's irritating to have it like this. figure 2 (arranging student's papers) How about if we put it here so that you can you have an idea of your color code, but it's going to be perhaps a little different this time	Teacher	
21	4:49.4 - 4:49.5	ok	Ruslan	
22	4:49.5 - 5:00.5	because all of us, we sort of change our ideas, you know, evolve our ideas, get bigger and different. Right? Does that make sense?	Teacher	meta-talk
23	5:00.7 - 5:00.8	mm	students	
24	5:00.7 - 5:08.4	Yeah. Well done. So please, let's not. And let's remember, we don't need to fill the page today	Teacher	
25	5:08.9 - 5:09.0	hmhm	Ruslan	
26	5:09.4 - 5:12.8	because remember, we added things a little at a time.	Teacher	
27	5:12.8 - 5:12.9	yeah	Ruslan	
28	5:13.7 - 5:13.8	do you spell endangered like EN.	Quincy	
29	5:17.9 - 5:52.3	EN correct, I was just coming to it. I was just coming to it. Half a moment, please, because I was trying to erase here. I was trying to erase. I was trying to erase. (creating space on the whiteboard) Good try. OK. Endangered animals OK. Because it has the word danger in it. Right? And EN means going in sort of sort of like in. Yeah.	Teacher	
30	5:52.7 - 5:53.1	Yes.	Quincy	
31	5:53.3 - 6:08.3	See what I mean but a little different? Little different. OK, OK. Yes. But OK, so I'm going to try to erase here a little bit. And you start working, how it can be, please.	Teacher	

III kelp forest - transcript 2 – animals unit transition lesson, concept map presentation and discussion (edited), conclusion of Episode 1

Turn	Timespan	2020-01-06 animals unit transition lesson 2 concept map presentation and discussion (abridged and edited)	Speaker	Annotations
		(Dai has just presented his concept map draft)		
47	3:33.0 - 3:48.2	Well done. Well done. Do you have, this is as far as you got just now. Do you have, I see some other boxes (T indicating empty boxes on the map) Do you plan to do more? You have other ideas.	Teacher	inviting reasoning
48	3:49.0 - 3:49.3	Yes.	Dai	
49	3:49.5 - 3:51.9	Say, "I'm getting to my next ideas.".	Teacher	
50	3:52.0 - 3:55.3	I'm getting to my next idea. I just need some time.	Dai	
51	3:55.5 - 4:01.6	Perfectly, perfectly, perfectly. Because remember, what did we say? An idea is never…(pausing)	Teacher	
52	4:02.3 - 4:02.5	stopped	Dai	
53	4:03.1 - 4:33.4	stopped or finished. It never ends. It never ends. Our talk about an idea. We're still some ideas we're still talking about 5000 years. We are talking about it. Yes. And we're not finished. Still not finished. Well done. So you don't worry, finished or not finished. That's not possible with the concept, right? So you don't worry. Yeah. Well done. Is there for now, something more you wish to say, dear?	Teacher	
54	4:37.0 - 4:43.5	Well, I'm like, I put bugs here, (pointing to empty box in the concept map) but I don't think bug is a kind of animal figure 3	Dai	epistemic work through meta-talk
55	4:43.5 - 4:43.6	ok	Teacher	inviting reasoning
56	4:43.6 - 4:44.0	insects,	Dai	
57	4:46.3 - 5:01.1	insects, you mean it's, OK, first bug, you you thought bug and then insect. Well done. What's the difference? (to all) Bug and insect (in Russian, what's the difference) Yeah. What's the difference? Bug and insect? Everyone is thinking, What's the difference? Bug and insect?	Teacher	invite reasoning
58	5:01.4 - 5:07.9	Well, I think bug is, like, baby words,	Dai	epistemic work
59	5:08.6 - 5:09.0	sorry? (there was noise)	Teacher	
60	5:11.3 - 5:19.9	I think bug is like, you say like in Primary school.	Dai	
61	5:23.3 - 5:26.1	uh huh What do you think? (to others) What do you think? Do you agree with that?	Teacher	invite reasoning
62	5:26.2 - 5:30.4	I disagree with Dai	Ruslan	
		(more discussion on this)		

78	7:44.2 - 7:46.8	So I kind of agree with…	Quincy	
79	7:47.9 - 7:55.6	what did he say? Oh, you agree with Dai? Repeat what? Repeat the point that you agree with. "I agree that…"	Teacher	
80	7:55.8 - 8:11.9	I agree that the bug is, I think, a bit bigger and the insect is like a fly or. Or a….	Quincy	
81	8:13.7 - 8:26.8	At any rate, the smaller, how interesting, how interesting. All right. But you said something else before. Uh. You didn't talk about the big or small. What else did you talk about, dear? (to Dai)	Teacher	
82	8:27.0 - 8:37.8	Oh, I'm just thinking, bug it's like. Like you speak it at kindergarten or. like primary school.	Dai	epistemic work
83	8:41.8 - 8:42.4	Mm-Hmm.	Teacher	
84	8:42.6 - 8:47.9	(pointing to the word pair with the pen) And *insect* is like speak in middle school or high school. figure 4	Dai	epistemic work , Rich Point
85	8:48.4 - 9:00.1	Mm hmm! Mm hmm. So that's what I wanted you to think about just now, how do you feel about what he just said?	Teacher	invite reasoning
86	9:02.8 - 9:02.9	hm	Ruslan	
87	9:02.9 - 9:34.2	Yes. No. No. That's interesting, that's interesting. Well, it turns out, it turns out. Remember, one day we did a concept map about I had it over here, vertebrates and invertebrates, do you remember that? It was. It was over there. It was just here. (indicating a spot on the board) It was here and then I erased it, you can sort of see still see parts of it. Yeah. Do you remember that?	Teacher	connecting
88	9:34.4 - 9:35.0	Yes,	students	
89	9:35.2 - 11:30.6	you remember that. Well, it turns out you may or may not remember, *insect* was on it. Can you please write, no not just because that's your you will do it later as you wish, this is your page, you will do as you want with that. However, you'll decide if we say some words that you want to put there. You decide that, OK. … .. So it turns out, friends, there are two important categories of animals. One is vertebrates, do you remember that?	Teacher	
90	11:31.2 - 11:31.3	yes	Ruslan	
91	11:31.2 - 11:56.6	You remember here, Charlie. Here's Charlie here (indicating the human skeleton model) vertebrates. Remember his vertebrae. These are the vertebrae. (pointing to them) So thank you, Charlie. I hope you don't mind. voilà. And then there are animals that are invertebrates. What does that mean, do you think?	Teacher	invite reasoning
92	12:04.3 - 12:04.4	hm	Quincy	
93	12:04.4 - 12:17.5	Your clue is because we always say vertebrates and invertebrates. So what do you think invertebrates mean? (emphasizing *in-*) Yes, (indicating student)	Teacher	
94	12:18.0 - 12:19.1	that it's not a vertebrate.	Quincy	epistemic work
95	12:19.7 - 12:29.1	Yeah, yeah, yeah, totally, totally totally. So it means it really means not these things.	Teacher	

96	12:31.8 - 12:31.9	Yeah,	Ruslan	
97	12:32.0 - 12:36.1	yeah. It's like, remember possible and…(pausing)	Teacher	connecting
98	12:36.6 - 12:37.1	impossible	Dai	
99	12:38.7 - 12:57.5	You see, the opposite, sort of. Yes, very good, very good. So let's use more of these important book words because these are this is the everyday word, bug is the everyday word. *Insect* is the…(pausing)	Teacher	meta-talk
100	12:58.9 - 12:59.2	book word	Dai	epistemic work
101	12:59.2 - 13:08.7	Well done, well done, you can even hear it. Yeah, when you say bug and then you say *insect*. Right.	Teacher	
102	13:09.2 - 13:09.4	yeah	Dai	
103	13:09.4 - 13:45.0	When you hear it even, right, so dear children. Let's go like this, I'm going to help, I'm going to help, I'm going to make the first category here. (writing on the board) *vertebrates*. And then excuse me, it's ok don't worry, do not worry dear. And then I'm going to go here, *invertebrates*, have I run out of time? Oh good lord, I, I'm so sorry.	Teacher	

III kelp forest - transcript 3 – animals concept map discussion, connections (edited, abridged) Episode 2

Turn	Timespan	2020-01-08 animals concept map discussion connections (edited, abridged)	Speaker	Annotations
1	0:01.1 - 0:04.1	So in our word wall, what words do we not need? figure 5 Excerpt 1	Teacher	
2	0:04.6 - 0:04.8	We don't need the blue category	Ruslan	epistemic work
3	0:08.0 - 0:10.4	this blue category, we don't need it anymore	Teacher	
4	0:11.5 - 0:14.4	and healthy	Ryu	
5	0:14.8 - 0:31.3	and maybe about the healthy specifically. But wait, what did one person just to say repeat again about that connection? Repeat again what you said about the connection.	Teacher	
6	0:31.4 - 0:37.2	Oh, why I put continents population	Quincy	
7	0:37.3 - 0:40.0	and why you wanted to	Teacher	
8	0:40.0 - 0:47.4	yeah. Well, I wanted to put environment, because I made a connection from healthy. Because we're animals. figure 6	Quincy	epistemic work through MT
9	0:47.7 - 0:48.2	Mm hmm.	Teacher	
10	0:48.8 - 1:00.2	And there was environment and and everybody needs space and everybody needs air. So the same thing here.	Quincy	epistemic work
11	1:00.3 - 1:00.7	Mm hmm.	Teacher	
12	1:01.6 - 1:12.3	And because of space, I put continents, countries. And, for example, from a continent Asia.	Quincy	epistemic work
13	1:12.7 - 1:13.1	Mm-Hmm.	Teacher	
14	1:14.6 - 1:23.1	And population people, because we are animals as well. And I'm still going to add more things	Quincy	epistemic work
15	1:23.3 - 1:24.1	such as	Teacher	
16	1:24.8 - 1:58.0	such as birds for a population. And I'm going to put more endangered animals and more extinct animals and why I put forests is because today, before I put forests, hm Miss P-- said that a lot of animals died because of forest fires.	Quincy	epistemic work
17	1:58.4 - 2:00.8	aah, in Australia,	Teacher	
18	2:00.8 - 2:01.1	yeah.	Quincy	
19	2:01.8 - 2:15.7	So that's our current problem. Absolutely. This is really brilliant. Thank you. Let's see. So what items here? So then some of the items from healthy? Are we going to delete all of them?	Teacher	
20	2:15.8 - 2:15.9	yes	Ruslan	
21	2:15.9 - 2:19.1	No, because some of the word is important for	Ryu	

22	2:19.6 - 2:25.5	and those black words. Are we going to still use the black words?	Teacher	
23	2:26.2 - 2:26.5	Yeah,	Ruslan	
24	2:27.0 - 2:35.3	because probably we're still going to use estimate and interior and description	Teacher	
25	2:35.5 - 2:37.2	and exterior	Quincy	
26	2:37.2 - 2:38.7	exterior,	Teacher	
27	2:39.3 - 2:46.1	how the how the animals wash. We might, for the life cycle, be connected.	severall y	
28	2:46.4 - 2:59.5	We make the connection. Brilliant. But maybe we don't need rollerblading. Maybe. Yeah, maybe we don't need rollerblading. And maybe we don't need oh. But are we going to need vertebrates?	Teacher	
29	3:00.8 - 3:01.6	Mm yeah,	Ruslan	
30	3:02.0 - 3:03.4	because it's about animals, right	Ryu	
31	3:03.4 - 3:03.7	right	Ruslan	
32	3:05.2 - 3:07.9	So let's write the vertebrate with a black word	Teacher	
33	3:09.1 - 3:10.7	and environment and life cycle and hygiene.	Ruslan	
34	3:11.5 - 3:12.0	Right	Teacher	
35	3:14.9 - 3:16.5	Movement, I think we have to erase	Ruslan	
36	3:16.5 - 3:22.8	aha movement, we have to erase you feel? Hmm.	Teacher	
37	3:23.1 - 3:25.1	No the rest we have to erase	Ruslan	
38	3:25.1 - 3:27.0	the rest we have to erase. All right.	Teacher	
39	3:28.8 - 3:29.0	healthy we also erase.	Ruslan	
40	3:33.6 - 3:35.1	Are we going to erase healthy?	Teacher	
41	3:39.4 - 3:39.8	(unclear) environment and space figure 7	Ruslan	
42	3:39.8 - 4:02.6	Okay. Let's decide that later. Maybe we can decide it later. do we need to decide everything now?	Teacher	
43	4:02.9 - 4:03.1	No,	Ruslan	
		(a side discussion)		
54	5:11.9 - 5:42.8	this is it quite what I want to do with you is the whole context. For example, we started writing about we started saying tropical rainforest. I want us to learn more about the habitats. Yes, where those animals live, right? So we're going to investigate all the ideas that are part of endangered. Yes. Do you agree?	Teacher	
55	5:42.9 - 5:43.3	Yes.	students	
56	5:44.5 - 5:49.2	So that you have the words the ideas and the facts. Yes.	Teacher	

57	5:51.7 - 5:51.8	hmhm	students	
58	5:51.8 - 6:51.5	Then you bring that to the class of Ms Philipp. Yes. Then you can bring it to her class, right, Ruslan? Yes, you get it. You see.	Teacher	
75	9:22.1 - 9:23.7	Is this good?	Ryu	
76	9:27.7 - 9:59.8	Hmm! (pointing finger on different parts of the concept map) You are connecting. Yes. Animals, yeah, farm animals. This is these animals. These are animals and we are doing something to them. Hmm. Absolutely. And then we see how all of these things, how endangered animals fits into the bigger picture. Right?	Teacher	
77	9:59.9 - 10:00.6	Thank you.	Quincy	
78	10:01.6 - 10:06.4	Oh, you can write the the major category endangered	Ryu	
79	10:12.0 - 10:41.4	that's that's sort of what that's sort of what this person did this person. Do you see this person wrote, Farm animals, extinct, endangered farm birds, land, water, insect environment, pet. So we're see we're finding how all of these things fit together, endangered animal fits into a bigger picture, right? Repeat	Teacher	
80	10:41.7 - 10:47.1	endangered animals fits into the bigger picture.	all	
81	10:48.1 - 11:24.8	I want you to think of the idea. We can't understand endangered animals, except in the bigger picture. We needed a bigger picture. I want you to think about this. And what you think of. Yes. And they will. Yes, yes. All right. Do you see why I want you to see why we are doing it like this? Do you see sort of why we're doing it like this? Excerpt 2	Teacher	
82	11:27.0 - 11:40.6	Yes. I like making concept maps, plus it's you can also see the idea ideas that was in your head, so you're not forgetting because you already wrote it	Ryu	epistemic work; initiating
83	11:41.0 - 11:45.8	and then you can, and then you can...(pausing)	Teacher	
84	11:46.5 - 11:47.2	review it.	Ryu	
85	11:47.2 - 11:54.7	review it, and when you review things what happens, you. ...(pausing)..	Teacher	
86	11:55.7 - 11:56.4	you can think	Ryu	
87	11:56.8 - 11:58.1	you can think...(pausing)...	Teacher	
88	11:58.4 - 11:59.4	or you can	Ryu	
		(extended intervention: Ryu presents and discusses his concept map; T gives feedback)		epistemic work
119	16:31.6 - 16:50.0	Good, (speaking to Quincy and Ruslan at the word wall) so you are looking here. So here you are, looking at how you did your color coding before, how you determined how you decided. Maybe you are thinking back how you decided. Are you thinking back? How you decided?	Teacher	meta-talk
120	17:02.1 - 17:02.2	yes	Quincy	
121	17:02.2 - 17:18.7	Can you please also write the word habitat? please. because then we're going to connect back remember that map we put in the farm map we put about temperate zone,	Teacher	

122	17:21.8 - 17:24.7	and tropical zone.	Ryu	
123	17:25.5 - 17:26.1	tropical zone, do you remember that?	Teacher	
124	17:26.9 - 17:27.0	yes	Ryu	
125	17:27.0 - 17:27.6	It's all connected	Teacher	
126	17:28.6 - 17:29.2	and climate	Ryu	epistemic work
127	17:29.7 - 17:32.3	please. write the word climate	Teacher	
128	17:35.7 - 17:42.8	after we are finished and maybe we can do the life cycle of each class.	Ruslan	epistemic work
129	17:45.0 - 17:46.3	Is that a life cycle?	Teacher	
130	17:47.1 - 17:47.5	Yes.	Ruslan	
131	17:48.3 - 17:48.4	No	Teacher	
132	17:49.5 - 17:49.6	it's a food chain	Quincy	epistemic work
133	17:50.9 - 17:53.8	brilliant. Are those things that you did in year four?	Teacher	
134	17:56.7 - 17:56.8	mm	Ruslan	
135	17:56.8 - 18:01.7	Where did you hear about that? Where did you just hear about that? (in Russian, from where)		
136	18:05.2 - 18:08.1	Mrs P--- was just saying some stuff about animals	Ryu	
137	18:08.5 - 18:09.2	in the food chain.	Teacher	
138	18:09.7 - 18:10.0	Or extinct	Ruslan	
139	18:13.7 - 18:17.9	OK, so these are all things that she gave to you. This is information she just gave.	Teacher	
140	18:18.2 - 18:18.4	Yeah.	Ruslan	
141	18:18.6 - 18:20.5	All right. All right.	Teacher	
		(boys discuss the project lesson from the mainstream class, where a food chain was explained)		epistemic work
221	27:50.3 - 27:53.2	And we last year we did a lot about food chains.	Quincy	connections
222	27:53.6 - 28:00.4	Did you really? Did you really? Please tell me, what were the things that you learned last year?	Teacher	
		(Quincy and Ruslan attempt to retell a story that their year 4 teacher had narrated from a book about an island with animals, and a problem with a food chain)		epistemic work

265	33:20.8 - 34:18.2	So what are we doing always? We're remembering our ideas. Right? …Is that a good idea? Is that what you want to learn? Do you want to learn this? Yes, I would like us to learn more about habitats and more about the science words so that it will help us do what. Understand why some animals are endangered. Understand again about that fantastic story about the island with the different groups of animals.	Teacher	
266	34:19.1 - 34:31.1	Yeah, it may be that there was too much or like there was too much of the meat eaters, and maybe dodos also died because of it. Yes, and somebody disappeared to eat the wolves,	Ruslan	Rich Point
267	34:37.4 - 34:40.7	the name for the big picture is *ecosystem*.	Teacher	
268	34:42.8 - 34:43.0	*ecosystem*	Ruslan	
269	34:43.0 - 34:43.3	Everyone	Teacher	
270	34:43.8 - 34:45.8	*ecosystem*,	all	
271	34:46.2 - 34:51.5	this is the science name of the big picture. Yes. Yes.	Teacher	
272	34:52.5 - 34:52.8	I heard that, I've heard it	Ryu	
273	34:52.8 - 34:52.9	I've heard it Yes.	Quincy	
274	34:52.8 - 34:58.1	Yes. Yes. Ecosystem, because it's a system, all the parts work together repeat	Teacher	
275	34:58.8 - 35:02.0	all the parts work together	all	
276	35:02.0 - 35:18.0	in the way that you described the wolf, the grass, the rats, the owl, they all work together and the name of that is *ecosystem*. The part cannot come out without bothering everyone. You get it.	Teacher	
277	35:18.3 - 35:19.8	Yes. Now I remember.	Quincy	connecting
278	35:20.0 - 35:20.3	Yes.	Teacher	
279	35:20.3 - 35:21.3	And last year,	Quincy	
280	35:21.3 - 35:21.7	yes,	Teacher	
281	35:21.7 - 35:25.2	at the end, Mr. H-- said, it was *ecosystem*	Quincy	connecting
282	35:25.2 - 35:33.8	brilliant. You see where it's all going to come together, children, and you're going to all be able to say all the science words. Yes. Yes. Do you agree with that?	Teacher	
283	35:33.9 - 35:34.2	Yes.	students	
284	35:34.4 - 35:54.2	OK, now you may go. Thank you. And I'll see you again tomorrow. Thank you very much. (to each student) Thank you very much. Thank you very much. Thank you very much. Thank you very much. Yes, dear.	Teacher	

III kelp forest - transcript 4 – ocean life ch 2 food webs and over-writing diagram and text (edited) Episode 4

Turn	Timespan	2020-01-28 ocean life ch 2 food webs and over-writing diagram and text (edited)	Speaker	Annotations
1	0:04.0 - 0:12.5	And then instead of plant plankton you can write…(pause)	Teacher	suggesting
2	0:16.0 - 0:16.2	*phytoplankton* figure 13	Ryu	MT
3	0:16.1 - 1:08.1	Well done. I see your point. I see your point. So we know this already. What's nice about this page, though is that it's color, (comparing the anchor text and the activity cutout) and you can see really more clearly that exact same animal, right? That's not it. (teacher corrects herself) It's that one. Hi, honey, it's. (Quincy arrives) Let's see if he gets it, too. Let's see if Quincy gets it. here. Let's close this, look. You may be excused. (To Ryu) Excuse me. Go ahead. Oh, OK. (to Quincy) So look at this. Now we're reading this. And did you do this beautiful food chain, except that you did it in the form of a food web? (pointing to his previous work on the printed photo, fig. 10)	Teacher	connecting
4	1:10.0 - 1:10.2	yes	Quincy	
5	1:10.2 - 1:15.8	Mm hmm. Right away, Ryu had a comment, what comment do you think he had.	Teacher	invite reasoning
6	1:27.5 - 1:27.8	uh , I don't think	Quincy	
7	1:28.9 - 1:33.7	right, right here, right here, right here (hand hovering over the diagram) Sure, read some of the words	Teacher	
8	1:36.1 - 1:36.3	this is phytoplankton and this is zooplankton (pointing to each decisively)	Quincy	
9	1:39.9 - 1:53.1	brilliant. Totally. And one more terrible mistake, a terrible mistake. (Quincy points to the diagram and the phytoplankton) The Sun, missing the sun. So draw the Sun please right there. (Quincy proceeds to do so instantly, figure 14)	Teacher	
10	2:16.0 - 2:50.1	So we had done already. We had already. Well done. And you can think of how to put the. Put the word *phytoplankton* and the *zooplankton* someplace, please. And why do we need the Sun? Why does the Sun have to be there, because it's the ……(pauses)	Teacher	connecting, inviting reasoning
11	2:53.3 - 2:59.8	because the *phytoplankton produces* its own food with the help of the Sun	Quincy	Rich Point epistemic work
12	3:01.3 - 3:56.2	Beautifully, beautifully said. That is perfectly clear to me. And you said a book word, *produces*. Well done. But now we know that the word *zoo plankton*, *zoo* means it's going to mean animal. Well done. Well, what else can we add in this food chain that we used before, that we used before, yes, dear (indicating Ryu)	Teacher	evaluating, connecting
13	3:56.2 - 3:56.3	like *apex predator*	Ryu	reasoning

14	3:58.4 - 4:29.1	for example for example, *apex predator* So let's add some of those labels that we can that we learned how to use before, because there, it just simply has the names of of the actual organisms. But we need to know what role do they have What are they doing They are *consumers* and…	Teacher	reasoning
15	4:30.9 - 4:31.1	*secondary consumers*,	Ryu	
16	4:32.5 - 4:35.5	voilà, voilà. How about you? (gesturing to Quincy) Add some of those things	Teacher	
17	4:37.6 - 4:39.1	and *primary consumer*,	Ryu	
18	4:39.3 - 4:40.8	and *primary consumer* And then there's a …	Teacher	
19	4:40.8 - 4:40.9	*apex predator*	Ryu	
20	4:44.1 - 4:45.6	and there is a, (pointing to the image) what's he, he's a…(pauses)	Teacher	
21	4:48.5 - 4:49.1	*producer*	Ryu	
22	4:49.1 - 4:57.0	brilliant brilliant. So you figure out how you're going to do that. Please. (students proceed to write on the diagram, T gets up and moves away)	Teacher	
23	5:30.8 - 5:32.5	(looks up at the word wall) Is *producers* with a c	Ryu	
24	5:35.5 - 5:38.0	didn't we write it, did we write it here? (going to the word wall)	Teacher	
25	5:39.0 - 5:39.5	(also goes to the word wall) Oh, we did, *produce*. (it's not there)	Ryu	
26	5:48.4 - 5:59.8	*produce*, *food web, food chain ecosystem vertebra, eliminate* (reading off what is on the word wall). What do you think it's going to be because it's a bit like *terrace*?	Teacher	
27	6:01.2 - 6:01.3	c	Ryu	
28	6:01.7 - 6:13.4	with a c, because it's a book word, how about you write here, (to Ryu at the word wall) *producer*, please. Does that make sense Quincy, it's going to be with a c?	Teacher	meta-talk
29	6:13.8 - 6:13.9	Yes, (he looked at the board briefly when Ryu started to write) figure 15	Quincy	
30	6:13.9 - 6:20.8	yes, because book words have more c's in them, right? Yes?	Teacher	inviting
31	6:23.0 - 6:23.1	hm (not looking up, writing on his paper)	Quincy	
32	6:23.0 - 6:31.5	Well done. And then oh, and how about Ryu, you write, under *producer*, you write the word *consumer*, how's that.	Teacher	
33	6:31.8 - 6:32.1	Yes,	Ryu	
34	6:32.2 - 6:32.3	What is it dear (to Quincy)	Teacher	

35	6:33.9 - 6:36.0	the small fish is a *consumer*, right?	Quincy	
36	6:36.2 - 6:40.9	Yes, it has to be. Because nobody, there's only one *producer*. And what's that?...	Teacher	

III kelp forest - transcript 5 – ocean life ch 2 food webs 1 discussion kelp forest intro (edited) Episode 5

Turn	Timespan	2020-01-29 ocean life ch 2 food webs 1 discussion kelp forest intro (edited, abridged)	Speaker	Annotations
1	0:00.4 - 0:09.6	I'm looking at your beautiful work (arranging photos of the students' ocean web work fig. 10, 12 on the table in front of the students), and you realized that this terrible title, this terrible title (referring to the chapter title "Who Eats What") excerpt 3	Teacher	inviting reasoning
2	0:10.5 - 0:12.2	And it doesn't make any sense.	Ruslan	epistemic work
3	0:12.5 - 0:27.4	It doesn't make any sense because, Quincy, it can even make us think about.... people who is people, and then it can make us think about when you first see the title, it makes you think about what...	Teacher	
4	0:27.9 - 0:28.4	people eating, sleeping	Ruslan	
5	0:31.2 - 0:31.7	or not.	Teacher	
6	0:32.8 - 0:33.0	yes	students	
7	0:33.0 - 0:49.7	Or they'll say, Well, I don't like seafood or who eats what, well I eat a healthy and healthy food, Are we, What topic are we? Are we talking nutrition or what are we talking?	Teacher	
8	0:50.0 - 0:54.8	Are we talking about healthy life or are we talking about the web and ecosystem	Ruslan	epistemic work
9	0:56.5 - 1:00.7	yeah! completely terrible, completely terrible.	Teacher	
10	1:00.7 - 1:05.3	It doesn't make any sense. When we look at it, it's means like we have 100 questions about this title.	Ruslan	epistemic work
11	1:05.7 - 1:17.4	We have a 100 questions about this title. We have a 100 questions about this title. And why did you want to highlight the word ocean?	Teacher	inviting reasoning
12	1:18.1 - 1:19.8	Because then you know it's really about that	Quincy	epistemic work
13	1:22.6 - 1:26.1	and people, you said that when we highlight,	Teacher	
14	1:26.9 - 1:36.5	people think, OK, what is highlight for? And so people think so people say, I know that we need to look at that,	Quincy	
15	1:37.5 - 1:41.1	yeah, we need to think about that.	Ruslan	
16	1:41.9 - 1:43.4	It's to help critical thinking.	Teacher	
17	1:44.4 - 1:57.6	And also, if we could only look want it with anything, we didn't get to just think, what is the deal or	Ruslan	
18	1:58.6 - 2:02.5	what is the biome of this situation? Totally, totally. And	Teacher	
19	2:02.5 - 2:15.5	people and people will think like, OK, people eat that and that and thing that people eat in their animals. It could be land animals, it could be ocean animals.	Quincy	
20	2:16.5 - 2:18.0	It could be anything.	Teacher	
21	2:18.6 - 2:18.9	Yeah.	Ruslan	
22	2:19.4 - 2:28.4	So it's misleading. And that's very not science when it leads you in the wrong direction. Well done. Well done. Totally.	Teacher	evaluating

23	2:28.6 - 4:25.4	So now we took a break too before reading and you read it quietly, you had a chance to read quietly within yourself. And now it's your turn to read out loud. Totally. Let's go back to you, please. (review of reading intonation)…. Yes. Read	Teacher	suggesting new task
24	4:25.9 - 4:26.7	(reading from the text) in the ocean... there are	Dai	
25	4:28.6 - 4:29.1	brilliant.	Teacher	
26	4:29.8 - 4:55.5	(reading from the text) There are lots of very small animal and plants called plankton. The plankton live near the top of the ocean because they need sunlight. Small fish eat plankton the big animal eat the small fish, small fish. Then the bigger animals eat them. Eats them. So plankton are important for almost every ocean animal. This is called a food chain.	Dai	
27	4:55.9 - 5:29.7	Well done. So you saw how he paused. Big animals eat them. So, plankton are important for almost every ocean animal. Please put a comma after, *so*, here. So please put a comma after, so, do you see where the so is? I put a nice, good comma. Well done. Do you see why it looks better? Because here the *so* it really means*, in conclusion*. (repeating in Russian)	Teacher	meta-talk
28	5:33.9 - 5:34.2	Yeah.	Ruslan	
29	5:37.2 - 5:41.4	yeah, How do you say Quincy conclusion in Dutch?	Teacher	
30	5:45.2 - 5:45.3	(speaking in Dutch, very similar word)	Quincy	
		(discussion about cognates to "conclusion")		
35	7:13.7 - 8:46.9	… So, is one way to say, because that's what it really means. In conclusion. Plankton are important for almost every ocean animal. And this is why it's a food web, and we saw that we proved that with this amazing work that you did. What is really at the center of everything you put, you put the apex predator at the center. (placing photos of fig 10 and 12 on the whiteboard with magnets)	Teacher	reasoning, connecting
36	8:50.2 - 8:50.3	hm	Ruslan	
37	8:50.2 - 9:07.4	That's really interesting. You put the apex predator, and now I'm going to put my copy of it here. You put the apex predator at the center. Why did you put the apex predator at the center? honey, (indicating student)	Teacher	inviting reasoning
38	9:08.0 - 9:22.7	because we put it around another animal because of, blue whale Yeah, well, it's like a lot of things in here,	Ruslan	epistemic work
39	9:23.1 - 9:24.4	and we wanted to make sure	Teacher	
40	9:25.0 - 9:26.6	that everything is there.	Ruslan	epistemic work
41	9:26.9 - 9:29.9	So everything was going there, everything.	Teacher	
42	9:30.4 - 9:45.2	also the second predator is the sea bird because it also eats a lot of things. And already it eats it eats a lot of things it eats three and killer whale eats four.	Ruslan	epistemic work
43	9:47.3 - 9:52.6	right, so out of this out, this totally so it was more convenient to put it in the middle.	Teacher	
44	9:52.9 - 9:53.1	Yeah,	Ruslan	
45	9:53.3 - 10:00.7	totally. I see your point. I see your point. I see your point. And then we put we put the two types of plankton at the top	Teacher	
46	10:01.8 - 10:02.8	because it starts from there figure 16	Ruslan	epistemic work
47	10:04.2 - 10:05.6	everything starts from...(pause)	Teacher	

48	10:09.3 - 10:09.4	from the plankton,	Quincy	
49	10:10.7 - 10:15.9	phytoplankton, totally. I see your point. I see your point. I see your point.	Teacher	
50	10:18.9 - 10:39.0	You look --- from the bottom---- like energy pyramid --- it's gonna be real messy like a ---- square.	Ruslan	
51	10:42.8 - 11:05.4	So there. There, I see your point. I see your point. And then these guys made it a little bit more like a, energy pyramid. this team (indicating other team's photo) And it worked because their table was a different shape. You had a problem because your table was a rectangle, so it was not easy.	Teacher	connecting
52	11:06.6 - 11:06.7	hm	Ruslan	
53	11:06.7 - 11:09.2	And you had to do it again. But that's what science people do.	Teacher	connecting
54	11:10.8 - 11:10.9	you look at it	Ruslan	
55	11:10.9 - 11:22.3	You look at it and then you think about all angles. Let's fix it. Brilliant, Ruslan. That is science work, right? We don't try to do it right the first time. Repeat,	Teacher	
56	11:22.4 - 11:27.1	we don't try to do it perfect the first time.	all	
57	11:27.8 - 12:01.6	Nobody does. So, well done, well done. So now we're getting an idea, what's different, we're getting an idea, what's different? Why did we do it like that? We're looking at it. We're working on it. All right. So and then we're learning how to say instead of so, in the book, we should say "in conclusion". Yeah. So it's sort of like a talking word, you know? Well done. Well done. Let's keep reading. Let's keep reading because, I'm sorry. (indicating student)	Teacher	meta-talk
58	12:02.6 - 12:02.7	can I read	Ryu	suggesting
59	12:02.6 - 12:34.6	I mean, why not? Let's go to you. Why not? Oh, actually, honey, (to Ryu) I'm sorry. Ruslan didn't get a chance the other day, either, yesterday. Is it OK, please? Well, let's give it a go. Let's give it a go to what do you think? And we're going to, go and blow your nose. Careful. Careful. Well done. OK. So honey, (to Ruslan) now it's your turn, and then we'll we'll go around two times. Is that okay? Good. Good. So please, please read. (indicating Ruslan)	Teacher	
60	12:36.4 - 12:50.7	(reading from the text) animals that eat other animals are called predators. Animals that they eat are called prey. Most sharks are predators. Sharks can swim very fast to catch their prey.	Ruslan	
61	12:51.0 - 12:54.8	Well done. Thank you. What did you say (to Ryu)	Teacher	inviting
62	12:57.8 - 12:58.0	Maybe we can put *consume*	Ryu	meta-talk
63	12:58.0 - 13:16.0	Well, you're thinking already. You can start underlining while we're reading and then we'll start fixing all those things. You are right, Ryu . You can start underlining already close to another. Yeah. All right. So Quincy. Is it OK? Can you read the one in the purple box, please?	Teacher	suggesting task
64	13:16.4 - 13:28.3	So, (reading from the text) whale shark is the biggest fish in the world. It's as long as a bus. It has no teeth, so it only eats plankton and small shrimp.	Quincy	
65	13:29.0 - 13:31.8	Well done. Well done. Yes, (indicating student)	Teacher	
66	13:32.0 - 13:38.9	I think they made a mistake because when they're born they're not as big as this, they need to write,	Ruslan	evaluating
67	13:40.8 - 13:41.4	I'm sorry, (there was external noise)	Teacher	

68	13:41.8 - 13:42.6	we have to write, adult	Ruslan	
69	13:46.2 - 13:55.5	ahh, they're not born like that. oh là là what a terrible mistake (theatrically). Well, they just simplified it too much. They made it too simple. Speak (indicating student)	Teacher	
70	13:56.7 - 14:01.1	maybe in the, uh, in the book.	Quincy	epistemic work
71	14:01.8 - 14:02.1	Yes.	Teacher	
72	14:02.4 - 14:09.7	In our science book, we in our humanities book. We have. We can write. Step one Step two and step three.	Quincy	epistemic work
73	14:11.2 - 14:41.3	This is it, in the notebook, we can explain a little better. But right away we could say the adult whale shark, let's right away because it's just so silly. The adult whale shark. Well done. Thank you for that comment. The adult whale shark can it's not is OK, then it's as long as it can. What did we write before?	Teacher	connecting
74	14:42.8 - 14:43.1	it can grow	Ruslan	
		(discussion about the whale shark and re-writing the sentence at Quincy's suggestion)		
113	22:23.4 - 23:40.0	Well, yeah, I see your point. I see your point. I see your point. So well done. So dear. So we read a lot. Dai. I'm sorry. You have to go. ... (Dai leaves for a different lesson) Well, you. All right. Thank you, children. Now we're fixing this. We are fixing this. So, so it means what? In conclusion? Well done. All right. And we wrote the adult. And so the the the the the whale shark is a filter feeder voilà good. Lots of seaweed called kelp. Now it's your turn. (indicating Ryu)	Teacher	
114	23:40.3 - 23:55.6	(reading from the text) Lots of seaweed called kelp grows near the seashore. The kelp is a safe home for many fish, no, many fish.	Ryu	
115	23:56.2 - 23:59.2	Wait. this is the *habitat*.	Teacher	
116	24:02.6 - 24:02.9	kelp	Ryu	
117	24:02.9 - 24:05.4	let's write next to	Teacher	
118	24:06.3 - 24:06.4	kelp is the	Ryu	
119	24:08.1 - 24:22.7	kelp wait wait the kelp is a type of seaweed. Let's write the word the kelp forest is the *habitat* of the sea otter, the kelp forest	Teacher	
120	24:23.8 - 24:24.7	is that sea otter? (pointing to the picture of the sea otter on the page)	Ruslan	
121	24:24.9 - 24:30.8	that's a sea otter. The kelp forest	Teacher	
122	24:32.9 - 24:33.7	seaweed called	Quincy	
123	24:34.8 - 24:35.0	where do we write	Quincy	
124	24:37.6 - 24:39.4	is that where do we write it?	Teacher	
125	24:40.1 - 24:40.3	here, here	Ruslan	
126	24:42.4 - 25:10.9	instead of, well done. Let's write that over. Good question. Let's write that just over where it says the kelp is a safe home for many fish. This is silly. A home is what people have. All right, you see what I'm saying. It's a silly word. (exchanges meaningful glance with Ruslan) The correct word is *habitat*. So let's correct the sentence and write the kelp forest	Teacher	meta-talk
127	25:12.3 - 25:13.4	and it's not actually the safe because you...	Ruslan	reasoning

128	25:14.7 - 25:56.3	Yeah, yeah. Yeah, well, it's safe. Yeah, it's it's it's a silly thing to say because every animal has an enemy except the apex predator and not even talking about humans. Let's not go there. So *the kelp forest is the habitat for many organisms*. Yes, for habitat for many organisms. Because why it's a habitat, Ryu because it's a specific place in the ocean biome, repeat	Teacher	
129	25:56.5 - 25:59.3	in the ocean biome.	all	
130	25:59.5 - 26:03.4	This is a specific place. Yes, does it make sense?	Teacher	
131	26:04.0 - 26:06.3	Yes. Yes.	Quincy	
132	26:07.3 - 26:07.4	for living organisms	Ruslan	
133	26:08.3 - 26:36.2	For many living organisms. Yeah. The kelp forest. So the kelp actually when you go in the water. I haven't done this, but I've seen programs. The kelp look like trees. There's a lot of them, and then it looks like trees and all the animals are happy in there. It looks really amazing. And so they call it the forest, scientists call it the kelp forests because it looks just like it.	Teacher	
134	26:38.4 - 26:38.5	how do you write *organism*	Ryu	
135	26:38.5 - 26:42.9	You should know, isn't it, (looking at the word wall) there isn't. Not here,	Teacher	
136	26:42.9 - 26:43.7	can I try it? (offers to go to the word wall)	Quincy	suggesting task
137	26:44.4 - 27:04.2	Absolutely. I mean, there's there's a is there. Here's a green. (handing him a green whiteboard marker) Here's the green. There you go. Well done. Is it not here? No, it is not, to find a place for it. Good	Teacher	
138	27:06.2 - 27:06.6	can I say to Ruslan about the web.	Ryu	epistemic work
139	27:10.8 - 27:37.3	aha, no, first prompt Ruslan, first ask Ruslan, Ruslan. Now let's have comments about the diagram tell me your comments about the diagram, (to Ryu) right? It's, so tell me (to Ruslan), tell me your comments about the diagram.	Teacher	
140	27:38.5 - 27:42.8	My comment is, it's not very good because it doesn't have the Sun.	Ruslan	epistemic work
141	27:43.0 - 27:50.6	It doesn't have and it doesn't have the sun. Life starts with the ....(pause)	Teacher	epistemic work
142	27:51.5 - 27:51.9	Sun.	severally	
143	28:01.8 - 28:02.0	here, like this, o-r-g a n i s m s. (writing on the word wall)	Quincy	
144	28:09.1 - 28:19.4	yeah, yes, take away the s, because we don't need to say many, just one, does that look good to you. Look good to you. What do you think?	Teacher	
145	28:20.6 - 28:20.9	yes	Quincy	
146	28:20.9 - 28:39.1	Or-ga-ni-sm let me say it again and look at it. Say it again. Oh it looks good. Yeah, you can see you can see for yourself that it's perfectly good, but I agree. Thank you for asking . Thank you for asking. You're doing a great job.	Teacher	
147	28:42.5 - 28:42.7	and I have an idea	Ruslan	
148	28:44.4 - 28:45.6	you have an idea, what else	Teacher	
149	28:46.3 - 28:46.7	maybe we can erase this at the top (gets up and points to words)	Ruslan	suggest task
150	28:49.3 - 28:50.3	What can we write?	Teacher	

151	28:51.5 - 28:52.0	We can erase	Ruslan	
152	28:52.3 - 30:10.6	"who what, when, where, why" (words at the top pf the word wall) OK, let's hear it very clearly. So I'm just going to put it here. So I see your point because we know this already. All right. Okey dokey. And I forgot to write the bullet points, I forgot to write the bullet points . Okey dokey. So there is, specific, vast and where's organism. I can't see any more organism. Well done. Well done. All right. And then I'm going to put that bullet point and you put the bullet point. Well done. (finished writing on the word wall) So what's missing? So let's see if Ruslan can criticize all the elements, criticize all the elements, criticize all the elements of this silly diagram. Mm hmm. Mm hmm. (looking at Quincy's diagram where he has added over-writing and labels) And then instead of this title (for the diagram) so then you put what…	Teacher	
153	30:12.2 - 30:12.6	the food web	variously	
154	30:13.0 - 30:22.6	ocean, the ocean, because here again, it says *a* (emphasizing) food chain. Yeah. Is that very special? Is that very specific?	Teacher	
155	30:22.9 - 30:23.3	No,	Quincy	
156	30:23.5 - 30:31.4	not really. Not really. What do we need to say, the ocean	Teacher	
157	30:32.7 - 30:32.8	food web	Quincy	
158	30:34.3 - 30:34.4	do we have to write "the", because there is more	Quincy	reasoning
159	30:39.8 - 31:00.3	(claps once) Thank you. And let's write, An ocean an ocean food web. He is right.	Teacher	
160	31:00.7 - 31:02.0	Can I get a drink of water?	Ruslan	
161	31:02.4 - 32:05.1	Of course you can. …. The sea otter is a very important animal. The sea otter kills the enemy, it's the enemy of the kelp. The sea urchin, it turns out, eats the kelp. If there are too many, the kelp forests will disappear. So here is where we get to back to that story. Remember Quincy, you were telling about Mr H-- the last year (he nods), who said that there was not enough of something, Excerpt 4	Teacher	connecting
162	32:05.7 - 32:11.9	If there is not enough of one thing, then most of the things will disappear.	Quincy	connecting, Rich Point
163	32:12.4 - 32:15.8	Yeah. Imagine if the sea otter isn't there,	Teacher	inviting reasoning
164	32:17.2 - 32:17.5	the	Quincy	
165	32:17.9 - 32:24.7	the urchin will eat the kelp forest and the habitat of all those animals will disappear.	Teacher	
166	32:26.3 - 32:26.8	habitat loss	Ryu	
167	32:26.8 - 32:27.5	Habitat loss	Teacher	
168	32:28.8 - 32:34.6	meant that the animal who lives that	Ryu	
169	32:36.1 - 32:36.2	the organisms that live in that habitat	Teacher	
170	32:37.5 - 32:37.6	or biomes because there's more	Ryu	
171	32:38.8 - 33:15.3	we're speaking just about speaking about the kelp forest habitat, the biome is a bigger thing and maybe the biome is affected also. But the biome contains more than just the kelp forest, right? And but the biome is affected and everybody else.	Teacher	

		You are right about the biome being affected. Absolutely, I see your point. Now, friends. Can I ask you to write three study questions?		
172	33:16.4 - 33:17.5	Oh, like we did in chapter 1.	Ryu	
173	33:19.0 - 34:25.4	Yes, we did it before we did it before. Remember about the study question? Yes, the answer is right there. Well done. Well, yes. One two three. (indicating areas on the page) Please write one here, right? One here. How about OK, write one here to go right. One here to go with their answers? How about if you first write in the beautiful OK, whiteboard, right? …(proceeds to help the students organize their whiteboards for the task)	Teacher	

Transcripts – Iteration IV Energy

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IV energy - transcript 1 - energy introduction discussion 1 (edited, abridged) Episode 2

turn	Timespan	2020-03-04 energy introduction discussion 1 (edited, abridged)	Speaker	Annotations
1	0:02.4 - 0:26.7	I think you're saying that a table of contents is really it's a type of notes, but is, is, how is it different, I still don't know. (T speaking while adjusting iPad) Tell me again how it's different from, tell me again, how it's different from the concept map, because now I forgot excerpt 1	Teacher	inviting epistemic work
2	0:27.7 - 0:38.0	The concept map is kind of notes, and diagrams it's, it's not, the table of contents it's kind of what what you did,	Ruslan	
3	0:39.3 - 0:48.9	but how is that different from? So I'm still not sure, OK, because is that not what a table of contents is? It's what you did, yes (indicating student)	Teacher	inviting epistemic work
4	0:52.2 - 1:34.0	So in my idea, I think uh the table of contents is like what we did and we can come back so if there's no table of contents it's like where are we now again. And so I think the table of contents is for that and the energy and concept map, as I said before, and it's to put our idea here, so I think 15 days later, if you don't write a concept map, you will forget everything. (he pauses)	Ryu	meta-talk
5	1:35.6 - 1:37.9	For example, *prominences*, it's (pauses)	Ryu	meta-talk
6	1:38.5 - 1:48.5	hard to remember the first time. If we were writing a concept map, you can we can see our ideas clearly and then come back	Ryu	meta-talk
7	1:50.4 - 2:19.8	and come back to it. But but but here also we can see some ideas. (pointing to the board and table of contents) OK, I didn't finish writing the names of the chapters. OK, I didn't do that right? Not yet, because we didn't do it yet, but. How is how is OK, I get I get that. Aren't both of these things to help us remember? Yes.(students agree) Now, Kassim come back to what you were saying, please do you remember what you just said. (aside in Russian)	Teacher	inviting epistemic work
8	2:21.0 - 2:30.7	So like a concept map, it's like you show one idea, only one idea like this is the idea.	Kassim	
9	2:30.9 - 2:33.5	And here and	Teacher	extending
10	2:33.8 - 2:38.6	Here you divide the idea is in the idea that there is a lot of little ideas	Kassim	
11	2:38.6 - 2:54.6	A lot of little ideas, whereas, right. That's another word on the on on the one hand and on the other hand, repeat on the other hand, on the table of contents doesn't....	Teacher	
12	2:59.6 - 3:12.7	doesn't show lots of little ideas. And on the concept map, there is lots of little ideas in the idea	Kassim	
13	3:14.0 - 3:15.6	in the big idea. (indicating another student)	Teacher	inviting epistemic work
14	3:17.2 - 3:20.6	I disagree with Kassim about the table of contents	Roman	
15	3:21.1 - 3:39.8	Oh, say, how about if you say, I see it differently I see it differently (both speak) different*ly* (emphasis) different*ly*, I see the table of excuse me, I'm sorry, I say, I see the table of contents differently repeat. (both) I see the table of contents different*ly*	Teacher	

16	3:41.4 - 4:09.3	for the table of contents you need, if you found a really good idea and like in a chapter, like in chapter one, (teacher points to the table of contents and chapter one on the WB) you found a really good idea like you read something. And if you don't, if you don't remember like what chapter did I read it and where did I find this idea, in table of contents you just wrote where did I find it, and after you re-read it and you like, and you remember it,	Ruslan	
17	4:10.0 - 4:12.2	Oh so you're saying, you're saying, add	Teacher	extending
18	4:14.5 - 4:15.1	add	Ruslan	
19	4:15.6 - 4:19.2	we can we can put more. Is that what you're saying?	Teacher	extending
20	4:19.4 - 4:28.5	No, like if you put a chapter in a name of it, chapter that you read like, uh, the energy	Ruslan	
21	4:29.8 - 4:34.7	chapter one, let's call it, uh, x rays, (writing on the board)	Teacher	extending
22	4:35.2 - 5:10.0	x rays, and there's something there's like, uh, really important like about those colours like the visible light violet, green, yellow, orange and and you don't remember. And if you didn't write it like where did I get this idea and you forgot it, you like you check everything you find. You look 20 hours and here in table of contents you just wrote it and you just see it	Ruslan	
23	5:10.0 - 5:27.7	brilliant so so I think what I understand from you is that we can add more things here. (pointing to the board) Yes (he agrees) , we have a big thing x rays and then we learn, OK, it's to take special photos (writing it in)	Teacher	extending
24	5:28.5 - 5:36.1	Yeah. Or you can write something about like the the visible light and you say so you remember where it was and you write	Ruslan	
25	5:36.8 - 5:39.2	Do you mean what page number, where is that, what, you mean?	Teacher	Extending
26	5:39.2 - 5:46.2	Yeah like you don't remember if chapter one or chapter twenty	Ruslan	
27	5:46.6 - 6:01.1	OK, so then. But but yeah, this is it. So this is why we write details in the table of contents. You are right. I see your point, but your point was which I thought was interesting. Don't you think that we have a couple more things	Teacher	
28	6:02.0 - 6:02.3	Yeah	Ruslan	
29	6:02.4 - 7:28.8	So it's sort of like the subcategories. Les sous-catégories, t'es d'accord (in French, looking at Kassim). Right? You agree. Just like you wrote here, (taking up the concept map in front of Ryu and indicating on it) your titles and subtitle category and subcategory. All right. All right, so we could add those too. (pauses) Friends! (pausing and looking at everyone) That sounds like a really great note taking and strategy. Right, a strategy to help yourself. Because of the problem that Ruslan just pointed out. We can say, Oh, gosh, where was it about that amazing ultraviolet? And then you put you add. You add it. (looking at the table of contents on the board) Well, it's not going to be here and it's not going to be here. So you add it in the chapter, maybe it's in here, maybe it's in here and. (writing on the board) Ultraviolet, then you're going to, oops, I can't even write. Then you're going to. You're going to write maybe a little a little bullet points under that. To say…	Teacher	evaluating, suggesting task
30	7:30.9 - 7:32.2	what you like the most	Quincy	
31	7:33.7 -	or what was the most striking, the most prominent. Just like the solar prominence. (speaking dramatically, looking at the students) …	Teacher	

	11:11.4			
		Discussion continues…		

IV energy - transcript 2 – energy ch 1 part 1 note taking diagram (edited, abridged) Episode 3

turn	Timespan	2020-03-10 energy ch 1a note taking diagram (edited, abridged)	Speaker	
1	0:02.3 - 0:27.2	(teacher is going around the table with the iPad) So the photo just shows a person getting ready to run to use kinetic energy. The photo but and the box says 25 percent is heat energy (teacher misspeaks). So what is the other? That leaves what? Seventy five percent (both teacher and Ryu)	Teacher	
2	0:28.6 - 0:33.6	It says (pointing to the text) when people run only 25 percent of the energy is kinetic	Ryu	
3	0:33.6 - 0:36.2	kinetic energy (with Ryu). And then what?	teacher	
4	0:36.4 - 0:38.5	75 percent is what	Teacher and Ryu	
5	0:38.9 - 0:39.5	is heat	Ryu	
6	0:39.5 - 1:50.5	Good. Put a diagram, put that in your diagram, show that in your diagram. (pauses, students are drawing) Make a diagram that explains this. And maybe you need to draw a little bit more and maybe you need to add … (stopping and pointing to Ryu's drawing) this doesn't do it. I'd like a little bit more for that, you just wrote two more text boxes …(continues rephrasing) (pointing alternately to the two different text boxes) In what is, in what what is the heat and what is the kinetic? You haven't explained what is the kinetic energy, you just put a text box. You see what I'm saying? (going around again) How can you show kinetic energy? What are you going to do to show kinetic energy?	teacher	
7	1:50.5 - 1:51.1	It's running.	Quincy	
8	1:51.5 - 2:06.8	Yes. So how are you going to show that? You make you make the stick figure look a little bit like, OK, a little bit like what? What?	teacher	
9	2:07.9 - 2:08.0	Like he's running	Quincy	
10	2:08.8 - 3:14.0	yeah, he or she. He or she. He or she. He or she. So then we want to, we want a diagram that shows the two types of energy. …(rephrasing) Don't just write more words (to Ryu, pointing to his page). Because then that's just the same as this. The text box for this photo in the photo, I don't understand. I look at the photo (of the athlete) and I'm trying to learn. I don't understand. Where is the heat energy and where's the kinetic energy? (iPad stops recording)	teacher	

IV energy - transcript 3 – energy ch 1 part 2 diagram work KE and heat energy (edited, abridged) Episode 3

Turn	Timespan	2020-03-10 energy ch 1b diagram work KE and heat energy (edited, abridged)	Speaker	Annotations
1	0:04.4 - 0:39.4	(teacher has restarted the iPad recording) Please draw a diagram that shows kinetic energy and heat energy. Because this photograph does not really do it. I look at the photograph. I don't really understand. It's not enough. They should have added something to the photograph. And you can do it with the stick figures. So these are called stick figures. The name of this is a stick figure. Yes.	Teacher	
2	0:39.6 - 0:39.9	Yes.	Ryu	
3	0:40.0 - 1:34.0	Good. So show, please, stick figures with these stick figures, aha, aha,(looking at Ryu's work) show, please, the heat energy and the kinetic energy. Please. Because that's what science people do. They try to represent. In particular, things that you can't really see that you need to, like, get evidence for like those molecules yesterday, (on the web site) we can't really see them, can we?	Teacher	
4	1:36.2 - 1:36.3	no .... (more examples discussed)	Ryu	
7	1:43.6 - 2:29.5	Not really, except for those clouds. Right? And carbon dioxide, you can never really see it, except when it's ice. .... (asides) So we are trying to represent. Repeat,	Teacher	
8	2:29.5 - 2:33.5	we are trying to represent	all	
9	2:34.0 - 3:00.6	the two types of energy. In this diagram, with stick figures. How about using two colours, two colours use two colours. One colour for the stick figure and then a colour code. Why not use a colour code, boys?	Teacher	
10	3:02.0 - 3:04.6	I was I was going to use,	Quincy	
11	3:04.8 - 4:44.7	please use a colour code, because then I get to understand a little better with a colour code, don't I. If I have a colour code. (pause) Good, how are you doing? How are you doing? So did you use a colour code? All right.	Teacher	
12	4:48.9 - 4:49.0	I did	Ryu	
13	4:49.0 - 5:01.5	What's wrong with that? It gives it gives an idea like a goal. No, I know that's OK, because then all of us really understand, the stick figure represents repeat.	Teacher	
14	5:01.7 - 5:04.1	The stick figure represents	all	
15	5:04.4 - 5:33.6	the footballer making an effort and anybody, well, I don't know who can't understand, ..(continues rephrasing).. So that is something that in pretty much	Teacher	
16	5:33.9 - 5:34.9	people know	Ryu	
17	5:34.9 - 6:08.9	people know and will see will realize, OK, that makes an effort. (miming running motion with arms moving) So the kinetic is happening. Good, but how are you showing? OK, I suggest putting these numbers a little bit below (pointing to Ryu's whiteboard), OK, I suggest first of all, first of all. First of all, the number is last. Now how did you show the heat energy.	Teacher	

18	6:10.9 - 6:11.0	The orange (pointing to the drawing)	Ryu	
19	6:15.0 - 7:03.3	heat energy is orange. *(*Ryu begins to explain*)* not really but OK, OK, OK, honey, you made you made the stick figure orange. Is that what you did? *(*Ryu agrees) Yeah. Does that really help me understand? *(*pause as Ryu considers*)* I want this because I don't really get. Yes. *(*Ryu explains*)* The reason why I did the orange, to show the runner does. But it's the same runner that has the heat and kinetic, the same runner. *Yeah.* So you don't put the runner, if you put the runner orange…(iPad stops recording)	Teacher and Ryu in rapid exchanges	

IV energy - transcript 4 – online environment, energy ch 6 coal formation, first part of the lesson (edited)
Episode 6

turn	Timespan	2020-05-05 energy ch 6 coal formation lesson part 1 (edited)	Speaker
1	0:02.1 - 0:17.3	How did the coal happen over time? (using zoom pen to draw a box around the text sentence "Coal was made like this")Then this question doesn't really work. (pause) ok. excerpt 2	Teacher
2	0:18.0 - 0:39.9	My question on that is that, um, (pause) like on the first sentence, yes, on the first sentence, it said that lived on Earth.	Ryu
3	0:42.6 - 0:44.2	uh repeat, please.	Teacher
4	0:44.2 - 1:00.2	Millions of years ago. And I'm so I'm trying to ask the question how? How long? fossil fuels are made from	Ryu
5	1:00.8 - 1:08.6	how it how it started. The fossil fuel. Yeah. Yeah, I see your point because your answer. yes (indicating student)	Teacher
6	1:09.2 - 1:18.7	And the answer is supposed to be plants and animals that lived on Earth millions of years ago.	Ryu
7	1:18.8 - 1:36.2	Excellent, excellent. That is because you have pointed out, Ryu a very important point that we should know from this page. And the study question is about an important point.	Teacher
8	1:38.4 - 1:38.6	yes.	Ryu
9	1:39.7 - 2:15.9	You are focusing on a very important point. I'm proud of you and you are making a question about the important point so we remember it better. This is why we make study questions. Well done, well done. Let's look at how you made your study question, though, you said, how are fossil? How are fossils produced? Right? So we can't here, Ryu and everybody. We cannot use the word "produce" here	Teacher
10	2:18.6 - 2:20.3	in the and we say,	Ryu
11	2:21.2 - 2:21.6	yes,	Teacher
12	2:22.7 - 2:25.2	Then what can we say?	Ryu
13	2:25.5 - 4:16.5	Excellent. Excellent question. Because *produce*, *produce* is like making, ..asides .So now we're discussing Ryu's question. Can everyone see that here? If we say the word *produce*, hm it's not quite what we say in science, okay, because *produce* it more like what we really do in the in in our workshop. You are you are taking a piece of leather and putting it together to make our shoe. Right? We produce shoes from leather. OK. So it doesn't quite work. It doesn't. ...Who can say instead of "made from"? Yes. What should we say instead of "made from"? Because that's the word that you're (referring to Ryu and his question) trying to work on. ((underlining with the zoom pen, figure 16)	Teacher

14	4:19.2 - 4:19.7	Yes.	Ryu
15	4:21.0 - 4:50.0	What can we say? Can anyone have another idea.... What can we say instead of *produce*	Teacher
16	4:54.2 - 4:54.6	made?	Ruslan
17	4:55.6 - 5:16.8	Yes. Well, made didn't help. Made is not science. So what we're going to say is this. *Fossil fuels are*. (teacher is typing it in the sticker) Can everyone see what I'm typing.	Teacher
18	5:18.5 - 5:18.9	Yes	Ryu
19	5:24.4 - 5:31.9	(begins to read aloud what the teacher is typing in the sticker) *are are the result of a long process of*	Quincy
20	5:33.2 - 5:34.3	*converting*,	Teacher
21	5:35.5 - 5:46.7	(reading aloud) *of converting plants and into compressed*... (pause) Oh yes!	Quincy
22	5:53.2 - 7:09.5	All right. So that's what we're really trying to talk about. .... I'm going to go to Google and search, and .... OK, here we go. You get some amazing images. Let's try this one here. (inserts image from the online search function) That's right. Do you see?	Teacher
23	7:12.2 - 7:12.6	Yes.	Ryu
24	7:13.6 - 7:19.3	So we're really using we have to use the word formed. figure 17	Teacher
25	7:24.2 - 7:30.0	OK. So the formed, yes, is like how it changed.	Ryu
26	7:30.9 - 8:12.0	Exactly. Ryu, you have it. It is material that started like a plant and then it rained down. Yes. And what happened was it was buried under more stuff, under more material, and the material pushes it down. The material with pine gets pushed down. And then it becomes all pushed together. The word is you see the word pressure. You see the word heat.	Teacher
27	8:13.7 - 8:14.1	Yes.	Ryu
28	8:15.0 - 9:07.8	So this is the process of coal, the formation of fossil fuel formation. Three hundred million years ago, it takes a long time because it is formed through heat and pressure. Yes. All right. But Ryu, you understood beautifully. We say formed because there is one form here you have a plant and then it changes in the form. Can everyone see that? Say yes, yes, yes, teacher, yeah. You see it. So Ryu, your point is brilliant. That is why we have to use the word form,	Teacher
29	9:09.6 - 9:10.5	maybe because	Ryu
30	9:10.6 - 9:56.5	well done, well done. And you see, I'm using a proper source from a public, from a from science people in the National Energy Education Project....	Teacher
		...managing technical issues...	
40	10:55.0 - 14:14.3	.... So now let's look at it together. So this is a very nice little comic that explains with some diagrams with a text box, diagrams with a text box. So this is very well done. You know what we can add here? I'm going to add the time. Three hundred million years ago. ok, that goes here. Well done, and then what	Teacher

		can I do here? Who can say what time this is or this list? It's already here.(indicating with the zoom pen) One hundred million who can make a sticker and put it here, please. Someone makes a sticker and puts it here and someone makes a sticker and puts it there. I delete my sticker. Oh, you deleted my sticker. This has to be three hundred and now. Yeah. OK, so that goes there. figure Now, we don't say the word "now". What do we say in science? We don't say the word "now".	
41	14:16.0 - 14:17.2	Maybe today	Ryu
42	14:18.4 - 14:51.2	close. Close. Thank you. Yeah, Ruslan. don't put your name. Good. We don't say the word. What do we say? What do we say? I don't remember. Did we do? Do you remember how we did? Did I do with you? I can't remember at the moment the timeline	Teacher
43	14:51.2 - 14:52.1	I think I know.	Kassim
44	14:52.5 - 14:53.0	Yes.	Teacher
45	14:53.3 - 14:54.6	Our days	Kassim
46	14:55.6 - 14:55.7	pardon	Teacher
47	14:55.7 - 14:58.2	in our days.	Kassim
48	15:00.4 - 15:01.1	oui you're saying in French de nos jours,	Teacher
49	15:03.3 - 15:03.5	oui de nos jours (in French)	Kassim
50	15:05.3 - 17:41.4	oui, sauf que on ne dit pas ça même en français c'est ce que quelqu'un dit à l'oral. (in French). So when you present in science, you don't say that is. So we're going to change this. (pointing to text with zoom pen) We're going to change that. In the science we don't say, "now", we say, "present day", OK, this is what we say in science. (Quincy has retyped the sticker) Oh, OK, well done. (pause) So now what I'd like you to do is you're going to draw your own card in your notebook, in your blue notebook, (pause), you are going to draw this comics. (pause) Open a new page completely.	Teacher
		...more technical issues...	
82	22:14.0 - 22:35.1	Is everyone OK? So your beautiful Jamboard. Yes, beautiful Jamboard, I see. I think everyone is on it. Yes, I think so. And you do exactly like this. You make a nice title. "How coal was formed" (pause)	Teacher
83	22:36.2 - 22:55.2	(Student holds up notebook to the camera) Well done (noise) Well done. (pause)	Teacher
84	23:11.0 - 23:28.8	(Student holds up notebook to the camera) Well done. (noise). (pause)	Teacher
85	23:34.4 - 23:54.3	And then you put exactly like this, exactly like in the Jamboard because they are doing it in the science style on this page (noise).	Teacher

IV energy - transcript 5 – in person environment, reviewing work on students' energy diagrams and re-reading chapter 2 (edited) Episode 8

turn	Timespan	2020-05-28 reviewing work on students' energy diagrams and re-reading chapter 2	Speaker	annotations
1	0:09.9 - 0:25.4	Does. Yes. Sure. Yes. Oh, I (students' background talk while working at the word wall and consulting their energy project posters, teacher adjusting the iPad)	students	
2	0:26.6 - 0:48.9	Mm hmm. So here we are. How heat energy moves, so how heat energy is *transmitted*. (teacher is walking to the table with the iPad) *Quincy, simultaneously: transmitted* So how did we write it? Good job. (students over-writing "transmitted" in their booklets) You first thought of *transformed*, but but but here *transformed* is what happens here (pointing to the student posters)	Teacher	meta-talk
3	0:49.1 - 0:49.5	Yes,	Quincy	
4	0:49.6 - 0:59.4	right? From from this heat energy of this train. (pointing to the student posters) And then it *transforms* to this kinetic energy.	Teacher	meta-talk
5	0:59.7 - 1:00.1	Yes.	Quincy	
6	1:00.3 - 1:09.9	Well done. So here it's *transformed*. (pointing again to the diagrams on the posters) Here it's *also transformed in the process of coal formation*.	Teacher	meta-talk
7	1:10.2 - 1:12.8	oh then we have the *transmits* over there, (pointing to the word on his poster text box)	Quincy	
8	1:13.8 - 1:25.2	Hey, you wrote it already before, that's what you are trying to remember because these are words that you wrote from using what we learned when we were doing this.	Teacher	
9	1:25.8 - 1:26.0	Yes	Quincy	
10	1:26.0 - 1:30.3	Well done. Well done. So whose turn is it now?	Teacher	
11	1:34.2 - 1:40.7	*How heat energy is transmitted*	Quincy and Kassim	
12	1:44.2 - 1:53.2	*how heat energy is transmitted* (while preparing to set down the iPad, while students are deciding who reads aloud next in the booklet)	Teacher	
13	1:54.8 - 1:59.3	OK, now we can (looks at the teacher placing the iPad on the stand) heat energy doesn't (prompts Kassim)	Quincy	
14	1:59.3 - 2:05.7	(reading from the booklet) heat energy doesn't stay still, it moves from from, uh, (pauses and looks up to recall a different word;) an object (Ruslan thumps the table with his arm, Quincy sits up and gets set to write. Kassim has uttered a different word in place of the one in the anchor text) figure 29	Kassim	
15	2:07.5 - 2:07.9	oh first let's write "object" (he smiles at Kassim; pause while all three write the word in their booklets) figure 30	Quincy	suggesting epistemic task

16	2:30.5 - 2:31.4	that are warmer to another object. (another pause as students write in "object" each time to over-write "thing")	Kassim	
17	2:39.7 - 2:41.1	To other objects.	Quincy	
18	2:45.5 - 3:01.1	(away to see other students not in the group, sitting elsewhere in the room, and speaking to them) . ..,	Teacher	
19	3:02.0 - 3:05.1	objects that are cooler	Quincy	
20	3:05.1 - 3:10.5	to other objects that are cooler	Kassim	
21	3:11.2 - 3:11.6	to other objects.	Quincy	
22	3:13.7 - 3:16.2	To other, yes, (T standing by holding the iPad for a closer view of Kassim's over-writing work)	Kassim	
23	3:26.7 - 3:36.0	it's just two Ts, it's hard to believe.(pointing to Kassim's booklet, he proceeds to correct his notes, "transmitted") But there are two Ts, like little kids when they say, Putted, where did I putted? Where did I put that?	Teacher	
24	3:37.2 - 3:40.2	Ryu. Hi, Ryu, (Ryu has joined in a google meet call; the laptop with his call is placed on the table by the T)	Quincy	
25	3:40.4 - 3:44.1	(to Ryu in the laptop call) how are you doing? Nice to see you. There you are.	Teacher	
26	3:44.7 - 3:44.9	two Ts on transmitted transmitted.	Quincy	
27	3:44.9 - 3:56.0	transmitted. It's sort of like little kids when they say, putted. Did you ever hear a little kid say they put in? I putted it to me to get	Teacher	
28	3:56.3 - 3:57.2	to object.	Quincy	
29	3:57.8 - 3:59.6	Very good. Well done.	Teacher	
30	4:01.2 - 4:09.0	Ryu, we are reading chapter two and correcting heat energy page 10.	Ruslan	
31	4:10.5 - 4:20.8	OK, so I'm going to put you here. Ryu. I'm going to see if I can put you here. It's not easy. (placing the laptop with Ryu's call on the table, where his place used to be, facing the others and the whiteboard)	Teacher	
32	4:22.3 - 4:22.9	We're moving.	Quincy	
33	4:22.9 - 4:26.3	It's not easy moving everything around. Help	Teacher	
34	4:27.4 - 4:30.1	... between ... (reading from the booklet)	Quincy	
35	4:30.7 - 4:43.8	Isn't that amazing? He is so far away and there he is. Everything you need to know about science. Yes. Well, we're doing it already. We're doing it already, right? Okeydokey (Ryu answers "yes" in the call) We're doing it already.	Teacher	
36	4:44.0 - 4:46.0	I found about energy (he found the page in the booklet)	Ryu	
37	4:46.2 - 4:46.8	Aha.	Teacher	
38	4:47.3 - 4:50.3	heat energy the page number 10.	Ruslan	

39	4:50.7 - 4:54.6	So look in your booklet page 10, please. (Ryu answers "ok" in the call)	Teacher	
40	4:56.1 - 4:56.4	Good	Ryu	
41	4:57.1 - 4:58.7	after Kassim is going to be you, Ryu	Ruslan	
42	4:59.4 - 5:04.9	between between another object (continues reading aloud)	Kassim	
43	5:05.5 - 5:05.8	two objects	Ruslan	
44	5:05.8 - 5:17.7	when heat, when heat is transmitted between, uh, (interrupting himself) "things" is not a science	Kassim	meta-talk
45	5:17.8 - 5:28.4	*objects* (Quincy interjects; Kassim continues) Maybe we can say to help to other matter or something to other matter between. (translanguaging with "matière")	Kassim	meta-talk
46	5:28.4 - 5:52.4	Well, the thing is (interrupting Kassim's meta-talk), the thing is, no matter how can we say, how can we use the word matter, the matter here? Because this is this is a collection of matter right here. (patting Quincy's shoulder) And here's another collection of matter. (patting Ruslan's shoulder) This is matter, matter. This is matter. And this is matter. OK, so heat. If you lean your arm (patting Ruslan's arm) on this table, what happens excerpt 3	Teacher	Suggest epistemic task
47	5:52.8 - 5:54.0	after, you're, it gets	Quincy	
48	5:54.6 - 5:56.1	you're *transmitting*	Teacher	
49	5:56.4 - 5:56.9	the heat	Quincy	
50	5:57.0 - 6:21.1	to the table. So these are two objects (alternately patting the student's arm and the table). These are still two objects. Yeah. One with more heat energy, a system. Your body is a system with heat energy. This table doesn't have any (patting the table, students chuckle). So if you put your arm there, after a moment, that part of the table is a little bit warm due to what	Teacher	suggests epistemic task
51	6:21.8 - 6:30.4	*due to the heat transmitting the heat energy to the table*	all	epistemic work
52	6:30.6 - 7:55.0	Well done. Well done. So we can still say heat is transmitted from the high energy system. (Quincy suggests) Yeah, yeah, yeah. So now we're going to write this here. Write it here. Let's write this example of this person's arm. Heat is transmitted. From an an object of high energy. To an object of low energy, is transmitted. Make your T higher (to Quincy), you see, two Ts two Ts. Heat is transmitted. Does that make sense, from a s- Let's write a system because Ruslan is a system. The human body is a system, right Mo (to a different student outside this group) right, from a system of high energy because Ruslan is a high energy guy, haha (laughing theatrically), and a system of high energy. Because that's what we say, we don't say high temperature, right? excerpt 4	Teacher	suggests epistemic task
53	7:56.3 - 7:59.2	(Looking up from writing) High energy, high heat energy. figure 31	Kassim	
54	7:59.4 - 8:05.4	Brilliant. To an...	Teacher	
55	8:06.1 - 8:06.7	an object,	Ruslan	

56	8:06.9 - 8:48.6	an object of lower energy, it's always relative. You must know boys temperature is relative in the universe. OK. It's always something relative to another. Mm hmm. All right. To an object of a lower temperature or lower energy, I'm sorry. Lower energy. Well done. Does that make sense to you? Then you write, for example, for example, Ruslan, Ruslan's arm, write the example of Ruslan's arm, what can we say about Ruslan's arm,	Teacher	Suggests epistemic task
57	8:49.4 - 8:51.8	for example, my friend's arm,	Quincy	
58	8:52.0 - 9:13.6	for example, comma, my friend's arm sits on the table. (walks away to place the iPad on a stand) What can we say about Ruslan's arm? My friend's arm leans on the table.	Teacher	
59	9:16.4 - 9:16.7	Maybe we could make a little diagram figure 31	Ruslan	Suggests epistemic task
60	9:18.4 - 9:25.3	you could make a little diagram ! (repeats, exclaiming; Quincy immediately looks up at the teacher and grimaces) That, is that what science people do? figure 32	Teacher	
61	9:25.9 - 9:26.3	Yes. (Kassim looks up; Ruslan looks up and nods) figure 33	Kassim	
62	9:26.8 - 9:28.2	Well, I don't really have space (looking at his booklet)	Quincy	
63	9:28.4 - 9:35.8	yes, you do, yes, you do. I'm sure you do right there (pointing to his booklet). Well done. So then we draw (gesturing at Ruslan theatrically with both arms) you know,	Teacher	
64	9:35.9 - 9:37.1	beautiful Ruslan (laughing)	Quincy	
65	9:38.1 - 9:38.5	Yes.	Teacher	
66	9:40.0 - 9:40.8	Then we do	Quincy	
67	9:41.8 - 10:00.4	an artistic stick figure, and it can be a stick figure (Quincy showing Ruslan his work and chuckling). It can be a stick figure. to represent the transmission of heat	Teacher	
68	10:02.1 - 10:03.0	Yeah, I'm doing this here.	Quincy	
69	10:03.8 - 10:26.4	(moving to other students in the room but not in the group, while these students work on their representations)	Teacher	
70	10:27.7 - 10:28.4	(humming) C'est beau ... Beautiful (chuckling to himself)	Quincy	
71	10:33.8 - 10:40.1	And then we show then we show then, then we show (teacher is moving elsewhere in the room; students chuckling at each other as they work)	Teacher	
72	10:40.1 - 10:45.4	(showing Ruslan, chuckling) take a look at this figure 34	Quincy	
73	10:46.4 - 11:01.2	(asides, working with the other group of students) ...	Teacher	
74	11:04.0 - 11:06.1	Oh, hi. Hi, Ryu. (responding to Ryu in the google meet call on the laptop on the table)	Quincy	
75	11:06.6 - 11:16.6	You know, yesterday ... (aside to Ryu)	Ruslan	

76	11:23.2 - 11:29.8	heat system. Mm hmm.	Quincy	
77	11:36.1 - 11:49.4	(Ryu in the call showing his diagram; teacher approaches to see him in the call), good, good, Ryu, make this diagram, make a diagram. Well, Ruslan is sitting at the table and then	Teacher	
78	11:49.4 - 11:58.6	he has his hand on the table. Then the energy transmits through the table because it's after a while on the table.	Quincy	
79	11:59.7 - 12:01.7	It's all over. can you do that?	Teacher	
80	12:01.9 - 12:06.0	(stands up abruptly) Can I have a red to demonstrate that I'm kind of the heat is coming? figure 35	Ruslan	suggesting epistemic task
81	12:06.9 - 12:09.9	Yeah. What you're going to do is you're going to have a red pencil.	Teacher	
82	12:12.0 - 12:12.3	Yeah.	Quincy	
83	12:13.1 - 12:16.9	OK. Let's have a red pencil.	Teacher	
84	12:20.4 - 12:21.9	Ruslan can you sit on the table.	Ryu	
85	12:22.4 - 12:26.6	No, sit on a chair. Yes, it's not on the table,	Teacher	
86	12:26.6 - 12:36.8	so you could sit on the table. Oh, well, thanks. You don't like sitting on the table.	Quincy	
87	12:43.6 - 13:03.6	Well done. Well done. (while going around elsewhere in the room) So let's have a look. (picks up the iPad to start viewing the students' work) OK. Heat system. So how do you write system again? How is it again? Remember, it's a Greek word. So the Greek words	Teacher	
88	13:04.2 - 13:07.5	can I say, yes? It's s-y-s -t-em	Quincy	
89	13:07.5 - 13:19.2	yes. Correct. Correct. So if you know it's a science word, then you know it's a Greek word and the Greeks put a y, not an i. Voilà.	Teacher	
90	13:19.8 - 13:21.4	not an i-e.	Quincy	
91	13:21.9 - 13:23.8	Yes. Those are things. And no.	Teacher	
92	13:24.9 - 13:25.4	Sure.	Quincy	
93	13:26.6 - 13:34.1	good (in Russian). So here we have. (pointing to Ruslan's booklet as he is drawing) Here's the person with the red arms because the heat is... figure 36 excerpt 5	Teacher	
94	13:36.8 - 13:37.7	*Quincy*: all around, all around us *Ruslan simultaneously*: I'm going to make a little key	Quincy and Ruslan	
95	13:37.7 - 13:49.5	Well done. Well done. And you're making a diagram. Because, why? Why are we making a diagram, so... (prompting anyone to speak in general) figure 37	Teacher	meta-talk

96	13:49.5 - 13:58.4	so we understand better what we want to say, and we can see how is it,	Kassim	epistemic work
97	13:58.6 - 13:59.0	Mm-Hmm.	Teacher	
98	13:59.5 - 14:14.4	if It's only some blah blah, we will only know, but there will not be an example. So in our head, it will be more difficult to understand (gesturing to his head while looking at Quincy). figure 38	Kassim	epistemic work
99	14:15.4 - 14:20.0	Good. The word for that is concept. You have that in French also. Right?	Teacher	
100	14:20.3 - 14:20.5	concept le concept, (pronouncing in French)	Kassim	
101	14:20.5 - 14:38.5	le concept, well done. Well done. I see your point. I see your point. I see your point. And what did you do? (pointing to Quincy's diagram, where he has written a time expression) You wrote what? What does that say?	Teacher	
102	14:39.6 - 14:40.9	Five minutes later	Quincy	
103	14:42.9 - 14:44.7	What is this? This is a…	Teacher	
104	14:46.5 - 14:47.9	*Ruslan*: protses *Quincy interjects*: process	Ruslan and Quincy	
105	14:48.8 - 15:00.8	A-one. A-one ,what a scientist, what a scientist, you are showing and you're putting a (pointing to Ruslan's diagram key)-- key. (word spoken simultaneously with Ruslan)	Teacher	
106	15:05.7 - 15:06.4	High energy (Kassim is writing the text box for his diagram panel and pronouncing the words as he writes)	Kassim	
107	15:15.4 - 15:32.2	is Ryu doing this too back home. Ryu, you can put your microphone on unless somebody is, you know, chopping vegetables in the background. (teacher knows the student is in quarantine in a hotel)	Teacher	
108	15:38.9 - 15:40.8	From the high energy system	Kassim	
109	15:41.3 - 15:44.6	to a low energy.	Teacher	
110	15:44.6 - 15:48.0	How can we say "get" in a science way?	Kassim	
111	15:48.2 - 15:49.9	What do you mean, "get"?	Teacher	
112	15:50.2 - 15:58.6	Oh look, we have it over there (getting up and pointing to the word wall) It's *obtain* or *provide*. *Kassim continues* Oh yes, I'm going to say *obtain*.	Quincy and Kassim	
113	15:59.2 - 16:07.1	What? (speaking to students not in this group, elsewhere in the room).....	Teacher	
114	16:10.0 - 16:10.7	Going home,	Quincy	

115	16:12.9 - 16:20.6	(to Kassim, commenting as he is writing) it is simply being transmitted heat from is being is transmitted, tout simplement (in French), quite simply. Mm-Hmm.	Teacher	
116	16:21.2 - 16:26.0	So here we have Ruslan sitting on the table. (pointing to his diagram, the first panel, with the red pencil, as he is speaking) figure 41 excerpt 6	Quincy	
117	16:26.6 - 16:28.1	At the, you mean at the table	Teacher	
118	16:28.1 - 16:36.4	At the table, Yes. And there he has heat energy, five minutes later (pointing to his second panel). The table's a bit warm. Then it's playtime, (pointing to the time expression)	Quincy	
119	16:37.4 - 16:37.5	the	Teacher	
120	16:38.1 - 16:42.5	he's gone and there's a bit of energy over there. (pointing to the third panel)	Quincy	
121	16:47.2 - 17:34.7	Are you a scientist? I can see that, this is my evidence, evidence. . figure 42 You are a science person. You represented the concept of energy, because, as Kassim said, the blah blah helps a little bit, but the best is a series of diagrams and you did it by yourself I didn't ask you to make this process. You Ruslan first, said what, Let's make a diagram because Ruslan is a young scientist. figure 43 And then you started to make a process because you realized just from this. Did it help, Quincy, that we had these? (pointing to the project posters on the whiteboard, with his diagrams glued on) This one here? Did that help	Teacher	
122	17:35.0 - 17:39.6	Yep. Yes. I learned it from that diagram.	Quincy	
123	17:41.4 - 17:48.4	*Teacher* The process of … *Quincy*: coal *Teacher* …formation. Wow.	Teacher	
124	17:57.0 - 18:02.3	*Quincy to Ruslan*: You need to make the key. *Ruslan*: No, I have here *Quincy*: OK.	Quincy	
125	18:05.5 - 18:25.6	Well, well, well, we might add a really super piece of information to this. I'm just going to check something I don't know if I'm online. …	Teacher	

Appendix B

Complete summary of findings, Iteration I – Farming

Farming weeks 1 – 3 "… we're also writing and we're correcting it to remember more."

Episode 1 Concept maps: ▪ Epistemic Work Rich Point: rewriting the concept map title, by Ryu	Finding ▪ Epistemic work (EW) o words begin to be seen as ideas ▪ Ss choices: authoring ▪ vocabulary work begins to be meaning-making through authoring and presenting to others ▪ idea generation begins as a discourse practice o authority: deciding what is important --> what "counts" o elaboration sequences of talk, initiated and sustained by Ss other Practices: ▪ noticing by T and Ss established: o noticing as affect ▪ interaction: writing o modelling of writing: exemplars o locus of epistemic work: student rewriting text, re-focusing the topic o opportunities opened: contingent questions, idea generation tasks , chance to interpret	Example ▪ concept map: - Rich Point Quincy presents unusual points figure 2 - Ryu rewrites the key concept and elaborates on it figure 3 ▪ presenting: - Quincy and Ryu interpret, respond and argue why their chosen terms are needed ▪ interaction: by T - publicly writing and re-writing figure 1 - taking photos of discursive acts, artifacts ▪ goal setting - ss deciding the focus of the topic figure 3	Design Principle ▪ prior knowledge ▪ epistemic goal-setting, shared ▪ integrated language and literacy with representations o student thinking is "made public": accountable o knowledge is inscribed as a resource, shared o ideas are made visible: o are objects of discussion ▪ dialogic and authoritative alternations: o deciding as a group o interpreting and responding ▪ affect: trust and time ▪ practices o constructing exemplars o noticing as connection making

Episode 2

Anchor text:

- Epistemic Work
- Meta-talk
- Languaging

Rich Point:

talk about and writing AL words, in first over-writing, by students

Finding

- Epistemic work (EW)
  - noticing as EW: seeing words as ideas in the anchor text
  - authoring:
    - writing study questions
    - writing new words: new ideas
  - editing study questions
- Meta-talk (MT)
  - words are discussed as ideas
    - read-alouds are a practice of reasoning aloud, hence
    - selecting the appropriate AL word is perceived as a need to be resolved
  - noticing: expressed in MT
    - ideas require tone and "correct" term
  - connecting
    - T invites ss to continue connecting terms with own experience
- Languaging (L)
  - words are authored as ideas:
    - over-writing the AL terms on the anchor text

other Practices:

- noticing by T and Ss : text-based discussion
- interaction: creating routines
  - *read-alouds*
  - *shared writing*
- opportunities taken by Ss to extend meta-talk with own connection making.

Example

- interaction: T and ss
  - performing read-alouds: prosody of expository text
  - discussion for AL: initiating practices
    - MT about AL, e.g. *tropical climate*
    - languaging: over-writing AL e.g. *suitable climate*; *produce*
    -
- interaction: by T
  - extending MT,
  - providing AL,
  - inviting connection making
  - goal setting,
- writing: Rich Point authoring text
  - study questions figure 4, figure 5
  - over-writing for AL: figure 6

Design Principle

- integrated language and literacy with representations
  - text is an *improvable object*
  - student thinking is "made public": accountable
  - knowledge is inscribed as a resource, shared
  - ideas are made visible:
  - are objects of discussion
- dialogic and authoritative alternations:
  - deciding as a group
  - interpreting and responding
  - opportunities
- affect: trust and time
- practices
  - constructing resources
  - noticing as connection making
    - local culture: noticing as practice
    - AL as practice
- modalities, paper, wb
- enacting AL:
  - speaking the tone of AL
  - authoring text in AL
- identity building: prosody of read-alouds

Episode 3 Anchor text : ▪ Epistemic Work ▪ Meta-talk ▪ Languaging Rich Point: "is there another word for water," by Ruslan	Finding ▪ Epistemic work (EW) o noticing as EW: reading and seeing words as ideas in the anchor text, for over-writing o authoring: reading comprehension tasks are now acts of knowledge construction ▪ Meta-talk (MT) o words are discussed as ideas ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need to be resolved o noticing: expressed in MT ▪ ideas require "correct" term ▪ ss initiate noticing ▪ T prompts for more instances and elaborations ▪ Languaging (L) o words are authored as ideas: ▪ over-writing the AL terms on the activity page text ▪ editing own answers for AL other Practices: ▪ opportunities ▪ initiated by Ss to extend meta-talk with own connection making ▪ taken by Ss to extend meta-talk with own noticings ▪ extended by T	Example ▪ interaction: Rich Point initiated by ss - discussion for AL: Ruslan in figure 8 - over-writing for AL: figure 7 - Ruslan initiates MT by giving an example, as EW, turn 2 - Ruslan's initiating MT turn 4, extending turn 59 - Quincy follows with own MT turn 24 - Ryu reformulates with EW and MT turn 38 - Ryu evaluates the practice, specifying that the book words are humanities book words, turn 46 - Ruslan evaluates the practice, ▪ defining the discourse as about writing and correcting, turn 55 ▪ defining the community: "we are" - Ryu initiates, provides a reformulated AL sentence for the current example, using the new AL turn 67 ▪ writing: - written comprehension tasks - over-writing as authoring ▪ interaction: by T - prompt, press, extend MT, e.g. turn 5, turn 25 - providing AL, turn 37 - goal setting, turn 13, turn 47, turn 58 - translanguaging, turn 41 - requesting evaluation, turn 54	Design Principle ▪ prior knowledge ▪ epistemic goal-setting, shared ▪ integrated language and literacy with representations o text is an *improvable object* o student thinking is "made public": accountable o knowledge is inscribed as a resource, shared o ideas are made visible: o are objects of discussion ▪ dialogic and authoritative alternations: o deciding as a group o interpreting and responding o opportunities: opened by S ▪ affect: trust and time ▪ practices o constructing resources o noticing as connection making ▪ local culture: noticing as practice ▪ AL as practice ▪ modalities, paper, wb ▪ identity building: ▪ prosody: enacting AL ▪ speaking the tone of AL ▪ authoring text in AL ▪ epistemic authority: evaluating practices

Farming – weeks 4 – 6 "So you can maybe draw a picture to say."

Episode 4

Anchor text;
Representations:
- Epistemic work
- Languaging

Rich Point:

representation construction, by Ryu

Finding

- **Epistemic work (EW)**
  - noticing as EW: seeing
    - words as ideas in the anchor text
    - connections between ideas
  - authoring:
    - writing study questions
    - editing: adding information
    - modalities
    - representations:
      - drawing tables : digital
      - drawing diagrams paper
      - devising colour codes and symbols as ideas
- **Languaging (L)**
  - words are authored as ideas: sentence level work
    - over-writing the AL terms
    - first re-writing EL to AL sentence

other Practices:

- **noticing** by T and Ss : text-based discussion
- **interaction**: routines
  - read-alouds
  - shared writing
- **opportunities** taken by Ss to represent own EW through discussion based process
- **multi-modal work:** representing ideas and connecting across modalities

Example

- note-taking: as discussion based practice, figure 10
- note-taking: **Rich Point** epistemic work
  - drawing tables figure 12
  - drawing diagrams as note-taking figure 13
  - drawing diagrams as idea elaboration, figure 14
  - writing as elaborating, extending ideas, figure 10
- writing: authoring text
  - study questions figure 11
  - over-writing for AL figure 10 figure 11
  - representations as text figure 13, figure 14
- modalities as epistemic practices:
  - selecting colour, text, layout, symbols
  - selecting modalities for purposes figure 12
- interaction: by T
  - providing AL,
  - providing new resources
  - suggesting semiotic work
  - goal setting,

Design Principle

- epistemic goal-setting, shared
- integrated language and literacy with representations
  - text is an *improvable object*: elaboration anchored in Ss constructions and edits of their representations
  - student thinking is "made public": accountable
  - knowledge is inscribed as a resource, shared
  - ideas are made visible:
  - are objects of discussion
- dialogic and authoritative alternations:
  - deciding as a group
  - interpreting and responding
  - opportunities: opened by S
- affect: trust and time
- practices
  - constructing resources
  - noticing as connection making
    - local culture: noticing as practice
    - AL as practice
- modalities, paper, wb
- identity building:
  - selecting semiotic signs
  - constructing semiotic signs
  - authoring text in AL

Episode 5 Anchor text: ▪ Meta-Talk ▪ Languaging Rich Point: - - ED grammar point, by Ryu	Finding ▪ Meta-talk (MT) o words are discussed as ideas: from word to sentence level ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need to be resolved ▪ ideas require sentence level to contain them o noticing: expressed in MT ▪ ideas require "correct" terms and sentences ▪ ss initiate noticing ▪ T prompts for more instances and elaborations ▪ Languaging (L) o words are authored as ideas: contained in the sentence level ▪ re-writing the AL terms and applying at sentence level ▪ constructing exemplars other Practices: ▪ noticing by T and Ss : words are objects and tools for discussion ▪ interaction: routines ▪ shared decision making ▪ student decision-making ▪ shared writing ▪ opportunities taken by Ss to lead in reasoning process ▪ multi-modal work: representing ideas and connecting across modalities ▪ framing and transfer : student inner speech reconstructed in social plane	Example ▪ note-taking: as discussion based practice, figure 15 ▪ note-taking: languaging as epistemic work figure 20, figure 21 - writing as elaborating, extending ideas, figure 15 - selecting AL figure 16 - object of reasoning and discussion figure 17 ▪ writing: Rich Point authoring text turn 93 figure 20, figure 21 - re-writing for AL figure 18, figure 19 ▪ modalities as epistemic practices: figure 19 - selecting colour, text, layout, symbols - selecting modalities for purposes ▪ interaction: by T excerpt 3 - prompting, extending student explanations - providing AL, - providing new resources - suggesting semiotic work figure 17, - goal setting figure 19 ▪ interaction: initiated by Ss excerpt 3 turn 93 - discussion for AL: - over-writing for AL: ▪ Ryu initiates MT by giving an example, turn 41	Design Principle ▪ epistemic goal-setting, shared ▪ integrated language and literacy with representations o text is an *improvable object* o student thinking is "made public": accountable o knowledge is inscribed as a resource, shared o ideas are made visible: o are objects of discussion ▪ dialogic and authoritative alternations: o deciding as a group o deciding as participant o interpreting and responding o opportunities: opened by S ▪ affect: trust and time ▪ practices o constructing resources o noticing as connection making ▪ local culture: noticing as practice ▪ AL as practice ▪ modalities, paper, wb ▪ identity building: ▪ selecting semiotic signs ▪ constructing semiotic signs ▪ authoring text in AL ▪ epistemic agency and authority: ▪ framing for transfer ▪ redirecting activity ▪ evaluating practices

Episode 6 Anchor text: ▪ Languaging ▪ Translanguaging ▪ Meta-talk Rich Point: translanguaging, finding 3 steps for AL in Dutch, through Meta-talk, by Quincy	Finding ▪ Meta-talk (MT) o words are discussed as ideas: from word to sentence level ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need ▪ ideas require sentence level to contain them o noticing: expressed in MT ▪ ideas require "correct" terms and sentences ▪ ss initiate noticing ▪ T prompts for more instances and elaborations ▪ Languaging (L) o words are authored as ideas: contained at the sentence level ▪ re-writing the AL terms and applying at sentence level ▪ writing AL process in own language o words are objects of reasoning: own writing becomes ▪ knowledge resource and ▪ manipulable objects other Practices: ▪ framing and transfer : student inner speech reconstructed in social plane ▪ translanguaging: student makes connections to own language ▪ noticing by T and Ss : words are objects and tools for discussion ▪ interaction: routines	Example ▪ note-taking: as discussion based practice, figure 22, figure 24, figure 25, figure 27, figure 28 ▪ note-taking: as epistemic work - writing as elaborating, extending ideas, - object of reasoning and discussion figure 24, figure 25, figure 27 - object and tool for reasoning: word wall figure 30 ▪ writing: Rich Point authoring text - re-writing for AL figure 29 - translanguaging for AL figure 23 ▪ modalities as epistemic practices: - selecting colour, text, layout, symbols figure 24, figure 25, - selecting modalities for purposes figure 26 ▪ interaction: by T - prompting, extending student explanations figure 22, excerpt 4 - providing AL, - providing new resources - suggesting semiotic work - goal setting ▪ interaction: initiated by Ss - discussion for AL: figure 24 - over-writing for AL: figure 26, figure 27 - Ryu initiates MT by giving an example, as EW, excerpt 4	Design Principle ▪ epistemic goal-setting, shared ▪ integrated language and literacy with representations o text is an *improvable object* o student thinking is "made public": accountable o knowledge is inscribed as a resource, shared o ideas are made visible: o are objects of discussion ▪ dialogic and authoritative alternations: o deciding as a group o deciding as participant o interpreting and responding o opportunities: opened by S ▪ affect: trust and time ▪ practices o constructing resources: sedimentation of practices o noticing as connection making ▪ local culture: noticing as practice ▪ AL as practice ▪ modalities, paper, wb ▪ identity building: ▪ selecting semiotic signs ▪ constructing semiotic signs ▪ authoring text in AL ▪ epistemic agency and authority: ▪ framing for transfer ▪ redirecting activity ▪ evaluating practices

	▪ joint decision making ▪ shared writing ▪ **opportunities** taken by Ss to lead in reasoning process ▪ **multi-modal work:** representing ideas and connecting across modalities		

Complete summary of findings, Iteration II – Healthy

Healthy – weeks 1 – 2 : *"because "food" is everyday"*

Episode 1	Finding	Example	Design Principle
Concept maps: ▪ Epistemic Work Rich Point: constructing concept maps using symbolic and aesthetic criteria, by students	▪ Epistemic work (EW) o words are used as ideas ▪ Ss choices: authoring ▪ words manipulated as objects ▪ idea generation at symbolic level as a discourse practice: devising symbols ▪ disciplinary conventions compared and constructed o authority: deciding what is important --> what "counts" other Practices: ▪ noticing by T and Ss practiced: o noticing as aesthetic ▪ interaction: building on routines o modelling of semiotic signs o locus of epistemic work: student designs for semiotic signs o opportunities opened: contingent questions, idea generation tasks, chance to interpret	▪ concept map: - Rich Point Ruslan presents unusual points figure 2 - Ryu writes colour key with adding math symbols figure 1 - Quincy writes colour key with own terms figure 3 ▪ interaction: T and ss - students interpret, respond and argue why their chosen terms are needed - publicly writing and re-writing - publicly devising symbolic and aesthetic criteria with colour keys and layout ▪ goal setting - students deciding how to apply conventions	▪ prior knowledge ▪ ideas are locus of activity ▪ epistemic goal-setting ▪ integrated language and literacy with representations o student thinking is "made public" o ideas are made visible symbolically: o are objects of manipulation o anchor discussion o mediate discussion o present personal path in EW ▪ dialogic and authoritative alternations: o discussing sign-making o deciding individually o interpreting and responding ▪ feeling: aesthetics ▪ practices o constructing representations o noticing as thinking mediated by semiotic signs o new tools for authoring

Episode 2 Anchor text: ▪ Epistemic Work ▪ Meta-talk ▪ translanguaging Rich Point: note-taking for idea elaboration, with categories and bullet points, by students	Finding ▪ Epistemic work (EW) o noticing as EW: seeing images as ideas in the anchor text o authoring: o writing captions o writing notes: idea elaborations ▪ Meta-talk (MT) o images are discussed as ideas ▪ read-alouds are a practice of reasoning aloud, hence ▪ selecting the appropriate AL word as symbolized by the image o noticing: expressed in MT ▪ practices are noted explicitly o connecting ▪ T invites ss to continue connecting practices to their own knowledge resource other Practices: ▪ interaction: routines o *read-alouds*: text-based discussion o new forms of note-taking o *shared writing* ▪ opportunities taken by Ss to extend meta-talk with own EW. ▪ translanguaging: student makes connections to own language	Example ▪ interaction: T and ss - discussion for representation work: initiating practices ▪ annotations e.g. *illustration, caption* ▪ identifying ideas : e.g. *exercise, nutrition, protein* ▪ note-taking as symbolic representation ▪ interaction: by T figure 4 - extending MT, - providing AL, - inviting epistemic work: ▪ note-taking forms ▪ translanguaging - goal setting, defining the practices: "we are …" turn 31 ▪ writing: Rich Point students authoring text figure 5 - note-taking - labelling for ideas: applying own new semiotic signs	Design Principle ▪ integrated language and literacy with representations o text is an "improvable object" o student thinking is "made public": accountable o knowledge is inscribed as a resource, shared o ideas are made visible: o are objects of discussion ▪ dialogic and authoritative alternations: o deciding as a group o interpreting and responding o opportunities ▪ affect: trust and time ▪ practices: note-taking as ideas ▪ annotations ▪ notes with categories ▪ modalities, paper, wb ▪ identity building: ▪ explicit discussion about enacting practices ▪ participants seeing themselves enacting practices by authoring

Episode 3 Anchor text : ▪ Meta-talk ▪ Epistemic Work Rich Point: note-taking on argumentation using AL, by students	Finding ▪ Epistemic work (EW) o noticing as EW: ideas in the anchor text, to be corrected through argumentation o authoring: own work is now anchor text o argumentation: rehearsing new AL ▪ Meta-talk (MT) o words are discussed as ideas ▪ reading comprehension tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need to be resolved o noticing: expressed in MT ▪ ideas require "correct" term ▪ ss initiate noticing ▪ T prompts for more instances and elaborations other Practices: ▪ interaction: routines o text-based discussion o new note-taking: interpreting text o shared writing ▪ opportunities o provided by T: ss can initiate EW o initiated by Ss to extend meta-talk with own AL o taken by Ss to extend meta-talk with own reasoning o extended by T through connection making	Example ▪ interaction: initiated by ss excerpt 1 - discussion for AL: Ruslan in turn 37 - Ruslan initiates MT by giving an example, as EW, turn 50 - Quincy example reasoning turn 46 - Ryu initiates, provides an example turn 82, using the new AL ▪ writing: Rich Point - note-taking on the argumentation, figure 6 - over-writing for argumentation turn 103 - word wall turn 117 ▪ interaction: by T - extending MT, e.g. turn 36, turn 53 - providing AL, turn 37, 109 - goal setting: practices of note-taking : - on AL turn 1, turn 61 - on argumentation turn 103 - on rehearsing study strategies turn 1, turn 8, figure 7	Design Principle ▪ prior knowledge ▪ epistemic goal-setting, shared ▪ integrated language and literacy with text o text is an "improvable object" o student thinking is "made public": accountable o sedimentation of practices: resources shared and used across time o ideas are made visible: o are objects of discussion ▪ dialogic and authoritative alternations: o deciding as a group o interpreting and responding o opportunities: opened by S ▪ affect: trust and time ▪ practices o constructing resources o noticing as connection making ▪ local culture: noticing as practice ▪ AL as practice ▪ modalities, paper, wb

Episode 4	Finding	Example	Design Principle
Anchor text; Representations: ▪ Epistemic work ▪ Languaging Rich Point: authoring through over-writing, re-writing and representation through modalities, by students	▪ Epistemic work (EW) ○ noticing as EW: seeing ▪ words as ideas *in* the diagrams and tables ▪ diagrams and tables *as* ideas ▪ *connections* between diagrams and words as ideas ○ authoring: ▪ writing notes ▪ editing: adding information ▪ modalities ▪ new representations: - drawing tables : digital - drawing diagrams digital - devising new colour codes and symbols as ideas ▪ Languaging (L) ○ words are authored as ideas for investigation, hands-on and research ▪ over-writing the AL terms : process verbs ▪ over-writing diagrams other Practices: ▪ noticing by T and Ss : text-based discussion ▪ interaction: routines ○ text-based discussion ○ new note-taking ○ shared writing ▪ opportunities taken by Ss to represent own EW through discussion based process ▪ multi-modal work: representing ideas and connecting across modalities	▪ note-taking: as discussion based practice, figure 8 figure 14 ▪ note-taking: as epistemic work - drawing tables figure 11 - constructing diagrams digitally as note-taking figure 13 - writing notes as idea elaboration, figure 8, figure 10, figure 11 - writing word wall figure 14 ▪ writing: Rich Point authoring text - preparing images as text figure 12, figure 13 - over-writing for AL figure 10 figure 11 - representations as text figure 13, - writing elaborated text figure 14, figure 16 ▪ modalities as epistemic practices: - selecting colour, text, layout, symbols figure 11, figure 14, figure 16 - selecting modalities for purposes figure 8, figure 12, figure 13	▪ epistemic goal-setting, shared ▪ integrated language and literacy with representations ○ diagram as text is an "improvable object" ○ student thinking is "made public": accountable ○ knowledge is inscribed as a resource, shared ○ ideas are made visible: ○ are objects of discussion ▪ dialogic and authoritative alternations: ○ deciding as a group ○ interpreting and responding ○ opportunities: opened by S ▪ affect: trust and time ▪ practices ○ constructing resources as authoring ○ noticing as connection making ▪ local culture: noticing as practice ▪ AL as practice ▪ modalities, paper, wb ▪ identity building: ▪ selecting semiotic signs ▪ constructing semiotic signs ▪ authoring text in AL as knowledge resource

Healthy – weeks 3 – 4 "I think it's good. It's a real science sentence"

Episode 5

Anchor text:
- Meta-Talk
- Languaging

Rich Point: -

Languaging, shared re-writing and evaluating, by students

Finding

- Meta-talk (MT)
  - words are discussed as ideas: from word to sentence level
    - writing tasks are a context for reasoning aloud, where
    - selecting the appropriate AL word is discussed as a need
    - ideas require sentence level to contain them
  - noticing: expressed in MT
    - ideas require "correct" terms and sentences
    - ss initiate noticing
    - T prompts for more instances and elaborations
- Languaging (L)
  - words and sentences are authored as ideas
    - re-writing with the AL terms at sentence level
  - words are objects of reasoning: own writing becomes
    - knowledge resource and
    - manipulable object

other Practices:

- noticing by T and Ss : sharing authority over words as objects and tools for discussion
- interaction: routines
  - text-based discussion
  - new purpose for re-writing in topic
  - shared writing

Example

- note-taking: as discussion based practice excerpt 2
- writing: Rich Point authoring text through languaging and meta-talk re-writing practices figure 19
  - object of reasoning and discussion figure 17
  - writing as elaborating, extending ideas figure 19
  - selecting, re-writing for AL figure 20
- modalities as epistemic practices: figure 18, figure 19
  - selecting colour, text, layout, symbols,
  - selecting modalities for purposes
- interaction: by T excerpt 2
  - prompting, extending student explanations
  - providing AL,
  - providing new resources
  - suggesting semiotic work
  - goal setting
- interaction: initiated by Ss
  - discussion for AL: excerpt 2 turn 12
  - re-writing for AL: figure 20
- Quincy evaluates the re-writing for AL work, excerpt 2

Design Principle

- epistemic goal-setting, shared
- integrated language and literacy with representations
  - text is an "improvable object"
  - student thinking is "made public": accountable
  - knowledge is inscribed as a resource, shared
  - ideas are made visible:
  - are objects of discussion
- dialogic and authoritative alternations:
  - deciding as a group
  - deciding as participant
  - interpreting and responding
  - opportunities: opened by S
- affect: trust and time
- practices
  - constructing resources: sedimentation of practices
  - noticing as connection making
    - local culture: noticing as practice
    - AL as practice
- modalities, paper, wb
- identity building:
  - selecting semiotic signs
  - constructing semiotic signs
  - authoring text in AL through cultural practices
- epistemic agency and authority:
  - framing for transfer: stating goals

	▪ **opportunities** taken and initiated by Ss to lead in reasoning process ▪ **multi-modal work:** representing ideas and connecting across modalities		▪ initiating practices ▪ evaluating practices ▪

Complete summary of findings, Iteration III – Kelp Forest

Kelp Forest weeks 1 – 3 "Well, I wanted to put environment, because I made a connection from healthy. Because we're animals" figure 6

Episode 1	Finding	Example	Design Principle
Concept maps: ▪ Epistemic work ▪ Meta-talk Rich Point: "And *insect* is like speak in middle school or high school", by Dai	▪ Epistemic work (EW) o words are manipulated as ideas ▪ Ss choices: authoring ▪ Ss writing work : authoring. arguing and presenting to others ▪ Ss state idea generation as a local practice o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of shared writing ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T o ideas are the locus of conceptual elaboration and anchored in Ss representations ▪ Meta-talk (MT) o words are discussed as ideas with concept map as referent ▪ presenting concept maps is a practice of reasoning aloud, hence ▪ selecting the appropriate AL word is discussed as a need to resolve o noticing: expressed as MT ▪ ideas require review ▪ concept map is analysed by students o connecting ▪ T invites ss to continue connecting with prior work as anchor text	▪ concept map: - Quincy explains the process of constructing a concept map, and - the elements, including the key - presents reasoning about items on his concept map figure 1 - Rich Point: Dai presents and argues own points figure 3, figure 4, and - process of editing his concept map ▪ presenting: - Quincy and Dai interpret, respond and argue : purpose of chosen terms ▪ interaction: - publicly writing and re-writing figure 3, figure 4 - taking photos of discursive acts, artifacts ▪ goal setting - T and ss agree on concept map task figure 2 - ss deciding the focus of the topic, figure 1 figure 3, figure 4	▪ prior knowledge: resources constructed earlier ▪ epistemic goal-setting ▪ integrated language and literacy with representations o Ss thinking is made public o Ss ideas are made visible: o are objects of discussion as "text" o anchor discussion o mediate discussion o present knowledge ▪ dialogic and authoritative alternations: o deciding as a group o Ss and T interpreting and responding to decide "what counts" as knowledge ▪ affect: time and opportunities, public validation, taking photos ▪ practices o building on prior student resources, exemplars o noticing as connection making for reasoning

	other Practices: ▪ noticing by T and Ss established: ○ noticing as public validation of authoring ▪ interaction: writing ○ modelling of writing: exemplars ○ locus of epistemic work: student rewriting text, re-focusing the topic ○ opportunities opened: contingent questions, idea generation tasks		○ contingent questioning

Episode 2	Finding	Example	Design Principle
Concept maps: ▪ Epistemic work ▪ Meta-talk Rich Point: why some animals are endangered: "Yeah, it may be that ...there was too much of the meat eaters", by Ruslan	▪ Epistemic work (EW) o noticing as EW: arguing and discussing words as ideas in the word wall text o editing text ▪ Ss writing work : authoring. arguing and presenting to others ▪ Ss state ways that idea generation is a practice o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of shared writing ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T o ideas are the locus of conceptual elaboration and anchored in Ss representations o inferences: Ss infer conceptual connections with prompts ▪ Meta-talk (MT) o words are discussed as ideas with concept map as referent ▪ presenting concept maps is a practice of reasoning aloud, hence ▪ selecting the appropriate AL word is discussed as a need to resolve ▪ uses of concept maps argued o noticing: expressed in MT ▪ ideas require o connecting	▪ interaction: T and ss - discussion: Ruslan and Ryu justifying and writing /editing word wall: figure 5 figure 7: - discussion: concept maps as established practices ▪ Quincy explaining his concept map figure 6 and ▪ justifying connection with his prior concept map work ▪ connecting with the mainstream class ▪ initiating: Ryu evaluating concept map as practice - discussion: concept of food chain ▪ Quincy contributes term, recount follows ▪ Rich Point : Ruslan makes inference, following prompting ▪ interaction: by T - extending student EW through MT, ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic - inviting connection making - goal setting, using student ideas ▪ writing: Ss authoring text - word wall figure 5 - concept maps: figure 6	▪ prior knowledge: resources constructed earlier ▪ epistemic goal-setting ▪ integrated language and literacy with representations o Ss thinking is made public o Ss ideas are made visible: o are objects of discussion as "text" o anchor discussion o mediate discussion o present knowledge ▪ dialogic and authoritative alternations: o deciding as a group o Ss and T interpreting and responding to decide "what counts" as knowledge ▪ affect: time and opportunities, public validation, taking photos ▪ practices o building on prior student resources, exemplars o noticing as connection making for reasoning ▪ ▪ identity building: Ss exert authority in taking up points, in authoring writing; in justifying practices

	▪ T invites Ss to connecting ideas with own prior work other Practices: ▪ noticing by T and Ss : text-based discussion ▪ interaction: using routines ▪ presenting work for discussion ▪ shared writing ▪ opportunities taken by Ss to extend meta-talk with own connection making, explaining, justifying and arguing.		▪ transfer: Ss show evidence of transfer by externalising as explanations and justifications

Episode 3 Representations : ▪ Epistemic Work Rich Point: ocean food web representations, by students	Finding ▪ Epistemic work (EW) o noticing as EW: explaining and arguing ▪ signs and words as ideas in representations ▪ determining choices in semiotic signs o writing: text and representations ▪ Ss writing work : authoring. arguing and presenting to others ▪ Ss state ways that ideas should be represented o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of representation construction as shared writing ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T o ideas are the locus of conceptual elaboration and anchored in Ss representations o inferences: Ss infer conceptual connections with textual prompts other Practices: ▪ opportunities ▪ initiated by Ss to extend meta-talk with own connection making ▪ taken by Ss to extend epistemic work through own noticings ▪ extended by T	Example ▪ interaction: initiated by ss - discussion: arguing. interpreting, selecting signs, for ocean food web representation Rich Points figure 9, figure 10, figure 11, figure 12 ▪ writing: semiotic work with words and symbols figure 8 - writing notes: organized in a symbolic structure - using a colour code - other symbolic representations ▪ representation: diagram construction - comprehension task: interpreting text - representing concepts applying stylized signs and labelling ▪ interaction: by T - extending student EW through MT, ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic - inviting connection making - goal setting, using student ideas - extending time for EW - providing knowledge resources - goal setting - expressions of affect	Design Principle ▪ "improvable objects" ideas are the locus of conceptual elaboration and anchored in Ss edits and constructions of representations ▪ student agency and authority: shaping the practice in the context of its use - opportunities opened by Ss ▪ noticing: applying semiotic signs as choices in epistemic work ▪ identity – stated by Ss on diagrams ▪ visible thinking: Ss - learning, rehearsing semiotic signs individually but visible to the group - discussing applying signs as interpretation - carrying out sign making as shared epistemic work ▪ affect: time and opportunities, public validation, taking photos; visible enthusiasm and expression in using own scripts ▪ goal setting - modelled by T - agreed by Ss ▪ interplay of text modalities - words as text - signs as text - interpreting and constructing interplay

Kelp Forest – weeks 4 – 6 "They had to realize what would happen to the abundant kelp forest without the fantastic sea otter." figure 30

Episode 4	Finding	Example	Design Principle
Anchor text; Representations: ▪ Epistemic work ▪ Languaging ▪ Meta-talk Rich Point: representation construction and reconstruction, by students	▪ Epistemic work (EW) ○ noticing as EW: explaining and arguing ▪ signs and words as ideas in representations ▪ determining choices in semiotic signs ▪ comparing signs and terms across modalities, ▪ comparing signs and terms in work across time ▪ Ss infer conceptual connections, with prompts ○ authoring: text and representations ▪ Ss writing work: authoring and arguing ▪ Ss state ways that ideas should be represented, as representations or terms ▪ Ss editing and transforming ○ authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of representation construction, as shared writing ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T ▪ Languaging (L) ○ words are authored as ideas ▪ text and representation over-writing with the AL terms	▪ interaction: initiated by ss - discussion: note-taking figure 13, representations as text figure 13, figure 14 - discussion: arguing. interpreting, selecting signs, for ocean food web representation Rich Point figure 14 ▪ interaction: by T - extending student EW through MT, ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic - inviting connection making - goal setting, using student ideas - extending time for EW - noting connections to knowledge resources - goal setting - expressions of affect ▪ authoring: semiotic work with words and symbols - over-writing for AL figure 14 - drawing diagrams as note-taking figure 14 - drawing diagrams as idea elaboration, figure 14	▪ "improvable objects" ideas are the locus of conceptual elaboration and anchored in Ss edits and constructions of representations ▪ student agency and authority: shaping the practice in the context of its use - opportunities taken by Ss ▪ noticing: applying semiotic signs as choices in epistemic work ▪ identity – practices initiated, sustained by Ss ▪ visible thinking: Ss - learning, rehearsing semiotic signs individually - discussing applying signs as interpretation - carrying out sign making as shared epistemic work ▪ goal setting - modelled by T - agreed by Ss - ▪ interplay of text modalities - words as text - signs as text

	▪ Meta-talk (MT) ○ reading is discussing ideas: ▪ reading tasks are a context for reasoning aloud, where ▪ editing for the appropriate AL word is discussed as a need to resolve ▪ elaborating the appropriate sign is argued ▪ practices in representation construction argued ○ noticing: expressed in MT ▪ ideas require "correct" terms and signs other Practices: ▪ noticing by T and Ss : note-taking discussion ▪ interaction: routines ▪ reading as shared ▪ shared writing ▪ use of knowledge resources established ▪ opportunities taken by Ss to represent own EW through discussion based process ▪ multi-modal work: representing ideas and connecting across modalities	- using a colour code - other symbolic representations ▪ representation: diagram construction - comprehension task: interpreting text - representing concepts applying stylized signs and labelling ▪ modalities as epistemic practices: - selecting colour, text, layout, symbols figure 14, figure 15 -	- interpreting and constructing interplay ▪ using knowledge resources across time ▪ affect: time and opportunities, public validation, taking photos ▪

Episode 5 Anchor text, text and representations: ▪ Epistemic work ▪ Meta-Talk ▪ Languaging Rich Point: " If there is not enough of one thing, then most of the things will disappear", by Quincy	Finding ▪ Epistemic work (EW) o noticing as EW: explaining, justifying, arguing ▪ words as ideas in the anchor text ▪ problematizing: identifying gaps ▪ identifying, arguing practices ▪ comparing, justifying representations o authoring: text and representations ▪ Ss writing work: authoring study questions based on discussion ▪ Ss representation work: authoring based on discussion, using own inferencing and semiotic signs ▪ Ss state ways that ideas should be represented, as representations or terms ▪ Ss editing and transforming anchor text o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss noticing and deciding on a practice ▪ Ss authoring: study questions, representations as self assessments ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T ▪ Meta-talk (MT) o words are discussed as ideas: from word to text level ▪ read-aloud tasks are a context for reasoning aloud, where ▪ editing the appropriate AL word is discussed as a need to write o noticing: expressed in MT about text	Example ▪ interaction: initiated by Ss - discussion: Ryu and Quincy's text based noticing, justifying, arguing Excerpt 3 ;turn 66; turn 127 - Ryu and Quincy deciding a practice should be done, for over-writing and languaging turn 72 - discussion: arguing. interpreting, selecting signs; for anchor text representation Ruslan's epistemic critique turn 140 ▪ interaction: by T - extending student EW through MT, Excerpt 3, excerpt 4 ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic - inviting reasoning on representations figure 16 , turns 38-42 - inviting edits by Ss figure 19: - explaining grammar point and translanguaging turns 27-35 - goal setting, using student ideas excerpt 4 ▪ interaction: T and ss - discussion: Ruslan, Quincy and T justifying and arguing Excerpt 3, **all participants echo, extend, prompt** - writing /editing anchor text AL figure 17 figure 19: - discussion: over-writing as established practices through read-alouds	Design Principle ▪ "improvable objects" ideas as text and representations, locus of - conceptual elaboration and anchored in Ss edits and constructions - externalisation of inner speech ▪ student agency and authority: shaping the practice in the context of its use - opportunities constructed by Ss - Ss state points for EW - Ss determine that a practice should be done - Ss echo, prompt and press ▪ time ▪ noticing: applying semiotic signs as choices in epistemic work ▪ identity – - community expressed by Ss using "we", using echo, extend and prompt - practices initiated, sustained by Ss - stance of expertise expressed through justifying and arguing ▪ visible thinking: Ss - learning, rehearsing semiotic signs individually - discussing applying signs as interpretation

	▪ ideas require "correct" terms and sentences ▪ **Languaging (L)** ○ words are authored as ideas: contained in the sentence level ▪ re-writing the AL terms and applying at sentence level other Practices: ▪ **translanguaging:** T and Ss make connections to own language ▪ **multi-modal work:** Ss initiated representing ideas and connecting across modalities ▪ **interaction:** ▪ noticing: Ss ask questions to direct talking points for EW ▪ Ss determine a task is needed: applying practices	- discussion: concept of keystone species ▪ **Rich Point** : Quincy makes inference, following prompting excerpt 4 figure 17 ▪ writing: semiotic work with words and symbols - over-writing for AL figure 17 - representations as text figure 16 - drawing diagrams as note-taking figure 21 - drawing diagrams as idea elaboration, figure 22 - writing as elaborating, extending ideas, and as self assessment figure 20 figure 21	- carrying out sign making as shared epistemic work ▪ goal setting - modelled by T - agreed by Ss ▪ interplay of text modalities - words as text - signs as text - interpreting and constructing interplay ▪ using knowledge resources across time - constructing personal records of EW - first level of "sedimentation" of practices ▪ affect: time and opportunities, public validation, taking photos ▪

Episode 6 Text and representations: ▪ Epistemic work ▪ Meta-talk Rich Point: kelp forest lesson with the mainstream class, by students	Finding ▪ Epistemic work (EW) ○ noticing as EW: explaining, justifying, arguing ▪ words as ideas in the anchor text ▪ problematizing: identifying gaps ▪ identifying, arguing practices ▪ comparing, justifying representations ○ authoring: text and representations ▪ Ss writing work: authoring study questions based on discussion ▪ Ss representation work: authoring based on discussion, using own inferencing and semiotic signs ▪ Ss state ways that ideas should be represented, as representations or terms ▪ Ss editing and transforming anchor text ○ authority: deciding what is important --> what "counts" as knowledge: ▪ Ss noticing and deciding on a practice ▪ Ss authoring: study questions, representations as self assessments ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T ▪ Meta-talk (MT) ○ semiotic signs are discussed as ideas: ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need to be resolved ▪ ideas require paragraph level to contain them	Example ▪ interaction: initiated by Ss - discussion: , - discussion: arguing. interpreting, selecting signs, for kelp forest energy pyramid representation figure 23 ▪ writing: as epistemic work - shared writing as elaborating, extending ideas, - figure 24, figure 25, figure 26 ▪ modalities as epistemic practices: - selecting colour, text, layout, symbols figure 24, figure 25, figure 26 - selecting modalities for purposes figure 26 ▪ interaction: by Ss in class presentation - Rich Point figure 27 , figure 28 - Ss extending student EW through MT, figure 27 ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic - inviting connection making, figure 27 - goal setting figure 29, figure 30, figure 31	Design Principle ▪ shifts in dialogic-authoritative discourse ▪ agency in students ▪ practices are carried out by students ▪ making connections about practices ▪ authoring in disciplinary ways ▪ constructing personal records of EW ▪ "sedimentation" of practices ▪ affect: time and opportunities, public validation, taking photos ▪

	○ noticing: expressed in MT in group work ▪ ideas require "correct" terms and sentences ▪ Ss initiate noticing ▪ Ss prompt for more instances and elaborations other Practices: ▪ interaction: ▪ noticing: Ss ask questions to direct talking points for EW	▪	

Complete summary of findings, Iteration IV – Energy

***Energy** weeks 1 – 3* "...writing a concept map... we can see our ideas clearly and then come back"

Episode 1 Concept maps, anchor text, representations: ▪ Epistemic work ▪ Meta-talk Rich Point: "solar flares and prominences", by students	Finding ▪ Epistemic work (EW) ○ words are manipulated as ideas ▪ Ss choices: authoring ▪ Ss writing work : authoring. ▪ idea generation is a discourse practice ○ authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: through own and requested words, shared writing ○ representations are the locus of conceptual elaboration ▪ Meta-talk (MT) ○ words are discussed as ideas with concept map as referent ▪ sharing concept maps is a practice of reasoning aloud, hence ▪ selecting the appropriate AL word is discussed as a need to resolve gaps ○ noticing: expressed as MT ▪ ideas require review ▪ reference works are analysed by students ○ connecting ▪ T invites ss to continue connecting with prior work as knowledge resource other Practices:	Example ▪ concept map: - the elements, including the key - presents reasoning about items on his concept map figure 1 - Rich Point : students re-orient the purpose as note-taking and goal-setting, by adding new terms from discussion, figure 1 ▪ reference works and websites: - students interpret, respond and discuss : purpose of new terms ▪ interaction: read-alouds - publicly writing and re-writing figure 2, - interpreting new reference material ▪ goal setting - T and ss agree on concept map task figure 1 - ss deciding the focus of the discussion and the topic figure 1	Design Principle ▪ prior knowledge: resources constructed earlier ▪ epistemic goal-setting ▪ integrated language and literacy with representations ○ Ss thinking is made public ○ Ss ideas are made visible: ○ are objects of discussion as "text" ○ anchor discussion ○ mediate discussion ○ present knowledge ▪ dialogic and authoritative alternations: ○ deciding as a group ○ Ss and T interpreting and responding to decide "what counts" as knowledge ▪ affect: time and opportunities, public validation, taking photos ▪ practices ○ building on prior student knowledge resources ○ noticing as connection making for reasoning

	▪ noticing by T and Ss established: ○ noticing as public validation of authoring ▪ interaction: writing ○ locus of epistemic work: student writing new terms from discussion, re-focusing the topic ○ opportunities opened: contingent questions, idea generation tasks		○ contingent questioning

Episode 2	Finding	Example	Design Principle
Anchor text, representations: ▪ Epistemic work ▪ Meta-talk Rich Point: arguing and explaining about concept maps "we can see our ideas clearly and then come back", by Ryu	▪ Epistemic work (EW) o noticing as EW: arguing and discussing words as ideas in the word wall text o editing text ▪ Ss writing work : authoring. arguing and presenting to others ▪ Ss state ways that idea generation is a practice o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of shared writing ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T o ideas are the locus of conceptual elaboration and anchored in Ss representations o inferences: Ss infer conceptual connections with some prompts ▪ Meta-talk (MT) o words are discussed as ideas with concept map as referent ▪ presenting concept maps is a practice of reasoning aloud, hence ▪ selecting the appropriate AL word is discussed as a need to resolve gaps ▪ uses of concept maps argued o noticing: expressed in MT ▪ ideas require forms of note-taking o connecting	▪ interaction: T and ss - discussion: ▪ initiating: Ryu evaluating concept map as practice ▪ initiating : new student, Kassim evaluating and justifying practices excerpt 1 ▪ initiating: Ruslan justifying and writing /editing concept maps and other EW figure 6 ▪ Rich Point : evidence of intersubjectivity students argue about purposes of concept maps and other epistemic work excerpt 1 ▪ interaction: by T excerpt 1 - extending student EW through MT, ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic, - inviting connection making ▪ writing: Ss authoring text - word wall figure 3, figure 4 - table of contents : figure 6	▪ prior knowledge: resources constructed earlier ▪ epistemic goal-setting ▪ integrated language and literacy with representations o Ss thinking is made public o Ss ideas are made visible: o are objects of discussion as "text" o anchor discussion o mediate discussion o present knowledge ▪ dialogic and authoritative alternations: o evaluating as participant o evaluating as a group o Ss and T interpreting and responding to decide "what counts" as practices ▪ affect: time and opportunities, public validation, taking photos ▪ practices o building on prior student resources, exemplars o noticing as connection making for reasoning ▪ identity building: Ss exert authority in taking up points, in authoring writing; in justifying practices

	▪ T invites Ss to connecting ideas with own prior work other Practices: ▪ noticing by T and Ss : text-based discussion ▪ interaction: ▪ arguing about epistemic work ▪ shared writing ▪ opportunities taken by Ss to extend meta-talk with own connection making, explaining, justifying and arguing.		▪ transfer: Ss show evidence of transfer by externalising as explanations and justifications

Episode 3	Finding	Example	Design Principle
Anchor text, representations: ▪ Epistemic work ▪ Languaging ▪ Meta-talk Rich Point: energy diagram as AL, by Dai	▪ Epistemic work (EW) ○ noticing as EW: explaining and arguing ▪ new signs and words as ideas in representations ▪ determining choices in semiotic signs ○ writing: text and representations ▪ Ss semiotic work : authoring. arguing and sharing with others ▪ Ss state ways that ideas should be represented: comparing and justifying ○ authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of representation construction as shared writing ○ representations are the locus of conceptual elaboration: ▪ editing: adding information ▪ modalities ▪ inferences: Ss infer conceptual connections with textual prompts ▪ Meta-talk (MT) ○ words are discussed as ideas: from word to representation as text ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need ▪ ideas require new semiotic level to contain them ○ noticing: expressed in MT ▪ ideas require "correct" terms and signs ▪ ss initiate noticing	▪ interaction: T and ss - discussion: justifying. interpreting, evaluating, selecting signs, for heat and KE representation figure 9, figure 10, figure 7, figure 8 ▪ writing: semiotic work with words and symbols figure 6 - writing notes: organized in a symbolic structure - using a colour code - other symbolic representations ▪ representation: diagram construction Rich Point figure 10 - comprehension task: interpreting text - representing concepts applying stylized signs and labelling ▪ interaction: by T - extending student EW through MT, ▪ echo, press, prompt turn 6 ▪ give time, ▪ give examples turn 8 turn 9 ▪ prompt for justification turn 3, turn 17 - inviting semiotic work turn 1 - goal setting, "what science people do" turn 3 - expressions of affect: taking photos -	▪ "improvable objects" ideas are the locus of conceptual elaboration and anchored in Ss edits and constructions of representations ▪ visible thinking: Ss - learning, rehearsing semiotic signs individually but visible to the group - discussing applying signs as interpretation - carrying out sign making as shared epistemic work ▪ identity building ▪ selecting semiotic signs ▪ constructing semiotic signs ▪ authoring text in AL through cultural practices ▪ student agency and authority: shaping the practice in the context of its use - opportunities taken by Ss ▪ affect: time and opportunities, public validation, taking photos; enthusiasm ▪ goal setting - modelled by T - agreed by Ss

	▪ T prompts for more instances and elaborations ▪ Languaging (L) ○ words and images as text are authored as ideas ○ words are objects of reasoning: own writing and representation work becomes ▪ knowledge resource and ▪ manipulable object other Practices: ▪ opportunities ▪ taken by Ss to extend epistemic work through own noticings ▪ extended by T : time, resources		

Episode 4	Finding	Example	Design Principle
Anchor text: ▪ Epistemic work ▪ Languaging ▪ Meta-talk Rich Point: shared writing: re-writing for AL, by students	▪ Epistemic work (EW) o noticing as EW: explaining and arguing ▪ signs and words as ideas in text ▪ determining choices in semiotic signs o writing: text and ▪ Ss semiotic work : authoring. arguing and sharing with others ▪ Ss state ways that ideas should be represented o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of re-writing as shared writing o text is the locus of conceptual elaboration ▪ Meta-talk (MT) o words are discussed as ideas: from word to sentence level ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need ▪ ideas require sentence level to contain them o noticing: expressed in MT ▪ ideas require "correct" terms and sentences ▪ ss initiate noticing ▪ T prompts for more instances and elaborations ▪ Languaging (L) o words and sentences are authored as ideas	▪ note-taking: as discussion based practice figure 11 ▪ writing: Rich Point authoring text through languaging and meta-talk re-writing practices figure 12 figure 13 - object of reasoning and discussion - writing as elaborating, extending ideas - selecting, re-writing for AL ▪ modalities as epistemic practices: figure 12 figure 13 - selecting colour, text, layout, symbols, - selecting modalities for purposes ▪ interaction: by T figure 12 - prompting, extending student explanations - providing AL, - providing new resources - suggesting semiotic work - goal setting ▪ interaction: initiated by Ss figure 11 figure 12 - discussion for AL: - re-writing for AL: ▪ Ryu writes and evaluates the re-writing for AL work on WB figure 12 ▪ Kassim engages in new cultural practices, including semiotic sign making figure 13	▪ epistemic goal-setting, shared ▪ integrated language and literacy with representations o text is an "improvable object" o student thinking is "made public": accountable o knowledge is inscribed as a resource, shared o ideas are made visible: o are objects of discussion ▪ dialogic and authoritative alternations: o deciding as a group o deciding as participant o interpreting and responding o opportunities: opened by S ▪ affect: trust and time ▪ practices o constructing resources: sedimentation of practices o noticing as connection making ▪ local culture: noticing as practice ▪ AL as practice ▪ modalities, paper, wb ▪ identity building: ▪ selecting semiotic signs ▪ constructing semiotic signs ▪ authoring text in AL through cultural practices ▪ epistemic agency and authority: ▪ framing for transfer: stating goals ▪ initiating practices ▪ evaluating practices

	▪ re-writing with the AL terms at sentence level o words are objects of reasoning: own writing becomes; ▪ knowledge resource and ▪ manipulable object other Practices: ▪ noticing by T and Ss : sharing authority over words as objects and tools for discussion ▪ interaction: routines o text-based discussion o new purpose for re-writing in topic o shared writing ▪ opportunities taken and initiated by Ss to lead in reasoning process ▪ multi-modal work: representing ideas and connecting across modalities		

Energy *– online environment*	"_so the formed, yes, is like how it changed ___ "		
Episode 5 Text, representations: ▪ Epistemic work ▪ Languaging ▪ Meta-talk Rich Point: presentation: representations and explaining with AL, by Ryu	Finding ▪ Epistemic work (EW) o noticing as EW: explaining and arguing ▪ signs and words as ideas in representations ▪ determining choices in semiotic signs ▪ comparing signs and terms across modalities, ▪ comparing signs and terms in work across time ▪ Ss infer conceptual connections, with prompts o authoring: text and representations ▪ Ss writing work: authoring and arguing ▪ Ss state ways that ideas should be represented, as representations or terms ▪ Ss editing and transforming o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss authoring: choices requested by T in reasoning process of representation construction, as shared writing ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T o ▪ Meta-talk (MT) o reading is discussing ideas:	Example ▪ interaction: initiated by Ryu - discussion: note-taking figure 14, representations as text, figure 14 - discussion: arguing. interpreting, selecting signs, Rich Point figure 14 ▪ interaction: by T - extending student EW through MT, ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic - inviting connection making - goal setting, using student ideas - extending time for EW - noting connections to knowledge resources - goal setting - expressions of affect ▪ authoring: semiotic work with words and symbols - over-writing for AL figure 14 - drawing diagrams as note-taking figure 14 - drawing diagrams as idea elaboration, figure 14 - using a colour code - other symbolic representations ▪ representation: diagram construction - comprehension task: interpreting text - representing concepts applying stylized signs and labelling	Design Principle ▪ epistemic goal-setting, shared ▪ integrated language and literacy with representations o text is an "improvable object" o student thinking is "made public": accountable o knowledge is inscribed as a resource, shared ▪ dialogic and authoritative alternations: o deciding as a group o deciding as participant o interpreting and responding o opportunities: opened by S ▪ noticing: applying semiotic signs as choices in epistemic work ▪ visible thinking: Ss - learning, rehearsing semiotic signs individually - discussing applying signs as interpretation - carrying out sign making as shared epistemic work ▪ identity building: ▪ selecting semiotic signs ▪ constructing semiotic signs ▪ authoring text in AL through cultural practices ▪ epistemic agency and authority: ▪ framing for transfer: stating goals

	▪ reading tasks are a context for reasoning aloud, where ▪ editing for the appropriate AL word is discussed as a need to resolve gaps ▪ elaborating the appropriate sign is argued ▪ practices in representation construction argued ○ noticing: expressed in MT ▪ ideas require "correct" terms and signs other Practices: ▪ **noticing** by T and Ss : note-taking discussion ▪ **interaction**: routines ▪ reading as shared ▪ shared writing ▪ use of knowledge resources established ▪ **opportunities** taken by Ss to represent own EW through discussion ▪ **multi-modal work:** representing ideas and connecting across modalities ▪ **interaction:** ▪ noticing: Ss ask questions to direct talking points for EW ▪ Ss determine a task is needed: applying practices	▪ modalities as epistemic practices: - selecting colour, text, layout, symbols figure 14,	▪ initiating practices ▪ evaluating practices ▪ interplay of text modalities - words as text - signs as text - interpreting and constructing interplay ▪ using knowledge resources across time ▪ affect: time and opportunities, public validation, taking photos

Episode 6

Anchor text, text and representations:

- Epistemic work
- Meta-talk
- Languaging

Rich Point:

multimodal shared writing and re-writing with AL, by Quincy

Finding

- Epistemic work (EW)
  - noticing as EW: explaining, justifying, arguing
    - words as ideas in the anchor text
    - problematizing: identifying gaps
    - identifying, arguing practices
    - comparing, justifying representations
  - authoring: text and representations
    - Ss writing work: authoring study questions based on discussion
    - Ss representation work: authoring based on discussion, using own semiotic signs
    - T states ways that ideas should be represented, as representations or terms
    - Ss editing and transforming anchor text
  - authority: deciding what is important --> what "counts" as knowledge:
    - Ss noticing and deciding on a practice
    - Ss authoring: study questions, representations as self assessments
    - elaboration sequences of talk, initiated and sustained by Ss, or prompted by T
- Meta-talk (MT)
  - words are discussed as ideas: from word to text level
    - read-aloud tasks are a context for reasoning aloud, where
    - editing the appropriate AL word is discussed as a need to write
  - noticing: expressed in MT about text

Example

- interaction: initiated by Ss
  - discussion: Ryu and Quincy's text based noticing, justifying, arguing Excerpt 2 ;turns 9-25
  - Ss deciding a practice should be done, for over-writing and languaging figure 15 figure 17
  - discussion: arguing. interpreting, selecting signs; for anchor text representation Quincy's over-writing figure 18
- interaction: by T Excerpt 2
  - extending student EW through MT,
    - echo, press, prompt turn 15
    - give time, give floor
    - nominate student contribution as topic turn 13
  - inviting reasoning on over-writing figure 16 , turns 9-25
  - inviting edits on representations by Ss figure 17:
  - goal setting, using student ideas turn 9
- interaction: T and ss
  - discussion: Ss and T justifying and arguing Excerpt 2
  - writing /editing anchor text AL figure 17 figure 18 Rich Point:
- writing: semiotic work with words and symbols
  - Rich Point : Quincy makes re-writes coal diagram labels without prompting figure 18
  - over-writing for AL figure 15 figure 17
  - representations as text figure 17 figure 18

Design Principle

- "improvable objects" ideas as text and representations, locus of
  - conceptual elaboration and anchored in Ss edits and constructions
  - externalisation of inner speech
- student agency and authority: shaping the practice in the context of its use
  - opportunities constructed by Ss
  - Ss state points for EW
  - Ss determine that a practice should be done
  - Ss echo, prompt and press
- time
- noticing: used in
  - applying semiotic signs as choices in epistemic work
  - interplay of text modalities
- identity building–
  - community expressed by Ss using "we", using echo, extend and prompt
  - practices initiated, sustained by Ss
  - stance of expertise expressed through justifying and arguing
- visible thinking: Ss
  - learning, rehearsing semiotic signs individually
  - discussing applying signs as interpretation
  - carrying out sign making as shared epistemic work

	▪ ideas require "correct" terms and sentences ▪ Languaging (L) ○ words are authored as ideas: contained in the sentence level ▪ re-writing the AL terms and applying at sentence level other Practices: ▪ multi-modal work: Ss representing ideas and connecting using modalities ▪ interaction: ▪ noticing: Ss ask questions to direct talking points for EW ▪ Ss determine a task is needed: applying practices	- drawing diagrams as note-taking figure 19 - drawing diagrams as idea elaboration, figure 19 - writing as elaborating, extending ideas, and as self assessment figure 17 figure 18 figure 19	▪ using knowledge resources across time - constructing personal records of EW - "sedimentation" of practices ▪ affect: time and opportunities, public validation, taking photos

Episode 7 Text and representations: ▪ Epistemic work ▪ Meta-talk Rich Point: multimodal shared writing and re-writing of text and diagrams with AL, by Quincy	Finding	Example	Design Principle
	▪ Epistemic work (EW) o noticing as EW: explaining, justifying, arguing ▪ words as ideas in the student text ▪ problematizing: identifying gaps ▪ identifying, arguing practices ▪ comparing, justifying representations o authoring: text and representations ▪ Ss writing work: authoring explanations based on discussion ▪ Ss representation work: authoring based on discussion, using own semiotic signs ▪ T states ways that ideas should be represented, as representations or terms ▪ Ss editing and transforming own text and anchor text ▪ using own knowledge resources o authority: deciding what is important --> what "counts" as knowledge: ▪ Ss noticing and deciding on a practice ▪ Ss authoring: writing and representations as self assessments ▪ elaboration sequences of talk, prompted by T ▪ Meta-talk (MT) o words are discussed as ideas: from word to text level ▪ read-aloud tasks are a context for reasoning aloud, where ▪ editing the appropriate AL word is discussed as a need to write	▪ interaction: initiated by Ss - discussion: Ryu's text based noticing, justifying, arguing on his own text figure 20, - Ryu deciding a practice should be done, for over-writing and languaging figure 21, figure 22 - discussion: arguing. interpreting, selecting signs; for re-constructing representation and text, Quincy's over-writing figure 23, figure 24, figure 25 ▪ interaction: by T - extending student EW through MT, figure 21, ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic - inviting reasoning on over-writing figure 23, figure 24 - inviting edits on representations by Ss figure 23, figure 24: - goal setting, using student ideas figure 20, ▪ interaction: T and ss figure 23, figure 24, figure 25 - discussion: Ss and T justifying and arguing - writing /editing anchor text AL ▪ writing: semiotic work with words and symbols ▪ Rich Point : Quincy re-writes coal diagram text boxes without prompting, AL figure 23, figure 24 - over-writing for AL figure 23, figure 24	▪ "improvable objects" ideas as text and representations, locus of - conceptual elaboration and anchored in Ss edits and constructions - externalisation of inner speech ▪ student agency and authority: shaping the practice in the context of its use - opportunities constructed by Ss - Ss state points for EW - Ss determine that a practice should be done - Ss echo, prompt and press ▪ time ▪ noticing: applying semiotic signs as choices in epistemic work ▪ identity – - community expressed by Ss using "we", using echo, extend and prompt - practices initiated, sustained by Ss - stance of expertise expressed through justifying and arguing ▪ visible thinking: Ss - learning, rehearsing semiotic signs individually - discussing applying signs as interpretation - carrying out sign making as shared epistemic work ▪ goal setting

	○ noticing: expressed in MT about text ▪ ideas require "correct" terms and sentences ▪ **Languaging (L)** ○ words are authored as ideas: contained in the sentence level ▪ re-writing the AL terms and applying at sentence level other Practices: ▪ **multi-modal work:** Ss representing ideas and connecting using modalities ▪ **interaction:** ▪ noticing: Ss ask questions to direct talking points for EW ▪ Ss determine a task is needed: applying practices ▪	- representations as text figure 22 - drawing diagrams as note-taking figure 22 - drawing diagrams as idea elaboration, figure 22 - writing as elaborating, extending ideas, and as self assessment figure 20, figure 21	- modelled by T - agreed by Ss ▪ interplay of text modalities - words as text - signs as text - interpreting and constructing interplay ▪ using knowledge resources across time - constructing personal records of EW - "sedimentation" of practices ▪ affect: time and opportunities, public validation, taking photos ▪

Energy *– return to in-person environment* "...we are making a diagram so..." "so we understand better what we want to say, and we can see how is it,"

Episode 8	Finding	Example	Design Principle
Text, anchor text and representations: ▪ Epistemic work ▪ Languaging ▪ Meta-Talk Rich Point: " I learned it from that diagram", by Quincy	▪ Epistemic work (EW) ○ noticing as EW: explaining, justifying, arguing ▪ words as ideas in the anchor text ▪ problematizing: identifying gaps ▪ identifying, arguing practices ▪ comparing, justifying representations ○ authoring: text and representations ▪ Ss writing work: authoring study questions based on discussion ▪ Ss representation work: authoring based on discussion, using own inferencing and semiotic signs ▪ Ss state ways that ideas should be represented, as representations or terms ▪ Ss editing and transforming anchor text ○ authority: deciding what is important --> what "counts" as knowledge: ▪ Ss noticing and deciding on a practice ▪ Ss authoring: study questions, representations as self assessments ▪ elaboration sequences of talk, initiated and sustained by Ss, or prompted by T ▪ Languaging (L) ○ words are authored as ideas: contained in the sentence level ▪ re-writing the AL terms and applying at sentence level	▪ interaction: initiated by Ss - discussion: Ryu and Quincy's text based noticing, justifying, arguing Excerpt 3 ;turn 14, figure 29 - Ryu and Quincy deciding a practice should be done, for over-writing and languaging turn 15 figure 30 - discussion: arguing. interpreting, selecting signs; for anchor text representation, Ruslan's epistemic work turn 14, figure 35 Excerpt 5 - explanation: Quincy presenting and explaining the energy diagram Excerpt 6 ▪ interaction: by T - extending student EW through MT, Excerpt 3, Excerpt 4 Excerpt 5 Excerpt 6 ▪ echo, press, prompt ▪ give time, give floor ▪ nominate student contribution as topic figure 32 turn 60 - inviting reasoning on representations figure 36 , turn 95 Excerpt 5 - inviting edits by Ss: - goal setting, using student ideas Excerpt 4 ▪ interaction: T and ss Excerpt 6 ▪ Rich Point : Quincy presents his energy diagram without prompting Excerpt 6 - discussion: Ruslan, Quincy and T justifying and arguing Excerpt 3, - writing /editing anchor text AL: figure 29 figure 30	▪ "improvable objects" ideas as text and representations, locus of - conceptual elaboration and anchored in Ss edits and constructions - externalisation of inner speech ▪ student agency and authority: shaping the practice in the context of its use - opportunities constructed by Ss - Ss state points for EW - Ss determine that a practice should be done - Ss echo, prompt and press ▪ time ▪ noticing: applying semiotic signs as choices in epistemic work ▪ identity – - community expressed by Ss using "we", using echo, extend and prompt - practices initiated, sustained by Ss - stance of expertise expressed through justifying, explaining and arguing ▪ visible thinking: Ss semiotic work

	▪ Meta-talk (MT) ○ semiotic signs are discussed as ideas: ▪ writing tasks are a context for reasoning aloud, where ▪ selecting the appropriate AL word is discussed as a need to be resolved ▪ ideas require paragraph level to contain them ○ noticing: expressed in MT in group work ▪ ideas require "correct" terms and sentences ▪ Ss initiate noticing ▪ Ss prompt for more instances and elaborations other Practices: ▪ multi-modal work: Ss representing ideas and connecting using modalities ▪ interaction: ▪ noticing: Ss ask questions to direct talking points for EW ▪ Ss determine a task is needed: applying practices	- discussion: representation as established practices through work on text and ideas Excerpt 5 - discussion: explaining energy diagram ▪ writing: semiotic work with words and symbols Excerpt 4 - over-writing for AL figure 28 - representations as text - drawing diagrams as note-taking figure 45 - drawing diagrams as idea elaboration, figure 35 Excerpt 6 figure 45 - writing as elaborating, extending ideas, and as self assessment figure 31 figure 45	- learning, rehearsing semiotic signs individually - discussing applying signs as interpretation - carrying out sign making as shared epistemic work ▪ goal setting - modelled by T - agreed by Ss ▪ interplay of text modalities - words as text - signs as text - interpreting and constructing interplay ▪ using knowledge resources across time - constructing personal records of EW - mature "sedimentation" of practices ▪ affect: time and opportunities, public validation, taking photos

Appendix C

THE UNIVERSITY of EDINBURGH
Moray House School of Education

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Ref: 2535

Date: 17th October 2019

Dear Leila,

Title: Academic discoursing with ELLs: developing tools for 'thinking in the school disciplines'

The School of Education and Sport Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in your application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 2 criterion. This is defined as "applies to non-intervention research where you have the consent of the participants and data subjects. This may include, for example, analysis of archived data, classroom observation, or questionnaires on topics that are not generally considered 'sensitive'. This research can involve children or young people, if the likelihood of risk to them is minimal".

A standard condition of this ethical approval is that you are required to notify the Committee, of any significant proposed deviation from the original protocol. The Committee also needs to be notified if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

Should you receive any formal complaints relating to the study you should notify the MHSE Ethics Committee immediately by email to MHSEthics@ed.ac.uk

Yours sincerely,

Ben Scullion

On behalf of:
Dr Ailsa Niven
Convener, School Ethics Sub-Committee