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“This Is a Tool for You to Use”:
Expansive Framing and Adaptive Transfer in Two PBL Science Classrooms

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Abstract

"This Is a Tool for You to Use":
Expansive Framing and Adaptive Transfer in Two PBL Science Classrooms

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This dissertation is a qualitative, comparative case study investigating productive disciplinary engagement, framing for transfer, and tool use in two high school science classrooms. My goal was to investigate the implementation of material resources that were developed to support students' engagement, driven by my primary research question: How does the implementation of material tools as a learning resource support or impede students' productive disciplinary engagement in a project-based learning setting? Using a grounded theory approach, I analyzed video transcriptions and interviews of two teachers and their students at the same school as they enacted a coordinated project-based, advanced placement curriculum as part of a design-based implementation research project. Findings suggest that intentional framing and use of tools may help teachers support students in making connections across multiple parts of a project in ways that facilitate productive engagement in the discipline of science as well as students building on and adapting their knowledge over time.

Keywords: *Project-based learning, advanced placement, environmental science, scientific practices, dialogic discourse, grammar of schooling, situative theory, student engagement, productive disciplinary engagement, material resources, student authorship, framing for transfer, expansive framing, near transfer, adaptive transfer*

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CHAPTER 1.

Introduction

Curricula designed using a project-based learning (PBL) approach are gaining popularity as educators look for ways to actively engage students in their own learning, to produce graduates who are prepared for a work-world that values innovation, teamwork, and personal accountability. In this comparative case study, part of a PBL advanced placement environmental science (APES) curriculum was observed being introduced into two high-school classrooms comprised of mostly high-achieving students who had experience with non-PBL advanced placement (AP) courses. The two focal classrooms were ideal for analysis because they offered an opportunity to compare two teachers who were collaborating at the same school, with the same level of students, teaching the same content as part of an environmental science unit. While the teachers had differing levels of experience, they planned lessons together and intended to move through the curriculum at the same pace, using the same material resources and focusing on the same disciplinary content. These shared classroom features created a unique environment in which to observe the impact of teacher interactions (framing) on student transfer and engagement during the project-based activities, as the teacher was the primary element that differed between the two settings.

While describing each of the cases for comparison, I provided a rich description of teacher and student interactions with each other and material resources in both classrooms over the course of a 2-day lesson. By weaving together multiple layers of data on two high-school environmental science classrooms, I drew a picture of how teachers with deep content

knowledge—who were participants in a large-scale design-based implementation research (DBIR) study—enacted a PBL curriculum for the first time.[1]

Using a grounded theory approach, I analyzed video transcriptions (in addition to interviews and surveys) of classroom participants: *teachers* talking to the whole class, researchers, a focal group and other individual students and groups, as well as *focal students* talking to the teacher, researchers, each other, and other individual students and groups. Some of it was given to them to use and other parts were designed by the teachers themselves. Students all appeared to be engaging by doing their assigned school work during class. However, the types of interactions the students had on Day 2 were markedly different across the two classrooms. One class of students continued to build upon and adapt their knowledge on Day 2, while the other class primarily re-organized and added to their knowledge on Day 2—they did not appear to build on the Document on Day 2. While engaged in school work (following directions and getting assignments done), the students were not all engaged productively in the discipline of science.

This rich dataset provided a lens into how teacher moves are linked to students' disciplinary engagement, through the framing of material resources. Resources used as tools seemed to promote both connectedness between activities that were part of the same project in these classrooms as well as student authorship of disciplinary content via the use of scientific practices, findings that may be beneficial for practitioners who are implementing a PBL curriculum their own classroom.

[1] The dataset was collected during the fourth month of the school year.

Background of the Problem

In order to improve the learning and engagement of students in AP courses, some school districts are implementing PBL curricula as an alternative to outdated instructional methods related to the "grammar of schooling" (Parker et al., 2013; Tyack & Cuban, 1995). In contrast to "repeated lecturing, questioning, monitoring, and quizzing" (Goodlad, 1984), projects engage students in real-world activities involving participants, roles, and resources that are reminiscent of authentic disciplinary practices (Krajcik & Blumenfeld, 2006). Learning in a PBL setting involves more than a quantitative increase in knowledge, but also a change in students' roles as participants in disciplinary communities of practice, where "learning" implies movement toward more central participation in a community (Lave & Wenger, 1991). Participation in more authentic projects and practices impacts not only the productivity and disciplinarity of students' engagement in classroom activities (Engle & Conant, 2002), but also their transfer of knowledge from classrooms to real-world settings (outside of the traditional classroom) where knowledge and disciplinary practices learned in school are applicable (Bransford, Brown, & Cocking, 2000; Engle, Lam, Meyer, & Nix, 2012).

Initial research on the redesigned AP courses suggested that the curriculum and accompanying instructional methods were still lacking as resources to support teachers as the teachers figured out the best way to teach to facilitate students' learning and transfer using a project-based curriculum. To better understand the implications of day-to-day interactions between teachers and students in a PBL classroom, especially when mediated by curricular materials, the current study branches off from the larger data corpus (Nolen, Tierney, Goodell, Lee, & Abbott, 2014; Parker et al., 2013; Parker et al., 2011) to consider two classrooms consisting of high-achieving juniors and seniors.

There is currently little data on the relationship between framing and transfer in a PBL setting. The existing studies on framing include experimental designs and single case studies (Engle & Conant, 2002; Engle et al., 2012; Engle, Nguyen, & Mendelson, 2011; Meyer, Mendelson, Engle, & Clark, 2011), but not comparative studies where we see teachers using more or less expansive framing.

Problem Statement

As PBL curricula are gaining popularity as an alternative to traditional schooling practices (the "grammar of schooling"), teachers are faced with the challenge of how to implement the curricula in ways that engage students productively with disciplinary content and prepare students for the innovation, teamwork, and personal accountability required in today's work-world. Researchers have just started investigating how teachers can effectively frame social contexts in ways that support student transfer of knowledge and practices from one context to another. Even though framing is theoretically an important part of PBL classrooms, there has been very little research conducted on the how teachers use framing in PBL contexts in connection with the quality of student transfer and disciplinary engagement. While adaptive transfer is gaining popularity as a desirable student outcome (Parker et al., 2013), there are currently no case studies that describe students transferring more or less adaptively in settings where teachers are also framing for transfer in distinct ways.

Purpose of the Study

This study will add to the literature by exploring teacher framing and student transfer in PBL classrooms, focusing on the concepts of adaptive transfer and productive disciplinary engagement as goals that align with the values of PBL. Many of the complex relationships that the teachers and students develop with each other and with other aspects of the social context are

explored in this work, providing insight into experiences teachers have while navigating the implementation of a PBL curriculum. This deep dive into the practices of two teachers provides insight into the types of guidance that might be useful for novice PBL teachers, especially in their roles of framing by connecting settings and promoting student authority in order to support students' adaptive transfer (Engle et al., 2012).

Research Questions

The following four research questions arose from the background of the problem and from an initial review of the literature related to that problem:

1. How did the implementation of material resources as a learning resource support or impede students' productive disciplinary engagement in a PBL setting?

1a. Using positive transfer and PDE as measures for learning, in what ways did the curricular material tool from Day 1 come to function in the activity on Day 2?

2. When not focused solely on the teacher, what resources did framing involve in a classroom? What was the relationship between the teachers and the material resources?

3. Was there a relationship between the figured worlds (scientific practices versus the practices of schooling) with which students were engaged and the productivity of students' engagement (in the discipline)?

Study Rationale

In general, the field of the learning sciences is flush with theories of how students learn and what curricular methods or types of instruction are effective in supporting student learning. However, the field as a whole can benefit from more targeted, case-based studies of design-based curricular implementations, where close analysis can provide insights into moment-by-moment classroom interactions. Instead of vague or predetermined phenomena, which occur inside of the heads of individuals, learning needs to be examined through the lens of engagement, on the

shoulders of careful theoretical foundations such as those provided by sociocultural and situative theory:

> A challenge for the learning sciences is to advance our theoretical understanding of learning to provide more coherent and definite explanations of learning in these [science class] environments, as well as more helpful guidance for the design of productive resources and practices. (Greeno, 2006, p. 92)

The more we understand about the ways teachers and students interact around material tools and how students engage with disciplinary content, the better teachers can prepare curricula and materials for helping students to develop meaningful and lasting repertoires of practice (Gutierrez & Rogoff, 2003) that are valuable outside of the walls of the classroom.

Framing, as a "meta-communicative act of characterizing what is happening in a given context" (Engle et al., 2012, p. 217), can be a powerful tool for teachers to support student transfer, especially when they understand and can enact particular strategies for enhancing transfer. Past research, including single cases studies and experiments conducted in controlled laboratory settings, indicated that different types of framing can impact student transfer (specifically, that expansive framing leads to more transfer and bounded framing leads to less transfer; see Engle et al., 2012, for a review of this literature). However, these studies do not include an analysis of the role of material resources, nor do they research PBL settings or make comparisons across case studies (with the exception of 2012 et al., 2012, where they conduct a meta-analysis of current experimental and case study research).

This study has implications for the development of effective teaching and learning supports in PBL. Studying the ways that teachers frame and manage tools, as well as student use of tools in the context of projects, may offer insight into teaching practices that affect the productivity of student engagement in the classroom. Conceptualizing the teacher's role in the classroom as one that not only impacts student learning directly but impacts learning through

providing constraints and affordances for certain types of transfer and engagement, may offer classroom teachers and researchers further insight into the complex relationships between teachers and students in classroom settings. An understanding of the processes by which teachers and students negotiate learning supports can contribute to the development of tools and teaching strategies, such as PBL, that are more likely to result in successful student outcomes, such as positive transfer and productive disciplinary engagement.

Background of the Knowledge in Action Project

The dataset for this qualitative, comparative case study (Merriam, 2009) is a small part of an ongoing, large-scale design-based implementation research (DBIR) project (Penuel, Fishman, Cheng, & Sabelli, 2011). This DBIR project follows an iterative design, implementation, analysis, and revision process focused on the improvement of a PBL-APES (project-based learning, advanced placement environmental science) curriculum, which is a part of a larger project funded by the George Lucas Education Foundation (GLEF) called "Knowledge in Action" (KIA). The KIA research project is designed and managed by a collaborative group of university professionals (including learning scientists), content experts, and teachers, to design, research, and revise a number of PBL-AP courses that would "improve student learning and engagement when compared to traditionally-taught AP courses" (Parker et al., 2011). The primary goals of the KIA project are:

> (1) same or higher scores on the AP test, (2) deeper conceptual learning and greater capacity for adaptive reasoning, (3) greater engagement, with appeal and success for a wider array of AP students, and (4) a course that is sustainable and scalable by design. (p. 535)

The KIA project manages three different PBL-AP curricula using DBIR practices in multiple locations across the United States, in pursuit of deeper learning, adaptive transfer, and improved equity of access and outcomes for students.

PBL-APES Cycle Design

The PBL curriculum was organized into five, quasi-repetitive cycles that were intended to be used over the course of a year-long APES class. The five cycles were designed to align with both the National Research Council's "Framework for K-12 Science Education" and the AP curriculum guide for APES, and were oriented around a central driving question that tied all five projects together: "How can we live more sustainably?" By Year 3 of the DBIR implementation (2012-2013), the cycles had been arranged to broaden gradually from a student's immediate environment (where a student focused on reducing his or her family's ecological footprint), through community-based challenges (where students studied their State's ecology and food systems), to the interests of the global ecology (where students managed ocean health and negotiated global environmental regulations) (Goodell et al., 2014). In the 2012-2013 school year, these cycles were implemented in the following order: "Eco-Footprint, My Community Ecology (as state resource managers), Food Systems (as sustainable farm designers), Ocean in Action (as citizens debating the introduction of aquaculture to their island ecosystem), and Negotiation of Nations (representing countries in environmental negotiations)" (Nolen et al., 2014, p. 3).

Each cycle lasted several weeks, during which students learned by engaging in projects. According to the design principles, projects were "the spine of the course" (Parker et al., 2013, p. 1432) rather than activities to be done at the end of the unit. Students were "engaged first" (p. 1433) by taking on the roles of people using environmental science to address current environmental problems. Learning was done in service of the projects, orienting students to their participation in scientific practices (Ford & Forman, 2006) and communities (Lave & Wenger, 1991). Each cycle was subdivided into tasks that led to the final product. The video data for my

study were collected during Cycle 2 (“My Community Ecology”) of the 5-cycle curriculum during the third implementation year (2012-2013; see Chapter 3 for a full description of my dataset).

PBL-APES Revision

Two rounds of design–implement–analyze–revise had occurred prior to the 2012-2013 school year. Two major revisions were made between Years 1 and 2 in response to “students’ push-back based on the enormity of environmental problems and their own lack of power in addressing them” (Nolen et al., 2014, p. 2). The DBIR design team first revised the order of project cycles to begin locally and broaden to a more global perspective. The second major revision was to increase intentional support for transfer via expansive framing (p. 3). These revisions demonstrate the responsiveness of the school and curriculum developers to needs of students; however, the school and curriculum development were responding to needs at schools other than the focal school for this research study, Madison High School (as this was the first year of implementation in that location).

As part of ongoing revision of PBL-APES, the DBIR design team had created several material tools intended to support students’ productive disciplinary engagement and to support formative assessment of student thinking. In prior implementations, students had some difficulty adopting the roles and practices of scientists for the projects due to their unfamiliarity. The designed material tool for the “My Community Ecology” project cycle (the focus of this study) was intended to support them in adopting the role of state resource managers. The present analysis targets the implementation of material resources such as this tool in both classrooms.

PBL-APES Implementation

While the 2012-2013 school year marked the third year of the existence of the PBL-APES curriculum, it was the first implementation at Madison High School, a diverse public high-school in a large metropolitan public school district in Washington State. This school year was also the first implementation of the "My Community Ecology" cycle, which had been created after the second design year. The cycle was designed to broaden the students' perspective from a focus on their immediate families (in the first, "Eco-Footprint" cycle) to that of their local and state communities. The two focal teachers had modified the cycle tasks slightly to focus on the relationship of the state's resources to salmon (rather than the relationship between all resources in general), which is a culturally and economically important resource in Washington State in addition to being listed as a threatened species.

KIA Data Collection and Analysis

The project implementations, especially new revisions or additions to the curriculum, were continually being video recorded by the umbrella KIA research team. There was also a regular schedule of teacher and student interviews, surveys, fishbowl interviews,[2] and teacher development meetings in which a majority of the study participants participated. In the case of the dataset used for this research project, the teachers notified the research team when they intended to implement a material tool and the researchers arranged to video tape its use across 2 consecutive days.

[2] A fishbowl is a specific format for holding large group discussions using an outer circle of students that rotate in and out of an inner circle, where only students in the inner circle are contributing out-loud to the discussion.

Project-Based Learning

Behind the whole KIA research project is a notion of the value PBL curricula can bring to an AP class: "While PBL can take numerous forms, generally it interrupts the well-established classroom routine in which the teacher gives lectures, homework readings from the textbook, and quizzes and tests" (Parker et al., 2013, p. 1430). In response to the restrictions of practices related to this "grammar of schooling" (Parker et al., 2013; Tyack & Cuban, 1995), the KIA design team integrated projects into the structure of their PBL courses: "projects are the spine of the course, meant to provide a context and purpose for all learning activities" (Nolen et al., 2014). Students learn through engagement in the projects rather than completing projects at the end of a unit as a means of codifying prior learning.

Blumenfeld and her colleagues (1991) described projects as "relatively long-term, problem-focused, and meaningful units of instruction that integrate concepts from a number of disciplines or fields of study" (p. 370). The process of engaging in the multiple stages of project completion mirror the complex practices involved in disciplines outside of the classroom: "Through project activities—and the recurring phases of project anticipation, execution, and reflection—students have multiple meaningful opportunities to try out their current levels of understanding, revise them, and in this way deepen them" (Parker et al., 2011, p. 538). Projects help orient students to connections between classroom activities and the world outside of school where disciplinary practices are enacted as part of authentic communities of practice (Wenger, 1998).

With foundations in the learning sciences, PBL is a modern "innovative approach to learning that teaches a multitude of strategies critical for success in the twenty-first century" (Bell, 2010, p. 39).

> Many learning scientists are developing new types of curricula, with the goal of increasing student engagement and helping them develop deeper understanding of important ideas…. Project-based learning allows students to learn by doing and applying ideas. Students engage in real-world activities that are similar to the activities that adult professionals engage in. (Krajcik & Blumenfeld, 2006, p. 317)

Especially in the discipline of science, the practices of critiquing and revising knowledge claims in pursuit of a deeper understanding of the natural world is largely inseparable from disciplinary content and is more accurately embodied by principles of project work than by traditional "doing school" practices (Pope, 2003).

Project Artifacts

PBL involves the use and production of artifacts (material resources) to facilitate student engagement and to better simulate real-world contexts: "In project-based learning, students actively construct their knowledge by participating in real-world activities similar to those that experts engage in, to solve problems and develop artifacts" (Krajcik & Blumenfeld, 2006, p. 319). When students actively construct their own knowledge rather than passively receiving or memorizing pieces of information, they are better able to use (transfer) that knowledge in more diverse contexts outside of the classroom (Bransford et al., 2000), and PBL research has demonstrated that knowledge construction is facilitated through the process of artifact construction (Krajcik & Blumenfeld, 2006).

Students in PBL settings are encouraged to use material resources to both facilitate and externalize their learning, moving beyond the "grammar of schooling" where the teacher and approved texts are the sole source of content expertise (Parker et al., 2013). Adding the scientific community, nature, and other students to the mix as sources of knowledge and expertise in the classroom, students construct artifacts not only for the sole purpose of communicating with the teacher (although, this is still a factor in terms of formative assessment), but as a means of

enhancing understanding and manipulating disciplinary ideas in ways that are visible to other parties to which students are accountable:

> PBS [project-based science] focuses on artifact development for several reasons. First, through the development of artifacts, students construct and reconstruct their understanding. As students build and reflect on their artifacts, they actively manipulate science ideas… Second, because learning does not occur in linear, discrete steps, assessments should not be constructed around small, discrete bits of information… Third, when students publish what they create, it enhances their understanding. The artifacts that students develop make their understandings visible to others. Because artifacts are concrete and explicit, they allow students to share and have their artifacts reviewed by others—teachers, students, parents, and members of the community. (Krajcik & Blumenfeld, 2006, p. 327)

During the process of artifact creation, students learn, transfer knowledge in and out of the classroom, engage with relevant ideas and materials, and provide teachers with sources for assessment of students' knowledge construction via demonstration of their positive transfer and disciplinary engagement.

Roles in PBL Settings

Learners and teachers are asked to take on roles that are unlike those in other types of curricula: "Learners are required to utilize, wherever possible, the expertise of specialists and community members" (Etherington, 2011, p. 37). For example, in the "My Community Ecology" cycle of the PBL-APES curriculum, students are assigned the roles of managers for particular State resources that they in charge of understanding in depth, determining appropriate management goals, and resolving conflicts with other resource managers whose goals clash with their own. In the KIA courses:

> All instruction occurred in the context of… projects that provided reasons for learning from a variety of sources and experiences, and that attempted to cast students in roles as active problem-solvers in settings beyond the classroom (e.g., as 'green' event planners, as environmental consultants, as representatives of various countries). (Nolen et al., 2014, p. 2)

PBL student roles frequently involve the use of group work that encourages students to be more accountable to other students (rather than just a teacher; Engle & Conant, 2002).

To compliment these more active and inquisitive student roles, PBL teachers are more likely to adopt the role of "guide on the side" rather than "sage on the stage" (Greeno, 1998, p. 19). In addition to guiding students with regards to disciplinary content, teachers take on the roles of "facilitator or architect" (Etherington, 2011, p. 37), where they set activities and projects up for students and guide them in terms of the overall structure, while students have more responsibility for accessing the disciplinary content or practices needed to complete specific, project-related tasks.

During PBL activities, students are often asked to think outside of the classroom context, utilizing (transferring-in) relevant prior knowledge and experiences, gathering information from sources outside their immediate surroundings, or imagining future situations when new knowledge might become relevant (Engle et al., 2012). Curricular materials and teachers set students up to make these connections across time and space (Engle et al., 2012), providing relevant resources (Engle & Conant, 2002) and opportunities (Nasir & Hand, 2008). Teachers take on a supportive role while students grapple with project questions and problems, using strategies they have learned in school, but also transferring-in other relevant repertoires of practice (Nasir, Rosebery, Warren, & Lee, 2006, p. 489) and past experiences with curricular roles when relevant.

Projects Support Transfer

A primary benefit of learning through projects is support for far transfer, whereby students can use what they learn inside the walls of a classroom out in the world (Bransford et al., 2000). It also makes sense that the more authentic the projects are to the professional

discipline (such as environmental science), the better the support will be for transfer both in and out of the classroom. Projects also demand a certain level of both near and far transfer to orient students to the roles, artifacts, and practices of the discipline in ways that support their continued relevance from one task to the next in service to the completion of a larger project.

Nolen and her colleagues (2014) summarized Parker and his colleagues (2011), as well as Schwartz and Bransford (1998) as they described the outcomes of PBL-APES for learning and transfer: "The project-based, Advanced Placement Environmental Science (APES) course provided students with opportunities to prepare for adaptive transfer through multiple, quasi-repetitive opportunities to learn and apply scientific concepts and processes in the context of real-life projects and simulations" (p. 2). Highly desirable outcomes of learning through projects involve students engaging productively in the discipline and transferring disciplinary knowledge and practices adaptively in ways that are reflective of contexts outside of school in addition to success in the classroom.

PBL Summary

The projects and curricular strategies involved in PBL can be put into perspective using the conceptual foundations of situative theory, where the curriculum itself is only one piece of a bigger puzzle. The classroom is a complex activity system—including students, teachers, curricular media (PowerPoint slide, books, handouts, etc.), classroom practices (rules, rituals, etc.), cultural histories (experiences students and teachers bring with them into the classroom), and other resources (time, relationships, etc.)—where a PBL curriculum fits alongside, and is enacted through the lenses of, the histories and practices of teachers and students.

Organization of the Dissertation

Chapter 1 provided an introduction to the research project, followed by background information on the Knowledge in Action project and a review of relevant literature on project-based learning. Chapter 2 addresses the theoretical framework that describes the broad focus and unit of analysis for this study, followed by a review of current literature pertaining to teacher framing and support for engagement, as well as student transfer and productive disciplinary engagement. Chapter 3 describes the methodology and research design. Chapters 4 through 7 represent distinct but interrelated phases of my analytical process; the classrooms were so rich as individual cases that I structured their presentation as single case studies before proceeding to the cross-case analysis. Consequently, Chapter 4 is a single case study of Teacher 1, Chapter 5 is a single case study of Teacher 2, and Chapter 6 is a comparative study of the two cases discussed in Chapters 4 and 5. The organization of the cases in this way allowed me to take full advantage of the unique features of this dataset (particularly similarities and differences among the two classrooms), while also appreciating the value of rich description in case study research. Finally, Chapter 7 includes a discussion of the individual cases and cross-case analysis in light of my proposed research questions, related literature, and suggestions for future research.

CHAPTER 2.

Theoretical Framework and Literature Review

Transfer and engagement are features of student activity, but students do not exist in a vacuum. To understand student activity, they must be viewed in relation to the disciplinary content they are engaging with and transferring, the contexts in which they are engaging and where transfer occurs, and the social contexts where they engage with other students, teachers, and disciplinary experts that orient them to ways they can transfer their knowledge both in class and out of school. All of these connections between students and specific aspects of their environments speak to the phenomena of interest, or unit of analysis, in this research study. While it is the students who engage in more or less disciplinary ways and who transfer more or less adaptively, explanations for these behaviors can be found largely in the environments and experiences of the students rather than (or in addition to) the characteristics of the students themselves. The following theoretical framework describes how situative theory captures this "activity system" that brings meaning to the ways students participate, followed by detailed explanations of the transfer and engagement literature that was used in connection with the analysis of data in this research study.

Theoretical Framework

A cultural-historical view of mediated action (Vygostky, 1987), situative theory (Lave & Wenger, 1991), activity systems as a unit of analysis (Greeno, 2006), and Rogoff's (1995) "planes of analysis" approach come together in this research study as vital conceptual and methodological foundations. This project is oriented to an examination of learning, transfer, and engagement practices that are rooted in situated systems of interactions involving relationships

between a number of elements rather than any one element (such as a student's mind) in isolation.

Situative Learning

In the situative tradition, learning involves a participant's movement toward the center of a "community of practice" (Lave & Wenger, 1991; Wenger, 1998), where an "activity system" (Greeno, 2006) is the smallest unit of study appropriate for analysis: "The defining characteristic of a situative approach is that instead of focusing on individual learners, the main focus of analysis is on *activity systems*" (Greeno, 2006, p. 79). For students and teachers in a classroom setting, a community of practice such as the scientific community is largely present as an imagined, "figured" social world (Holland, Lachicotte, Skinner, & Cain, 1998). This world is accessible through "addressivity" during classroom interactions (Ford & Forman, 2006), where students address their contributions to a community of practice that resides largely outside of the classroom (for example, students write a letter to their senator regarding management of local natural resources). However, the scientific community can also enter the classroom in less imagined ways, through disciplinary experts (such as a panel of salmon scientists), field trips into the community (such as a nature center or preserve where the local ecosystem is accessible for direct experience), or other resources (such as websites) that give students and teachers access to authentic community participants and practices.

The classroom as an activity system involves some or all of these elements at any given point in time, extending the concept of "learning" to include aspects of the setting that provide content and context for learning, in addition to changes in an individual's cognition or the quantifiable amount of knowledge they possess. From a situative perspective, the concept of

learning cannot be fully captured by considering an individual's mind in isolation from the elements that are contributing to its change (such as teachers and scientific practices).

Unit of Analysis

When Vygotsky (1987) brought the socio-historical tradition of Marxism to the field of psychology, he preserved the idea of a dialectical whole that consisted of inseparable, integrated parts. When it came to doing research in the field of psychology, he critiqued people who studied language and verbal thought by breaking language into small parts such as a phoneme that did not maintain characteristics of the whole: "Psychology must identify those units in which the characteristics of the whole are present, even though they may be manifested in altered form" (p. 47). In his study of verbal thought, Vygotsky identified "word meaning" as the smallest unit of analysis, but he also recognized the value of the element–unit relationship for other psychological research:

> This form of analysis relies on the partitioning of the complex whole into units. In contrast to the term "element", the term "unit" designates a product of analysis that possesses all the basic characteristics of the whole. The unit is a vital and irreducible part of the whole. (p. 46)

In a way, Vygotsky and "first generation" cultural-historical theorists (Engestrom, 2001) broke out of the constraints of the "dialectical" model from the Hegelian and Marxist traditions (Engels, 1940) by introducing this distinction between units and elements (Vygotsky, 1987), where a unit might consist of the traditional "dual" dialectic (such as a stimulus and response), but it could also consist of a larger number of elements (such as subject, mediational means, and object).

This concept of units and elements retains some of the characteristics of a dialectic in that the whole unit can only be defined or fully understood through the unique combination of its elements, but the unit is not limited to the dual nature of the material|ideal relationship of

traditional Marxism. This unit–element relationship frequently shows up in education literature in terms of the development of higher psychological thought, which Vygostky contrasted with behavioral adaptations that can be impacted through a basic stimulus–response relationship. At minimum, the elements involved in a unit of interest involving higher psychological thought (such as engagement) involves at least a subject, mediational means, and object/motive,[3] but they usually involve multiple, unique elements depending on the activity system of interest.

A classroom activity system—the unit of analysis in this study—involves students (subjects), discourse (mediational means), material resources (curricular media such as PowerPoint slides and handouts), classroom practices (rules, rituals, etc.), cultural histories (experiences students and teachers bring with them into the classroom), and other resources (time, relationships, etc.). These elements all intersect at different points in time, interacting and influencing each other (such as teachers using discourse practices to frame a material resource expansively in promotion of transfer to an imagined, future context).

Planes of Analysis

Barbara Rogoff, a sociocultural researcher, developed the "planes of analysis" approach to analyzing elements of a larger system: "These are inseparable, mutually constituting planes comprising activities that can become the focus of analysis at different times, but with the others necessarily remaining in the background of the analysis" (Rogoff, 1995, p. 139; see also Herrenkohl & Mertl, 2010). Viewing classroom activity systems using the "planes of analysis" approach can be useful in terms of bringing particular elements into focus individually or in combination, while maintaining constant consideration of the whole activity system.

[3] I use the label "object/motive" to distinguish the object or purpose of an activity from the material object as media that might be a part of the mediational means (Engestrom, 2001).

> The parts making up a whole activity or event can be considered separately as foreground without losing rack of their inherent interdependence in the whole. Their structure can be described without assuming that the structure of each is independent of that of the others. Foregrounding one plane of focus still involves the participation of the backgrounded planes of focus. (Rogoff, 1995, p. 140)

While multiple elements are usually in play at any given time in a complex activity system such as a classroom, it can be useful to focus on only certain planes that are contributing in particular ways to the activities of interest at certain points in time, keeping other aspects of the activity system in mind, but in the background of analysis.

In order to explain students' transfer and engagement in the classroom, multiple aspects of the classroom activity system need to be included in analysis. In the case of transfer, analyzing how teachers frame for transfer, as well as the role of peers and material resources in this framing process, helps paint a situative picture that better explains how students transfer disciplinary knowledge and practices from one context to the next. In the case of engagement, analyzing the four ways that teachers foster engagement—by supporting students' authority and discipline-appropriate accountability, problematizing the discipline, and providing access to resources—in combination with a focus on including disciplinary knowledge and practices in the classroom, makes productive disciplinary engagement a valuable, situative lens with which to frame student participation.

Literature Review: Framing for Transfer

Defining Transfer

Transfer is a complex concept with a long history within cognitive theoretical traditions in educational psychology. Cognitive theorists typically define transfer in terms of storing information in the mind, moving it to a new context, and then applying it in that context: "the ability to extend what has been learned in one context to new contexts" (Bransford et al., 2000,

p. 51). Transfer has been transformed in recent literature, taken-up by situative researchers and defined without strong ties to cognitive representations[4]: "a theory of transfer does not have to assume that symbolic cognitive representations always mediate the transfer that occurs" (Greeno, Smith, & Moore, 1993, p. 156). A differing conception of knowledge is at the heart of the situative transformation of transfer:

> In the view of situated cognition, we need to characterize knowing, reasoning, understanding, and so on as relations between cognitive agents and situations, and it is not meaningful to try to characterize what someone knows apart from situations in which the person engages in cognitive activity. (Greeno et al., 1993, p. 100)

Like the situative definition of learning, a situative lens on transfer includes a broader unit of analysis that includes a more balanced focus on the social contexts in which transfer takes place, rather than the primary focus being on an individual learner as the source of transfer. Situative researchers align the (knowledge) content and (social) context aspects of transfer as part of a larger activity system: "the reason that contexts matter for transfer is that content knowledge is inextricably tied with its contexts of use" (Engle et al., 2012, p. 218). In this view, transfer includes more than a student, disciplinary content, and two contexts: "learning to participate in an activity in one situation… influence[s] (positively or negatively) one's ability to participate in another activity in a different situation" (Greeno et al., 1993, p. 100). This broadened perspective demands consideration of other parts of the activity system and their relationships, such as the role of teachers in framing aspects of social contexts (time, place, participants, and roles). While aspects of the traditional cognitive definition are still important (see Table 1), the role of social

[4] "Empiricist and rationalist accounts of transfer share the crucial assumption that transfer depends on the cognitive structure that the learner has acquired in initial learning and can apply in the transfer situation" (Greeno et al., 1993, p. 161).

context in transfer theory has taken the forefront, stealing the stage from isolated individuals and their minds.

Qualifying Transfer

In Table 1, I summarize the definitions of several of the qualifying terms commonly used with transfer that are relevant to this paper. This study primarily considers positive, near transfer, where students prepare to transfer-out of one content and transfer-in to another.

Table 1. Types of Transfer

Type	Definition
Positive	Content knowledge is brought into the learning context in a way that is useful for further learning (Bransford et al., 2000, p. 51). All mentions of transfer are assumed to be positive unless they are specifically qualified (labeled) as being negative.
Negative	Content knowledge is brought into the learning context is a way that impedes further (or correct) learning: "Transfer could also be negative in the sense that experience with one set of events could hurt performance on related tasks" (Bransford et al., 2000, p. 53), when content knowledge is "used inappropriately" (p. 63).
Near	Transfer (movement or application of content knowledge) that occurs between two closely related contexts: "transfer from one school task and a highly similar task" (Bransford et al., 2000, p. 53).
Far	Transfer (movement or application of content knowledge) that occurs between two dissimilar contexts. For example, "from school subjects to nonschool settings" (Bransford et al., 2000, p. 53).
Transfer-out	Use of content knowledge in a context besides the one where the content was originally learned: "productive action in potential future transfer contexts" (Engle et al., 2012, p. 218). When transfer is mentioned without an -in or -out qualifier, transfer-out of the learning environment is typically assumed.
Transfer-in	Use of content knowledge, that was acquired in a previously encountered context, in the present learning context: "Complementarily [to transfer-out], transfer is also encouraged to the extent that transfer contexts are framed as being connected back to past learning contexts" (Engle et al., 2012, p. 218).
Routine	Routine use of content knowledge, where content that was brought into an individual's mind is expressed in a highly similar way.
Adaptive	Adaptive use of content knowledge, where content that was brought into an individual's mind is expressed in a recognizable but transformed way: "the reshaping of prior… knowledge to fit new contexts" (DePalma & Ringer, 2011, p. 134).

Note. This table includes summaries of the definitions of several of the qualifying terms commonly used with transfer.

Near and far transfer.

Much of transfer research, including research in this design-based implementation research (DBIR) study (Nolen et al., 2014; Parker et al., 2013), focuses on far transfer, especially regarding transferring knowledge in and out of the classroom that is relevant to contexts outside of school. In this paper, I focus on near transfer, as it is important for supporting learning through projects that exist across multiple, often highly-related contexts.

Adaptive and routine transfer.

Adaptive transfer has recently emerged in educational psychology literature as something of value that may align with and serve as evidence of "deep learning": "We aimed also at deeper learning: specifically, learning for adaptive transfer" (Parker et al., 2013, p. 1420). In this sense, adaptive transfer is viewed as an outcome measure for gauging deep learning, where particular changes to an individual's mind (knowledge) become noticeable by the way they transfer knowledge. Bransford and Schwartz (1999) write about the shift in transfer theory toward more adaptive definitions of transfer: "Adapting to new situations (transfer) often involves 'letting go' of previously held ideas and behaviors. This is very different from assuming that transfer represents 'the degree to which a behavior will be repeated in a new situation'" (p. 80). DePalma and Ringer (2011) also argue that in the domain of writing and composition, transfer is not just about reuse, but also about adaptation: "We argue that discussions of transfer in L2 writing and composition studies have focused primarily on the reuse of past learning and thus have not adequately accounted for the adaptation of learned writing knowledge in unfamiliar situations" (p. 135). While not all transfer researchers refer to a specific type of transfer as being "adaptive" (Bransford & Schwartz do not, while DePalma & Ringer do), this distinction between a more

static, unchanging application of knowledge and a more flexible, changing use of knowledge is common in current transfer literature.

The terms "adaptive" and "routine" have their root in the distinction between adaptive and routine expertise outlined by Bransford and his colleagues:

> Adaptive experts are not accustomed 'to treat new information as ends to be memorized' (Schwartz & Bransford, 1998, p. 477) as some veteran AP students may be; rather, they are inclined to treat new information 'as tools to help them perceive and think.' (as cited in Parker et al., 2013, p. 1453)

If expertise involves application of knowledge in adaptive or routine ways, then these experts are in fact *transferring* adaptively or routinely when they use that knowledge:

> Hatano and Inagaki (1986) discuss 'routine experts' who become very good at solving particular sets of problems but do not continue to learn throughout their lifetimes (except in the sense of becoming even more efficient at their old routines). Those potential downsides of an overemphasis on efficiency, especially in the face of change, make it especially important to attempt to reconceptualize learning and transfer as something more than the ability to apply previously acquired skills and schemas efficiently for routine problem solving. The argument is not to eliminate efficiency but to complement it so that people can adapt optimally. (Darling-Hammond & Bransford, 2005, pp. 50-51)

Just like adaptive and routine expertise, adaptive and routine transfer both have a place in education contexts where some degree of (routine) knowledge continuity is vital, but can also be complimented by a flexible application of that knowledge.

Multiple sources in education literature position adaptive transfer as a valued practice in both school and in science disciplines (Nolen et al., 2014; Parker et al., 2013; Bransford et al., 2000). Literature on framing (Engle et al., 2012) shows that teachers who frame expansively through the promotion of student authorship over time provide an environment where adaptive

transfer can flourish. Science education literature (NGSS, 2013) show that the discipline of science also involves adapting knowledge based on new evidence.[5]

In *How People Learn*, Bransford and his colleagues (2000) addressed the flexibility of transfer in terms of how widely applicable knowledge is to a variety of *contexts* in lieu of the adaptability of the knowledge itself. For these authors, the reason adaptable knowledge is valuable is so that it can be applied in a variety of contexts, or for far transfer. However, the concept of flexible or adaptive transfer may also be used to focus attention on the knowledge or disciplinary content itself (transferring *knowledge* in a modified way = adaptive transfer). In this case, adaptive transfer is relevant to near transfer situations as well, especially as a sign of students exercising their authority within a discipline (Engle & Conant, 2002), and as an important part of the discipline of science (revising knowledge in response to new information).

Both adaptive and routine transfer are responsive to "framing for transfer" (Engle et al., 2012). While Engle and her colleagues (2012) do not specifically refer to a type of transfer that is "routine," they do refer to transfer and adaptive transfer as unique constructs by suggesting that framing that involves promoting student authorship may lead to adaptive transfer. "If authorship becomes a general practice that students regularly participate in, it may promote the practices of *generating new knowledge and engaging in adaptive problem solving*" (p. 222). Other authors suggest the implications of instruction for transfer as well: "Instructional strategies designed to

[5] "The nature of science is included in the Next Generation Science Standards. Here we present the NOS Matrix. The basic understandings about the nature of science are:

> Scientific Investigations Use a Variety of Methods
> Scientific Knowledge is Based on Empirical Evidence
> ***Scientific Knowledge is Open to Revision in Light of New Evidence*** [emphasis added]
> Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
> Science is a Way of Knowing
> Scientific Knowledge Assumes an Order and Consistency in Natural Systems
> Science is a Human Endeavor
> Science Addresses Questions About the Natural and Material World"
> (NGSS, 2013, p. 4).

facilitate innovation are quite different from those that merely facilitate efficiency" (Darling-Hammond & Bransford, 2005, p. 51). As part of the activity system of the classroom, types of instruction and framing appear to be directly connected with types of transfer.

Framing for Transfer

According to recent research in the learning sciences, individuals are impacted by aspects of their environment that serve to promote or discourage transfer through "framing": "Framing is the meta-communicative act of characterizing what is happening in a given context and how different people are participating in it" (Engle et al., 2012, p. 217). A teacher can frame content and contexts in ways that encourage or discourage transfer. Engle and her colleagues claim that one way to promote transfer is through expansive (as opposed to bounded) framing.

> A teacher can frame a lesson as a one-time event of learning something that students are unlikely to ever use again, or as an initial discussion of an issue that students will be actively engaging with throughout their lives. Our contention is that the first kind of framing, which we refer to as bounded, will tend to discourage students from later using what they learn, while the second, which we refer to as expansive, will tend to encourage it. (p. 217)

Essentially, expansive framing promotes transfer while bounded framing may either discourage transfer or just forego providing supports for transfer in ways that specifically encourage it. For students, this means they can be oriented more or less (via types of framing) to "aspects of the context" (Engle et al., 2012, p. 219) that cross boundaries of time, place, participants, and roles where disciplinary content is positioned as more or less relevant for transfer.

Aspects of the context.

"Aspects of the social context" (Engle et al., 2012, p. 219) are framed in expansive or bounded ways by classroom teachers, either promoting or not promoting transfer. Engle and her team defined these aspects in terms of settings (time, place, and participants) and roles. They outlined how each of these aspects were operationalized for their experimental studies of framing

and transfer, but they did not specifically chart any case study data in terms of which aspects of the context were framed expansively or not.

Methods for expansively framing.

In order to more deeply understand how transfer could be promoted, situative researchers Engle and her colleagues (2012) expounded the teacher's role in using particular methods to encourage transfer. They proposed that two ways teachers could expansively frame for transfer was by connecting settings (p. 220) and promoting student authorship (p. 221). Connecting settings involved showing students how content was connected across experiences: "When contexts are framed expansively, students are positioned as actively contributing to larger conversations that extend across time, places, and people" (p. 215). Promoting authorship involved positioning students so they were authoring content rather than copying it: "When two transfer contexts were reframed as having to do with active student sense making rather than simply the replication of knowledge, students were more likely to 'transfer-in' (Schwartz et al., 2005) their prior knowledge" (p. 219). Engle and her team did not specify to what degree framing moves needed to be made in order to see a difference in the occurrence of student transfer, or whether just connecting settings or promoting authorship was sufficient for promoting transfer. However, they make a connection (in their fifth explanation) between students adapting knowledge (adaptive transfer) and framing that promoted student authorship over time.

While the notion of "connecting settings" is intricately tied to the construct of transfer, "promoting student authorship" has implications that go beyond teachers encouraging students to transfer, including implications for the type of student engagement (Engle & Conant, 2002) they are also fostering in their classrooms.

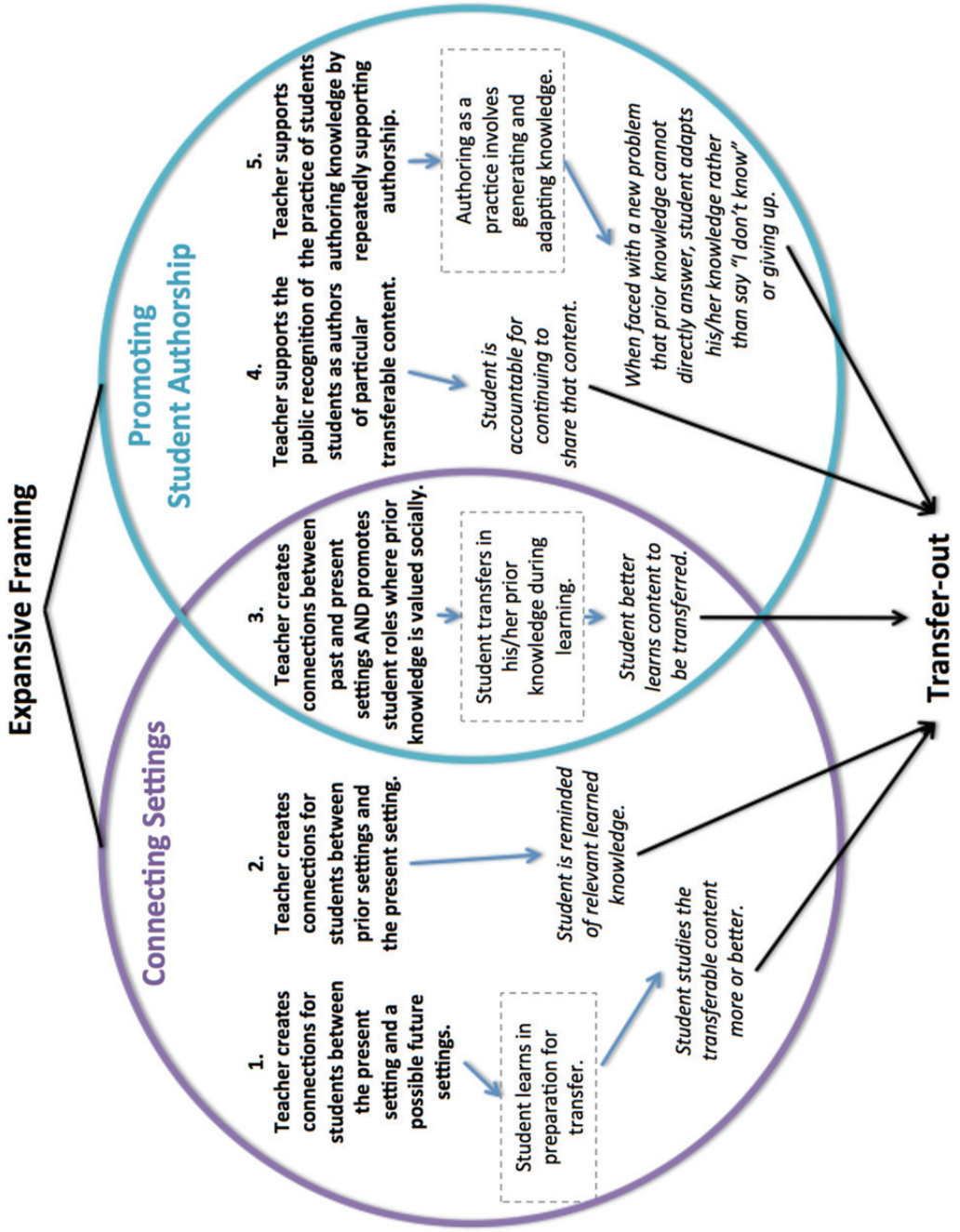

Figure 1. Expansive framing. This is a modified version of "Figure 2" from the Engle et al. (2012) article, designed to demonstrate: "Five potential explanations for how expansive framing may foster transfer" (p. 220).

Literature Review: Productive Disciplinary Engagement

Engle and Conant (2002) and Engle (2012) outlined a framework for defining and fostering *productive disciplinary engagement* (PDE) in order to help educators understand and support students' engagement with and progress in disciplinary practices. While the work of Engle and Conant (2002) also included detailed analyses of science classroom case studies, the PDE framework itself was designed for cross-disciplinary implementation (for example, the discipline of educational psychology in Engle & Faux, 2006). To move forward with an analysis utilizing this framework, a clear definition of each element of the framework is necessary, especially the discipline of interest (science), as it not only delineates what can be considered "productive" in terms of disciplinary practices, but also how the specific disciplinary practices might be fostered in a classroom environment.

Rating PDE

Engle (2012) used a rating system of weak, moderate, strong, or mixed to define each characteristic of PDE and the four methods for fostering PDE:

> I use reported findings from analyses and (when available) data from the studies as a basis for providing rough synoptic estimates of the degree to which: (a) each principle was embodied in the learning environment, and (b) each aspect of PDE was observed in it. I rated degree of embodiment as weak, moderate, strong, or mixed. Embodiment was rated as stronger to the extent that more aspects of the principle or criteria for productivity, disciplinarity, or engagement were embodied according to the authors of the study…. Obviously, this kind of coding cannot capture the nuances in each study's analyses, but it is helpful for identifying broad patterns across studies. (Engle, 2012, p. 181)

The same rating system is utilized in this study to maintain continuity with Engle's (2012) meta-analysis of PDE-related studies, allowing for ease of comparison between this study and those contained in Engle's analysis.

Engagement

Defined in isolation from productivity and disciplinarity, engagement involves a focus on students' behavior and interactions with each other and the disciplinary content (Engle, 2012; Engle & Conant, 2002). It is only through using the framework as a whole, as *productive disciplinary* engagement, that student engagement becomes tied to disciplinary practices. This makes the PDE framework particularly useful in the analysis of classroom activity, where the arbitrariness of student engagement comes into focus, gaining situated purpose and value through the lenses of productivity and disciplinarity.

Engle and Conant (2002) and Engle (2012) laid out the following six criteria for engagement:

> (a) More students in the group sought to make, and made, substantive contributions to the topic under discussion.
>
> (b) Students' contributions were more often made in coordination with each other, rather than independently of each other.
>
> (c) Few students were involved in unrelated 'off-task' activities.
>
> (d) Students were attending to each other as assessed by alignment of eye gaze and body positioning.
>
> (e) Students often expressed passionate involvement by making emotional displays.
>
> (f) Students spontaneously got reengaged in the topic and continued being engaged in it over a long period of time.
> (Engle, 2012, pp. 164-165; Engle & Conant, 2002, p. 402)

These criteria are useful for categorizing engagement in isolation from specific disciplinary practices and productivity. The qualities of engagement transform in mostly additive ways when the qualifiers of "productive" and/or "disciplinary" are incorporated.

Productive Engagement

Productivity, or progress, is a key modifier of engagement: "Students' engagement is productive to the extent that they make intellectual progress, or, in more colloquial language,

'get somewhere'" (Engle & Conant, 2002, p. 403). While productivity is associated with some type of content (with which to make progress), the content does not necessarily have to be tied to the discipline with which the students are supposed to engage (for example, they could be making progress in their understanding of math while in music class).

In the discipline of science, progress looks like students generating questions for investigation and making more connections between ideas over time (Ford & Forman, 2006, p. 11). However, productive engagement might follow the "grammar of schooling" (Tyack & Cuban, 1995), where progress could be defined in terms of completion of a task, for example, rather than improved learning or understanding of disciplinary content: "What constitutes productivity depends on the discipline, the specific task and topic, and where students are when they begin addressing a problem: (Engle & Conant, 2002, p. 403). Consequently, productive engagement itself is not a particularly useful concept for analysis; it is the combination of all three aspects of PDE that make it useful for analysis of students' disciplinary activity.

Disciplinary Engagement

In order for engagement to be considered disciplinary, there needs to be "some contact between what students are doing and the issues and practices of a discipline's discourse" (Engle & Conant, 2002, p. 402). It is necessary to have a clear understanding of what types of student activity can be considered disciplinary in order for that activity to be promoted. "If we are serious about supporting learning though participation in disciplinary practices, we need a way of thinking about which ones are of most consequence, both for the discipline and for students" (Ford & Forman, 2006, p. 25). Ford and Forman took up this challenge of explaining how to "connect classroom activities with science activities" (p. 11).

Science practices.

Ford and Forman (2006) "explicate key aspects of authentic disciplinary practice in science" (p. 16), the discipline relevant to this study. They expounded the disciplinary aspect of the PDE framework by focusing on a single, specific discipline: "Although their attention to features of student work in classrooms helps us scrutinize whether participation is productive, Engle and Conant's effort was less successful in identifying activity that is disciplinary" (p. 11). Unlike Engle and Conant's (2002) goal of creating a framework for analysis (of student engagement) that could be used across disciplines, the work of Ford and Forman (2006) achieved the end of describing science as a specific discipline of practice, including how it mapped onto the more general PDE framework.

Ford and Forman (2006) explained scientific practice in terms of the relationship between scientists and nature, as well as scientists and each other: "Scientists construct explanatory accounts of nature and debate with other scientists about these accounts, drawing on information they have gathered on nature's behavior as an arbiter for specific points in their arguments" (p. 15). The combined social and material aspects of their disciplinary goals work toward "achieving a better 'explicit connection' between the claim and nature's behavior" (p. 15), through taking on the "Roles of Constructor and Critiquer of claims" (p. 16). These roles, combined with an addressivity to the scientific community and reliance on nature for evidence, described the fundamental practices of the discipline of science in ways that could be taken up by students in classrooms.

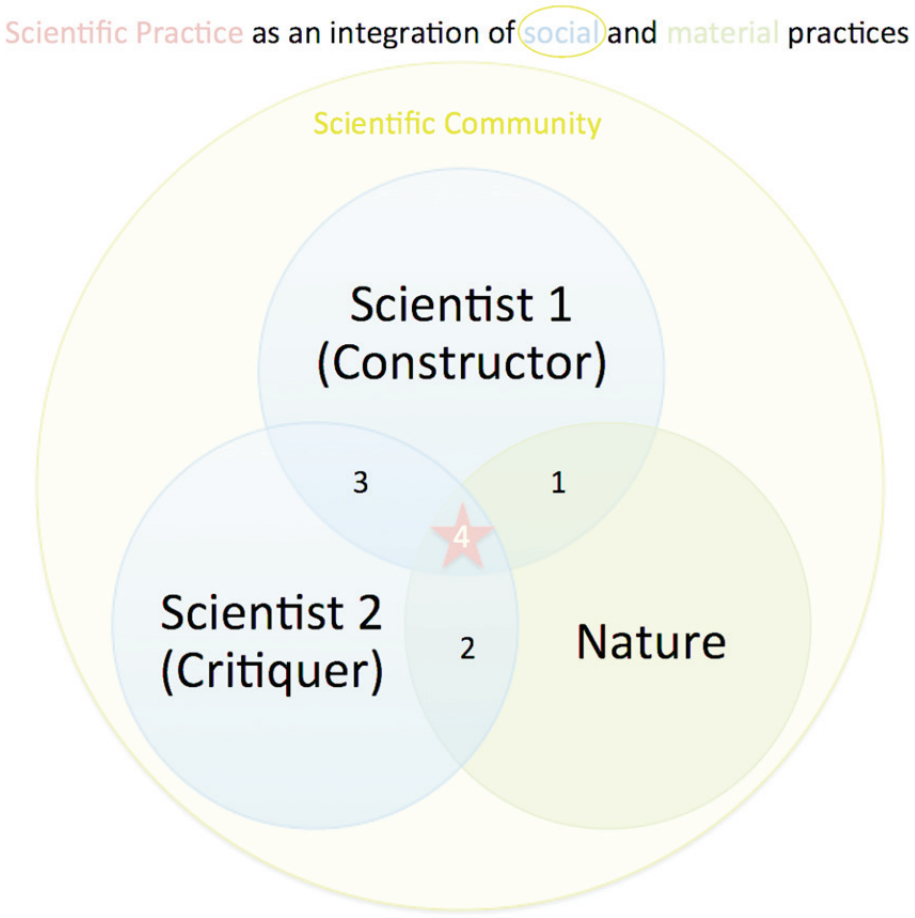

Figure 2. Scientific practice as an integration of social and material practices (Ford & Forman, 2006).

Figure 2 demonstrates the relationships between elements of scientific practice, indicating what to look for in the data in order to gauge if student work is disciplinary or not: the two roles of constructor and critiquer, the use of nature-based evidence, and addressivity to the scientific community. The numbers correspond to the movement scientists might make through the diagram, all the while maintaining addressivity to the scientific community (the yellow background): (1) a scientist conducts an experiment; (2) another scientist critiques the experiment in terms of the behavior of nature; (3) the first scientist revises according to recommendations from the critiquer; (4) the claim is accepted and becomes a product of the

community rather than only the original contributor (see Ford & Forman, 2006, p. 15, for more detail).

Schooling practices.

When students participate in science classrooms, a goal is for them to not only learn science content, but to become practitioners who are more central members of science communities (Lave & Wenger, 1991). Science content wrapped in the "grammar of schooling" (Tyack & Cuban, 1995) is scarcely science, and does little to facilitate students' meaningful participation in a community practice. In a schooling context of "extraordinary sameness," disciplinary practices that are widely diverse in out-of-school contexts are homogenized through the strainer of "doing school" practices (Pope, 2003), frequently "repeated lecturing, questioning, monitoring, and quizzing'' (Goodlad, 1984, p. 249).

> Studies have suggested that productive disciplinary engagement can be short-circuited when learning environments communicate to students that there is a single valid response to every question and that students' job is merely to determine what it is… In such environments, students may become highly engaged in getting possession of the right answer and having it validated by an authority. However, this kind of engagement is not characteristic of most authentic disciplinary practice, often makes less contact with deep disciplinary issues, and tends to be reproductive rather than productive. (Engle & Conant, 2002, pp. 408-409)

Traditional schooling practices frequently position the teacher as an authority and students as accountable to the teacher for knowing prescribed answers.

As "this grammar [of schooling] applies especially to AP courses," the implementation of a PBL curriculum in these two high school AP Environmental Science classes "interrupts the well-established classroom routine in which the teacher gives lectures, homework readings from the textbook, and quizzes and tests" (Parker et al., 2013, p. 1430). Instead, learning is done

primarily through projects that involve students taking on roles more authentic to the discipline; roles that give them more authority and accountability to the disciplinary community.

Whether it aligns with the disciplinary practices being promoted or it conflicts with them, the "grammar of schooling" is something that is deeply embedded in the tradition of participating in school:

> During the last century, there has been much continuity in the structure, rules, and practices that organize the work of instruction. These organizational regularities, the grammar of schooling, include such familiar practices as the age-grading of students, the division of knowledge into separate subjects, and the self-contained classroom with one teacher. (Tyack & Cuban, 1995, pp. 8-9)

Even with the introduction of a PBL curriculum built around different standards for students' and teachers' authority and accountability, aspects of this grammar remain intact in the traditional classroom structure (age-grading, division of subjects, etc.) and in the students' and teachers' histories of experiences classroom settings.

Teachers are frequently apprenticed into these "doing school" (Pope, 2003) practices through their "apprenticeship of observation" (Lortie, 1975), participating in acts of teaching as student participants in classrooms that enact shared schooling norms:

> And many teachers, accustomed to a familiar grammar of schooling and to solitary instruction in self-contained classrooms, lack the confidence and collegial support needed to try out new instructional ideas as well as the knowledge and skills needed to make them work well in their classroom. (Tyack & Cuban, 1995, p. 139)

It is perhaps even more difficult than current learning sciences research acknowledges to break out of a cycle of traditional schooling practices that has been perpetuated through generations of students learning the grammar of schooling through observation, participation, and finally, practice as teachers. When "the structure in learning activities is almost always established by the teacher" (Cornelius & Herrenkohl, 2004, p. 492), it is clear that an analysis of student

transfer and engagement in a classroom setting is largely inseparable from the activities of the teacher.

Four Supports for PDE

At its inception, PDE was not intended to be just a description of a particular type of student engagement, but a situative theory that captured elements of the environment (resources) and teaching moves (fostering authority, accountability, and problematizing) in addition to describing student engagement in particular ways.

> The goal of Engle and Conant (2002) was to abstract principles that could apply across learning environments in ways that could inform both the design of a wide range of new learning environments as well as research about existing ones. (Engle, 2012, p. 163)

Engle and Conant (2002) and Engle (2012) identified four supports for productive disciplinary engagement (PDE), two of which (authority and accountability) are also recognized as important for expansively framing for transfer (Engle et al., 2012):

> One way to foster productive disciplinary engagement is by creating learning environments that embody the following four principles:
>
> (1) *Problematizing*: Students are encouraged to take on intellectual problems.
>
> (2) *Authority*: Students are given authority in addressing such problems.
>
> (3) *Accountability*: Students' intellectual work is made accountable to others and to disciplinary norms.
>
> (4) *Resources*: Students are provided with sufficient resources to do all of the above. (Engle & Conant, 2002, pp. 401-402)

These four supports for PDE are valuable analytical tools in terms of explaining *why* students might be engaging more or less productively in disciplinary or schooling practices, drawing a broader more situative picture of interactions between elements of the classroom activity system.

Authority.

When students have an active role or authority to address problems related to disciplinary content and practices, they engage more productively in the discipline.

> Authority is a matter of students having an active role, or agency, in defining, addressing, and resolving such problems…. In addition, authority includes teachers and other members of the learning community positioning students as stakeholders. (Engle & Conant, 2002, p. 404)

Authority is connected to how disciplinary the classroom is; a teacher who uses primarily authoritative discourse (Scott, Mortimer, & Aguiar, 2006) would struggle to promote "intellectual authority" in students, the foundation of all of the other types of authority. Engle (2012) identified four types of authority that contribute to students' increasingly productive engagement with a discipline (see Figure 3): "We claim that there are at least four kinds of intellectual authority that build upon each other: intellectual agency, authorship, contributorship, and, finally, being positioned as a local authority" (p. 170).

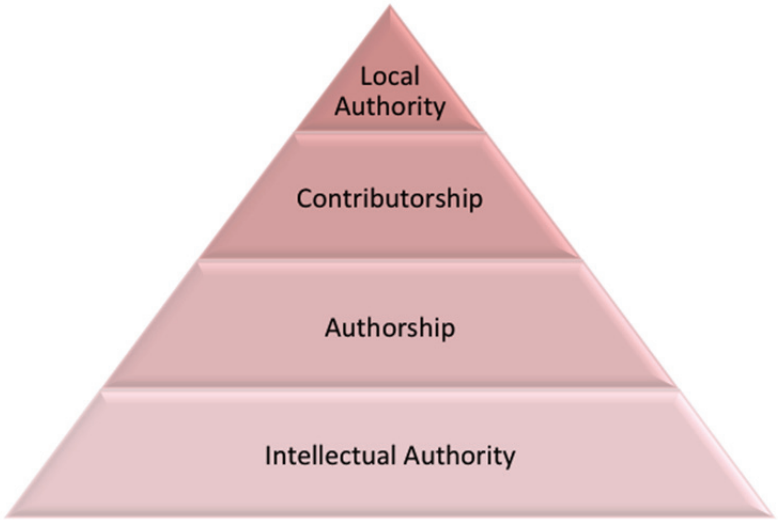

Figure 3. Engle's (2012) four types of authority. These authorities appear to be building upon each other from the bottom to the top.

When the teacher in a classroom has all of the authority and does not promote students' intellectual authority, students are less likely to engage productively in the discipline. They are also less likely to transfer disciplinary knowledge between settings, as their teacher is not "promoting student authorship" (Engle et al., 2012).

Accountability.

When students are held accountable to aspects of the activity system besides (or in addition to) the teacher, they maintain a closer connection with each other (as potential "local authorities") and with disciplinary community:

> Holding students "accountable to others and to disciplinary norms" means that the teacher and other members of the learning community foster students' responsibility for ensuring that their intellectual work is responsive to content and practices established by intellectual stakeholders inside and outside their immediate learning environment. (Engle & Conant, 2002, p. 405)

Teachers may use different forms of discourse and different methods of framing resources to encourage their students to be accountable to the teacher or accountable to other actors in the discipline of science (such as other students, critiquers, nature itself, or the scientific community) (Ford & Forman, 2006). Students who are accountable to more actors in the disciplinary community have a closer connection to the discipline and are more likely to be engaged productively in disciplinary work.

Problematizing.

When teachers encourage student questions and contributions (possible through dialogic discourse; Scott et al., 2006), they facilitate the problematizing of content, where students are challenged to solve authentic issues of a discipline. Problematizing can also be a part of the curricular plan, where students are exposed to pre-defined problems that they must work to resolve (ideally through their authority and accountability to others) (Engle, 2012, p. 168).

Resources.

Engle and Conant (2002) intentionally used a vague notion of resources that could include a variety contextual elements such as time, physical space, and curricular materials (so that the concept remained adaptable to a range of research applications). "A learning environment must provide learners with access to the necessary resources for that work" (Engle et al., 2011, p. 174). A more specific designator for *material* resources is needed in this research project to distinguish between teachers' use of particular types of mediational discourse practices and the physical resources (outside of spoken language) available for teacher and student use in the classroom.

Types of media.

I have chosen the term *media*, "any instrument or mode, natural or artificial, that can shape human communication" (Suhor, 1984, p. 250), to capture the broadest array of phenomena related to modes of human communication. Media terminology frequently fall into one of three main categories when used for the purposes of research: external (to an individual's mind), internal (to an individual's mind), or both internal and external simultaneously (an external–internal dialectical relationship). When media researchers add the modifiers "material," "mechanical," "technical," or "physical" to a media-designator, they are usually referring to the external, tangible aspect of the media. When they add the modifiers "mental," "psychological," or "ideal" to the media-designator, they are usually referring to the internal, conceptual aspects of the media (see Appendix A for a graphical representation of different types of media). Ambiguous combinations of the internal and external categories, such as "cultural tools" or "cultural artifacts," plus the use of the term "mediational means," typically identify the simultaneous, dialectical existence of both internal and external elements.

It is common for media-related terms to be used informally (or without referencing specific theoretical frameworks) in learning sciences literature. The following are a few generalizations about the way these terms are often used in the literature: "artifacts" suggest the presence of cultural history, "tools" hint at action, often primitive or material activity, and "representations" suggest the presence of signs or symbols. The same medium might be referred to as an artifact, tool or representation depending on what properties the author wants to orient the reader to. The term "material artifact" is often used when an author wants to stress the history of an object (Cole, 1996), "material tool" usually stresses the active and current function of the object (Nolen et al., 2012), and "representation" often invokes the connection between the medium and other media to which it refers or reflects (Wartofsky, 1979). "Objects" almost always refer to material things, unless they are qualified with a modifier such as "mental," and there are numerous ways of expressing the essential idea of the object: products, materials, artificial devices, physical manifestations, instruments, and so on. There are also several ways of expressing the essential idea of images, which are usually considered a type of representation, including diagrams, models, and pictures (Paivio, 1990).

Mediation in the classroom.

In a classroom setting, both mediational means and material resources are useful theoretical constructs because they help to identify means of expression and materials for assessment, and they fundamentally impact the way we think about, understand and engage with the world. Higher psychological tasks (such as learning about science) involve ideational and/or material mediational means such as language (Vygotsky, 1987), which is almost always a key component of classroom environments. However, curricular material resources—such as PowerPoint slides or handouts—are also a vital part of classroom activity. These material

resources may both mediate the instructions students receive and facilitate students' active engagement. In other words, students engage with disciplinary content and practices by using both language and/or other materials, such as talking with a group member (via mediational language) or working on their resource management goals (using the teacher-provided material tool). Mediational means take the form of discourse practices in this study, and material resources are addressed as a subset of the "resources" defined by Engle and Conant (2002).

Disciplinary discourse.

According to Scott and his colleagues (2006), teachers use different types of discourse practices with their students that parallel traditional schooling and science practices. Authoritative discourse involves "focusing on a single perspective, normally the school science view," while dialogic discourse involves teachers remaining "open to different points of view" (p. 628). Authoritative discourse is associated with the grammar and practices of schooling, where the teacher is an authority figure:

> In traditional classrooms, however, one typically sees teachers using a more authoritative style of speech.…because the teacher's charge is to evaluate student responses, one can infer that he or she has assumed some role of authority over the subject matter content. (Cornelius & Herrenkohl, 2004, p. 471)

Traditionally, authority in classrooms was a central part of the teacher's role. In contrast, dialogic discourse is associated with the discipline and practices of science, where the scientific community and nature are primary sources of authority (Ford & Forman, 2006). These two types of discourse practices are useful lenses through which to view teachers' discursive interactions with students, as they can facilitate analytical connections between teaching moves (choice of discourse type) and student engagement in particular (disciplinary and/or schooling) practices.

Summary: Themes and Gaps

The literature on transfer and engagement used in this study draws from traditions of cultural-historical and situative theories in the field of the learning sciences. The situative theories of framing for transfer and fostering PDE involve viewing a number of elements of the classroom in concert with one another, especially students, teachers, discourse practices, disciplinary practices, and material resources. These elements may be analyzed in relative isolation or in terms of more limited interactions as "planes of analysis," if the whole of the activity system is maintained in the background and included in analysis (Rogoff, 1995).

While the literature reviewed in this chapter is a great starting point for analysis, there are a few gaps in the literature that an analysis of this particular dataset may address. While PBL curricula are designed with transfer in mind, there is currently little data on how methods teachers use to frame for transfer might impacts the types of transfer they see their students use in a PBL setting. The existing studies on framing include experimental designs and single case studies (Engle & Conant, 2002; Engle et al., 2012; Engle et al., 2011; Meyer et al., 2011), but not comparative studies where we see teachers using more or less expansive framing. Also, while past research on framing does address the promotion of student authorship, it does not include 3 of the 4 supports for PDE addressed by Engle and Conant (2002): accountability, problematizing, and resources (including an analysis of the role of material resources as an aspect of the social context).

Finally, while adaptive transfer is gaining popularity as a desirable student outcome (Nolen et al., 2014, Parker et al., 2013), there are currently no case studies that describe students transferring more or less adaptively in settings where teachers are also framing for transfer in distinct ways. This research study attempts to address these gaps in the literature by comparing

and describing in detail two cases where teachers frame material resources more or less expansively and students transfer more or less adaptively, connecting the literature on transfer and engagement in new ways.

CHAPTER 3.

Methodology and Research Design

I conducted a qualitative, comparative case study of two high school classrooms, focusing on a 2-day activity segment that tracked teacher and student interactions around a curricular material tool. I analyzed the dataset (including videos, surveys, and interviews) using grounded theory to track types of framing, transfer, engagement, and use of material resources. My primary goal was to explain the differences in types of student engagement across the two classrooms that researchers observed while filming.

An examination of student learning through the lenses of situative transfer and engagement theory was best conducted through qualitative study, using detailed descriptions of each class to characterize the multiple elements of the classroom activity system. A case study design was appropriate for this research because it allowed for a moment-to-moment analysis of both classrooms in isolation and then in comparison that could address questions about this targeted implementation of a material tool. Because the lesson plans and material resources provided to the students were coordinated by the two teachers of the two focal classrooms, it was of theoretical interest to compare how the two teachers framed the tasks, in addition to the ways they interacted with small groups around the material resources in the classrooms.

Setting and Participants

During the 2012-2013 school year, two project-based learning (PBL), advanced placement environmental science (APES) classrooms were selected for study at Madison High School (MHS), a diverse public high school in a large metropolitan public school district in the northwestern United States. The two focal classrooms were part of the upper curriculum track at MHS, where a majority of the students were what the teachers referred to as “AP veterans.” The

six focal participants included two teachers and four students (two from each class). Other classroom participants were included in analysis as well, including a student teacher and other students who interacted with the teachers and focal students (for example, Male Student R), as well as the two researchers who were present for the filming (Researcher 1 and Researcher 2).

Teachers

The two focal teachers were Terry and Shila (pseudonyms), both white females who spoke English as their native language. They were both new to teaching an entirely project-based curriculum. They had collaborated to teach ecology in the previous year, but had not taught APES (nor other AP courses until the 2012-2013 school year). Terry had 8 years of high school teaching experience, including 5 years at MHS, where she taught primarily physical science, biology, and ecology. She had an endorsement in biology and National Board Certification in general science, in addition to her Bachelor's degree in biology and Master's in Teaching.

Shila was in her first year as a full time teacher at MHS after working there the previous year while completing her Master's degree. She had a PhD in Environmental Science in addition to her newly attained Master's in Teaching. Shila had participated in an ambitious science methods course at the university that was organized using principles of productive disciplinary engagement (Windschitl & Thompson, 2006). The ambitious teaching she studied aims to support students to deeply understand science ideas, participate in the activities of the discipline, and solve authentic problems (http://ambitiousscienceteaching.org).

While Shila was working toward her teaching degree, Terry was her supervising teacher. Both teachers participated in introductory professional development around PBL-APES during a 4-day summer institute, and attended three professional development sessions during the academic year, along with other teachers who were implementing the PBL-APES curriculum.

Throughout the year, Shila and Terry co-planned their classes, including a number of modifications and revisions, in preparation for the implementation of the curriculum.

Students

A group of two focal students in each classroom were selected by the researcher on the day of data collection from among pairs of students who agreed to allow their conversations to be videotaped and audio recorded for the entire period on both days. In Shila's classroom, Researcher 1 selected Greg and Nate (pseudonyms), two white male students who were native English speakers. In Terry's classroom, Researcher 1 selected Bree and Rae (pseudonyms), two white female students who were native English speakers.

The students in Terry and Shila's classrooms had previously enrolled in an average of two AP courses prior to APES, and only 8% of the students had not taken any previous AP courses. None of the students indicated that they had taken the only other PBL-AP course offered at the school (AP Government), but 13% were taking it simultaneously with APES. All of the students in APES had to pass biology and chemistry before being permitted to take the class, and the average GPA for the group was 3.55.

The demographic majority in the two classrooms were white, female students who spoke English as their native language. Sixty-two percent of the student population identified as female and 38% percent male. Sixty-nine percent of the students identified as White, 20% as Asian, 7% as African American, 2% as Hispanic, and 2% did not respond (no students identified as "Other"). Eleven percent of students indicated that people in their home spoke to each other in a language another than English, 37% indicated that one or both of their parents had been born in another country, and 4% indicated that they were born in another country, but none of the students identified as English language learners (there is no data on one student's ELL status).

Most of the students indicated that they were taking the class because the subject was interesting and they felt it was important to know the information rather than because it was a required class. All but two students surveyed indicated that they planned to attend college after graduation and 80% indicated that their mother had either graduated college or completed an advanced degree, suggesting that many of the students were both interested in the content of the course and its AP status (as preparation for college).

Sampling

Participants were selected for this analysis through convenience sampling. The two focal teachers and their PBL-APES students were selected because they offered an opportunity to study teachers who were collaborating at the same school, with the same level of students, teaching the same content as part of an environmental science unit. While the teachers had differing levels of experience, they planned lessons together and intended to move through the curriculum at the same pace, using the same material resources and focusing on the same disciplinary content. This coordination of a curriculum across classrooms with the teachers as the primary source of differentiation offered a unique opportunity to study the impact of teaching moves on the curricular materials and student engagement.

While the teachers were selected because they were participants in the DBIR study and curriculum implementation, the students were a convenience sample of whoever happened to be assigned to each of the classrooms. The data from this intimate sample is not intended for broad generalization, but the study of multiple layers of data over a short period of time offered an opportunity to examine the moment-to-moment interactions of teachers and students in their lived environment.

Data Collection

The two teachers from MHS (Shila and Terry) indicated to the research team when they intended to implement a material tool that the team had newly designed (during the 2012-2013 implementation year) to facilitate student engagement and transfer across 2 days of instruction. The researchers arranged to video tape the use of this tool across two consecutive days. The teachers used a slightly modified version of the researcher-designed tool (called herein the "Document") on the first day of filming, and then they used a teacher-designed tool (called herein the "Map") that built on the students' Document work on Day 2. Interview and survey data of the teachers and students in these classrooms was collected prior to the video recording of these classrooms, and additional interviews were collected afterwards.

Videos

The primary data sources for this study were eight video recordings, detailed in Table 2. During data collection, two video cameras, each with a wireless microphone (mic), captured two different aspects of both classrooms over the course of 2 days. One mic was carried by the teacher, and the camera operator tracked the teacher's movement about the classroom. The other mic was placed to capture the focal student group's interactions with each other and other groups. This camera stayed on the student group throughout the period. The wireless mics allowed the camera operators to maintain a discreet distance from their subjects. Each video recording was approximately 55 minutes in length, capturing a single class period.

Table 2. Video Data Table

Tran-script	Day	Classroom Mic	Description
P1	1	Terry Teacher	Terry assigned a warm-up (summary of resource fact sheet), had five groups share summaries with the class, explained the Day 1 Document, and then walked around the room checking-in and answering questions as students worked on the Document.
P2	1	Terry Student	Focal students Bree and Rae wrote their summary of "trees" on scratch paper, listened to five other groups' summaries, listened to Terry explain the Document, and then completed Side 1 of the Document before the end of class.
P3	1	Shila Teacher	Shila assigned a warm-up (summary of resource fact sheet), had all 14 groups share summaries with the class, explained the Day 1 Document, and then walked around the room checking-in and answering questions as students worked on the Document. At the end of class, Shila had six groups summarize their answers on Side 2 of the Document for the whole class.
P4	1	Shila Student	Focal students Greg and Nate wrote their summary of "fire occurrences" on scratch paper, shared their summary with the class, listened to Shila explain the Document, asked questions about the Document, and then completed the Document before the end of class.
P5	2	Terry Teacher	Terry reviewed how to complete Side 2 of the Document from Day 1, explained how to complete the Concept Map ("poster"), and then answered questions as she walked around the room.
P6	2	Terry Student	Focal students Bree and Rae listened to Terry review the Day 1 Document, listened to Concept Map ("poster") instructions, discussed their resource and plan of action, and then met with four other groups while they completed their Map.
P7	2	Shila Teacher	Shila had students summarize the Document from Day 1 as part of the Day 2 Map activity, explained how to create the rest of the Concept Map, and then answered questions as she walked around the room.
P8	2	Shila Student	Focal students Greg and Nate summarized the Day 1 Document on post-its, listened to Shila explain the rest of the Concept Map instructions, briefly discussed who to talk to first, and then met with five other groups while they created their Map.

Note. This table is a summary of all video data collected for this study. The first column denotes the "P" designator I used to identify the transcripts of each video recording. The second column indicates which day of data collection the video was recorded on, and the third column designates which teacher's classroom was recorded on that day and whether the microphone and video were focused on the teacher or focal student group, and the fourth column is a summary of the events that occurred on that particular video recording.

On Day 1, in both class periods, the video cameras captured the teacher introduction. When the small group activity began, a researcher approached a (previously consented) student group with the microphone to ask permission to record their small group activities; in each class

period, the first group approached assented to being recorded. This audio-visual arrangement provided in-depth data regarding two small groups' interactions over 2 days and also all of the teachers' interactions with other small groups, in addition to whole-class interactions, over this period of time. All videos and audiotaped interviews were transcribed verbatim.

Over the course of 2 days, the teacher mics captured their interactions with the focal group, other student resource groups and individual students, and the whole class. The student mics captured the focal students' interactions with each other, other student resource groups, and the whole class. Table 3 charts the variety of teacher and student interactions captured on video over the course of the 2 days.

Table 3. Data Matrix

	Focal Group (mic)	Teacher (mic)
Focal Group	Focal group interacts with each other	Teacher interacts with focal group
Other Students &/or Resource Groups	Focal group interacts with students outside their resource group	Teacher interacts with students besides the focal group
Whole Class	Focal group interacts with the whole class	Teacher interacts with the whole class

Note. This table charts the types of teacher and student interactions that were captured during data collection. In addition to the interactions captured by the data matrix, both teachers also interacted with researchers from the university and Terry interacted with her current student teacher.

Day 1 video summary.

The first day of video recordings captured students meeting with other students (resource partners) who were assigned the same resource in order to complete a Document[6] that was intended to prepare them for the next day's activities, notating their needs, values, and goals as resource managers (see Appendix B for the full text of the Document). They began with a warm-up where each resource group summarized their resource in a few sentences in preparation for a

[6] Document will be capitalized throughout the remainder of this paper to specify the specific the Document from Day 1. The (concept) Map from Day 2 will also be capitalized.

share out to the whole class, then spent the rest of class time working with their resource partner to complete the Document. This Document (as part of the PBL-APES curriculum) was designed to help the groups find other resources that were their "allies and adversaries" (P4), an exercise intended to prepare them for the activity on the following day. The Document was created by the DBIR research team to support students' productive engagement in the discipline of environmental science by helping them organize and keep track of their ideas for negotiating with other resource managers on Day 2.

Day 2 video summary.

On Day 2, video recordings captured the same groups of students meeting with other resource groups to negotiate relationships between their resources. By the end of class on Day 2, the students submitted a completed Map tracking the relationships between their resource and other natural resources in their community. Terry's class additionally submitted the Document they had created on Day 1. (See Table 2 for a summary of all video data collected by one of two cameras, in one of two classrooms, over the course of 2 days, including the "P" designator I used to identify the transcripts of each video recording.)

Interviews

Using semi-structured interview protocols, members of the DBIR research team interviewed Terry at the beginning of the school year (protocol in Appendix C) and both teachers at the end of the school year (protocol in Appendix D). Students were also interviewed during these times, and while I did review these interview transcripts, I chose not to include them in my analysis because the prompts used by the DBIR research team did not capture responses from the students that were relevant to my analysis. I also used a short interview of Terry conducted by Researcher 1 at the end of the Day 2 video. In addition, I conducted a number of informal,

unstructured interviews of Researcher 1 and Researcher 2 during the processes of initial review, transcription, coding, analysis, and composition to ensure the accuracy of information regarding the sample and DBIR project.

Surveys

I used beginning of the year teacher (Appendix E) and student (Appendix F) surveys to access primarily demographical information about my sample. While student surveys were also collected at the end of the year and I reviewed them, I did not use their content as part of this study because the student responses they captured reflected feedback about the PBL-APES course as a whole that did not offer any new information or triangulation for my analysis.

Material Resources

I analyzed classroom materials that were captured by the video recordings, including PowerPoint slides, writing on the white board, the Document template (see Appendix B), the Map template (Appendix G), and the two focal groups' completed versions of the Document and the Map.

Data Analysis

Design

A case study design was a good fit for this study because I looked at the interactions among several points of interest (especially material resources, teachers' framing, and students' engagement) in two focal classrooms, and a case study design "offers a means of investigating complex social units consisting of multiple variables of potential importance in understanding the phenomenon" (Merriam, 1998, p. 41). In addition to aligning with my unit of analysis (described in Chapter 2), the rich, detailed descriptions of the two classroom cases provided opportunities for both teachers and researchers to identify with features of the environments that

parallel their own classrooms, interests or data, offering insight into how theories of transfer and engagement map onto the day-to-day activities in high-school classrooms.

Role of the Researcher

While I had been involved in some facets of the larger APES project, I had no direct interactions with any of the teachers or students in this study. Researchers 1 and 2, who were present at the time of recording, are my university colleagues. Researcher 1 contacted me after data collection, suggesting that the data they captured aligned with my area of study and that I may be interested in conducting a comparative analysis of the two classrooms. After an initial review of the video data, I decided that a situative view of the classrooms had the potential to offer useful contributions to the literature, especially through the theoretical lenses of framing for transfer and productive disciplinary engagement. I then proceeded to write a research proposal for the current study that was reviewed and approved by four university professionals, including Researcher 1.

Analytical Strategies

I used *the constant comparative method* as part of a grounded theory approach (Merriam, 2009, p. 29) to analyze the dataset. With the grounded theory approach, theory emerged organically from the data as I constantly compared the two classrooms using theoretically-based and open codes as well as analytical memos (p. 29). Theoretically-based codes were chosen after an initial review of the data, where I assessed which theories could be supported and/or challenges through a detailed analysis of this particular dataset (especially considering the small sample size). The theoretical codes I chose left space for open coding to capture phenomena not adequately addressed by existing literature.

Microgenetic analysis.

Aspects of my analytical process were also what Engle and her colleagues (2012) considered microgenetic, or "focused on directly observing the hypothesized processes in action" (p. 227; see also Penuel & Wertsch, 1995). In this study, I observed multiple layers of classroom interactions (students, teachers, and resources) repetitively through video analysis, and I focused analysis on framing and transfer constructs through the use of theoretically-based codes from the outset of my analysis. This microgenetic analysis was a natural part of my data analysis process, as the detailed analysis was already being used in response to the multi-layered quality of the data, and I was already using numerous theoretical constructs from Engle and her team's work as part of my coding process.

Coding.

I began analysis using theoretically-based codes to account for framing for transfer, productive disciplinary engagement (PDE), supports for PDE, and material resources. Coding was iterative, as I added new, open codes and code categories each time the data was reviewed. Analysis proceeded until no new codes were needed to characterize the data. See Appendix H for a complete codes list, including accompanying connections with theory and the dataset.

Analytical process.

In pursuit of a contribution to theory that would arise out of the data, I followed a plan for data analysis that included transcribing, coding, re-organizing, and re-coding until I reached the point where noteworthy relationships between properties of the data could be organized in meaningful ways in relation to relevant literature.

First, I completed transcriptions for all eight videos (see Appendix I for transcription conventions), data-logging videos when they were repetitions of other video transcriptions (for

example, when both video cameras recorded the same teacher introduction to the activity), and time-stamping noteworthy episodes (where students or teachers were behaving in ways I thought may be relevant to my theoretical interests). I then created a hermeneutic unit in ATLAS.ti (a computer program for qualitative data analysis) with the completed video transcriptions as well as transcriptions of the teachers' interviews. The ATLAS.ti software supported my use of multiple codes organized into code families with options to comment on quotations within the transcripts and connect analytical memos directly with their relevant quotations.

Using ATLAS.ti, I coded the transcripts using *the constant comparative method* (Merriam, 2009, p. 30), starting with theoretically-based code categories (see section below on coding), and introducing individual codes in each category as needed. I added uncategorized, open codes (with descriptions) when the theoretically-based codes did not capture the complexity of interactions, as well as analytic memos to note data patterns, theoretical insights and interesting code relationships as they were revealed during the coding process. Throughout this process, I tracked noteworthy episodes in the data that I would revisit for deeper analysis.

After coding the dataset with the first round of codes, I categorized open codes and re-categorized theoretically-based codes,[7] adding analytic memos where appropriate to track insights about theory and potential findings. I then returned to theoretically-rich episodes for deeper analysis and began to organize different aspects of the data into various diagrams and tables that allowed me to better visualize similarities and differences between the two classrooms.

[7] "Data are grouped together on a similar dimension. The dimension is tentatively given a name; it then becomes a category" (Merriam, 2009, p. 30).

Using analytic memos and codes to find points of triangulation in student and teacher data, I continued to refine codes and write analytic memos until no new codes were needed to characterize the data. During this process, I generated hypotheses ("relationships drawn among categories and properties" of the data; Merriam, 2009, p. 31) based on codes, code-relationships and analytical memos, and discussed these potential findings with other researchers for feedback. I iteratively returned to the data to create more codes and revised visual representations and written explanations of the data until I had created a collection of representations and analytical notes that captured the quality of the dataset, addressed my proposed research questions and contributed to the literature in ways that other researchers in my field agreed were meaningful.

Ethical Considerations

The students in this study were primarily 16 to 18 years of age, and all provided signed consent forms to participate in the study (with the addition of a parent signature if they were under 18). These consent forms and other aspects of the data collection process were approved by the Human Subjects Division at the University of Washington. None of the students had records of compromised mental faculties that would place their consent into question, and the compensation for time that was provided to both teachers and students for participation in the study was concordant with approved IRB protocols.

I was not involved in the IRB process, nor was I involved directly with any of the students or teachers in this study. I only interacted with the research team who collected video data and conducted interviews of the teachers and students. I received this dataset in isolation from the larger data corpus and stored the data on a password protected computer. I anonymized the names of teachers, students, and researchers in the dataset using pseudonyms, as well as the name of the school.

CHAPTER 4.

Case 1: Shila's Classroom

The following chapter is a single case analysis of Shila's classroom, beginning with a focus on the teacher and description of events in chronological order over the course of the 2-day lesson. This section orients around how Shila framed the material resources that were either provided by the curriculum or co-planned with Terry, as well as Shila's support of student authorship in her classroom. The teacher analysis is followed by a focus on Shila's students, especially the focal students Greg and Nate. The student section is organized according to findings regarding students' use of disciplinary practices and transfer. This chapter wraps up with a summary of findings that segues into the case analysis of Terry's classroom in Chapter 5 and a comparison between the two cases in Chapter 6.

Day 1

Shila used the material resources provided by the PBL curriculum and co-edited with Terry: PowerPoint slides and writing on the board to remind students of what was due in class and orient them to the day's activities, scratch paper for a warm-up, fact sheets created by the students as homework, PowerPoint slides to introduce the Day 1 Document, and printed Document sheets of paper (see Appendix B). The class was 55 minutes long, with a few minutes at the beginning of class not described below where students were getting settled. The remainder of class time was broken down as indicated in Table 4, and each of the main class segments are described in more detail in the following sections.

Table 4. Time Table: Shila Day 1

Day 1: Shila	Time	Media
1. Beginning of Class	**5 min 40 sec**	PowerPoint/Board
- Teacher introduced researchers	55 s	
- Welcome (pleasantries)	15 s	
- Review	4 m 30 s	
2. Warm-up Activity	**20 min 55 sec**	PowerPoint/Board
- Teacher introduced warm-up	1 m 25 s	Scratch paper
- Student groups worked on warm-up	4 m 5 s	Fact Sheet
- Teacher introduced share out	15 s	
- Groups shared out	14 m 20 s	
- Teacher summarized share out	50 s	
3. Document Activity	**26 min 50 sec**	PowerPoint/Board
- Teacher introduced Document	8 m 50 s	Document
- Student groups worked on Document	16 m 10 s	
- Students shared out Document Side 2	1 m 50 s	

Note. Shila's class on Day 1 was 55 minutes long. The class time was broken down as indicated in the table, proceeding from the beginning of class, to the warm-up activity, and finally to the Document activity. There were a few minutes at the beginning of class not described in the table where students were getting settled.

Beginning of Class

Shila started the day by briefly introducing the two researchers who were collecting video data in the classroom, followed by a few comments to the students about their weekends and the school musical. She then asked students to first make sure they were sitting with their resource partners, and then to organize a number of assignments that they needed to use or turn in that day while she took attendance. She directed students to talk to her at lunch or after school if they had any questions about the assignments that were due, and the students spent the next few minutes moving around the room and shuffling papers until Shila gave them instructions for their warm-up.

Warm-up Activity

The Day 1 warm-up built on prior individual research conducted by students regarding their group's state resource (e.g., watersheds, trees, fires, etc.) and recorded on a "fact sheet."

The fact sheet contained information about students' resources such as their importance, potential conflicts with other resources and their importance to salmon. Shila checked that the resource groups had completed and remembered their fact sheet via a warm-up. She framed the warm-up in relation to previous work (the fact sheet), and made it clear that the students would be accountable to the whole class for sharing their responses:

> You guys, you just wrote a paper on this. You're putting this together in a very succinct manner. And then we're going to have a whip-around where every group shares this out. (Starts timer) (P4, 12:30)

The prompt for the warm-up was as follows:

> (1) Describe your resource in 1 to 2 sentences.
> (2) What's the most important aspect of this resource to our state? Is it economic, ecological or cultural?
> (3) What's the most important aspect of this resource as it relates to salmon? (P4)

Students worked on answering these questions with their resource partner(s) for a few minutes, using scratch paper to keep track of their ideas. Shila walked around the room answering questions while the students worked.

After about 4 minutes, Shila brought the class back together by drawing names randomly from a beaker. Starting with the focal group, Greg and Nate, Shila asked all 14 resource groups to share their answers to the warm-up questions with the whole class. At least one member of every group shared their summaries. Shila spent most of the brief time she talked directing the students in terms of how much content to share or which questions to answer:

> Ok, so great. So I'm going to jump you ahead. What was the most important aspect of this resource? (P4, 18:37)

Shila did not evaluate the students' responses during this time, except with nonspecific comments such as "ok" "all right" "nice" "good" "great" or "awesome" (P4, 17:00-31:16). Most of her interactions with the 14 groups looked something like the following:

Shila: [MSC], were you and [FSB] working together? (MSC: Yeah). Ok go ahead.

MSC: Our resource was watersheds. And an important aspect of our resource is ecologic, as in how watersheds are kind of like a center for fresh water ecosystems and kind of like a habitat(?) for biodiversity and wildlife to come together.

Shila: Okay. Um, are they important to salmon?

MSC: Yeah, because water quantity and quality is like a concern for salmon and we have it here in watersheds.

Shila: Ok, awesome. I'm going to jump over to [FSE]. (P4, 21:02)

If a group hesitated or was not sure what to share, Shila would redirect them with a question or prompt (using dialogic discourse; Scott et al., 2006), but did not rescue them by suggesting answers:

Shila: Ok, good. [FSO], what was your resource?

FSO: Mine was minerals. And um, they're found on and around mountains and what was-?

Shila: What- are they economic, ecological or cultural?

FSO: They're definitely ecological because, um, the mining procedures used to get them often erode the soil and earth that they're on and then how they relate to salmon- the minerals and dust from mining them and just in general often fall into rivers below mountains and they, like, swim around in it.

Shila: Ok. (P4, 24:19)

Through this whole class share out, where Shila gave the students a lot of class time to share their ideas, she promoted "symmetry in teacher–student interactions" by prompting further student contributions and avoiding giving students direct answers to questions about their resources (all indicators of dialogic discourse; Scott et al., 2006, p. 628). The warm-up activity, including the share out time, took just over 20 minutes, only 6 minutes less than the amount of time Shila dedicated to the Document activity. This amount of time, in combination with her summary of the warm-up, indicates that Shila saw the warm-up as an important part of that day's agenda:

> So the things I liked hearing was that you're really thinking about lots of connections here. You researched your resource in particular, but you're always thinking back to how it's affecting other things, and I know that that was planned in, but I'm really hearing it in what you guys just presented. So, we had you work on an individual resource, and this is probably the first time that you've heard all of the individual resources that were researched in this class. (P4, 31:20)

While a distinct activity in many ways, the warm-up was clearly framed as a stepping stone for the following Document activity.

Document Activity

Shila used the summary of the warm-up to segue into introducing the Document, asking students to contribute ideas about who their adversaries might be:

> Now you're going to need to find allies and adversaries. Are there some of these resources where the policies and practices might interfere with each other? Can you think of any? (Points to a student) What's one, [MSJ]? (P4, 32:10)

This teaching move, where Shila elicited students' ideas prior to handing out the Document, publically positioned students as authorities with regards to their resources, promoting student authorship. If she had instead presented examples of ally–adversary relationships, she would have positioned herself as more of an authority than the students.

After hearing from a couple of students, Shila handed out the Document, calling it a "tool," and framing it in terms of preparing for the next day's negotiation between different resource groups:

> Today you're going to set yourself up for the conversations that you're going to have… So I'm handing this tool out. You're going to be working through it in your group, but I'd like each person to have their own copy of it. I'm not going to collect it. (P4, 33:02)

By emphasizing that the Document would not be collected for evaluation by the teacher, Shila distinguished it from the familiar use in school of such handouts as "worksheets" or assignments with one correct answer for each question, where a primary goal of completing the assignment is

for it to be collected and evaluated by the teacher. Instead, the Document was framed in terms of its relationship to upcoming activities, as a tool to facilitate students' thinking and conversations.

The Document was designed (as part of the PBL curriculum) to problematize students' understanding of their resources, facilitating group's conversations around their relationships with the goals of other state resource managers where clashing goals could make them "adversaries" or "foes" (Engle & Conant, 2002). The Document was implemented as a "material tool" (written on the Document itself—see Appendix B) to prepare students for the activity of interacting with other groups during class on Day 2, a purpose that Shila communicated to her class. The curriculum was designed to encourage transfer from Day 1 to Day 2 where time, place and participants (aspects of the setting) were largely linked through the Document as a material resource, facilitated by Shila's expansive framing (Engle et al., 2012). The students' roles as resource managers (who were preparing to meet with other resource managers) were also expansive in the sense that as resource managers, they were "positioned as active participants in a learning context where they serve as authors of their own ideas and respondents to the ideas of others" (p. 218).

Document questions.

After her brief introduction to the Document, Shila had the students read it over in their groups for about 2.5 minutes and then brought the whole class back together for about 4 minutes to field questions before starting work on the Document. This teaching move supported students' authority. Shila allowed them time to think about their own resource in relation to the questions being asked on the Document and then dictate the direction of the following whole class discussion, instead of assuming to know the questions the students would have about the Document by going over it step by step. It is also possible that this teaching move reduced the

number of procedural questions related to how to do the Document, as students had the opportunity to look at it with their resource partners and come up with questions to ask in the whole class setting instead of later while Shila walked around the room interacting with individual groups.

While answering questions and explaining the activity, Shila framed the Document expansively in terms of time (referring to the next day), place (the following day's classroom), and participants (other resource groups). She made sure students understood that the Document's purpose was as a tool to prepare them for the following day's activity:

> You want to have very purposeful conversations with those groups so you're going to outline who you want to talk to. (P4, 39:15)

When a student appeared concerned about the details of completing the Document, Shila reminded her that it was a "tool":

> Female Student E: Would you like us to write in complete sentences?
>
> Shila (shakes her head no): This is a tool for you to use.
>
> FSE: Alright. (P4, 38:45)

At the end of her Document introduction, Shila led the students into their group work time by once again framing the Document's purpose as a tool to structure students' thinking:

> So you're using this to structure those conversations. We're going to have those conversations tomorrow. (P4, 40:21)

This whole introduction to the Document, including the time students took to look it over and come up with questions, took almost 9 minutes. Most of the remainder of the class time would be spent with resource groups working together on the Document.

Resource group work.

While students worked with their resource partners, Shila walked around the room, checking in with groups and answering questions. Shila offered more feedback to resource groups during this time than she did during the warm-up share out. She frequently responded to student's questions with a question or prompt (such as a reminder to think like resource managers), or let the group talk through their problem while she listened, rather than offering a direct answer:

> Shila (to native plants group): Questions or confusions?
>
> Female Student BL: I'm a little confused about like- (Shila: Mmhmm) one of my, I did like the American water weed which kind of takes over. (Shila: Ok) and so they try to like- people try to like get rid of it already. So our goal would be- not let it to take over, or is our goal just to let like every- all of our plants like-
>
> Female Student PR: Do we want like all of our plants to flourish? Or like to- or like-
>
> FSBL: Even if it's invasive?
>
> FSPR: Or just be manageable?
>
> Shila: You prob- as a resource manager you probably don't want that plant to flourish.
>
> FSBL: So it's okay if we want to get rid of something.
>
> Shila: Exactly, yes. (FSBL: Ok) Think about, you're a resource manager that's interested in like- in your case, limiting the growth (FSBL: Ok) so that it doesn't have an impact, Ok? And you can focus on one or two species now that (FS: Oh) like, if you need to narrow to those conversations. (P4, 42:13)

In this excerpt, Shila focuses students on the constraints of the activity in terms of this specific group's resource (responsibility as resource managers to limit the growth of invasive species), giving them direction on what to focus on without giving them specific resolutions to their problem.

This type of interaction was typical for Shila during her encounters with students over the course of these 2 days. She avoided positioning herself as an authority on the students' resources, orienting them to the goals of the activity and their roles as resource managers rather than specific ideas about how to resolve problems. Even when she spent more time talking than the students, her focus was less on telling the students answers and more on demonstrating how to think about their resources (as resource managers) more effectively:

> Shila: Well, as somebody who is an advocate for fossil fuels, you don't want to shoot yourself in the foot, right? (FS: No) and say you should stop using my resource. You should say: Look how responsible I am at making sure extraction is really clean and that we're not damaging. So you want to be promoting fossil fuel extraction and kind of selling-
>
> FS: And saying that like-
>
> Shila: Yeah and you could think of- biomes are my allies, because I'm going to be so good about the extraction, (FS: Ok) and minerals might be an ally because we're going to partner together, so think about your resource in positive terms (FS: Ok) and look for ways that you could, um- we're definitely going to find areas of conflict (laughs) with fossil fuels (FS: Right) but you want to think about like I'm promoting this because of the positive aspects of this.
>
> FS: Ok. (P4, 44:43)

In this excerpt, Shila helped a student think about how to complete Side 2 of the Document, where she needed to share her goals as a resource manager and explain the relationship she thought she had with that other resource. The recommendations Shila made did include a couple of examples of relationships with other resources, but she primarily focused on helping the student understand how to think about Side 2 as a tool for preparing for conversations the following day.

Completing Side 2.

While circulating and interacting with groups, Shila noticed that several groups were not completing Side 2 of the Document. She directed a few of the groups, including the focal group, to work on Side 2:

> Shila: Ok, and then you're, so that second side, you're coming up with: Here's your pitch to ea- your pitch is going to be different for each of those resources, and what you want to ask of them is going to be different.
>
> Greg: Ok. (P4, 48:30)

As explained in this excerpt, the charts on Side 2 particularly supported the purpose of Document to facilitate expansive framing of the Day 2 Map activity, where students would be talking to other resource groups, or "pitching" their management goals to those resources.

After repeatedly focusing student groups on Side 2, Shila deviated from her plan of having students work until the end of the class period. She started preparing the whole class for an end-of-class report out, where students were all positioned as accountable to each other and the teacher for being prepared for the following day's activity. Six groups ended up sharing content from Side 2 with the whole class:

> Shila: Alright, I want you to make sure that you're looking at the second part and you're structuring those conversations. This is where I see you stop- I see a lot of people stopping. So fill this in for one ally and one adversary at least. Right now.
>
> Shila: You guys, keep working on this for 2 more minutes. Two more minutes and then I want to hear one ally and adversary from each group. What you think is going to be one ally and one adversary.
>
> [Shila walks to front of room and then through the students again.]
>
> Shila: All right, if you could finish whatever statement you're writing right now and then turn your attention to the front.
>
> Shila: Alright, [FSM], your group, what is one ally that you want to talk to, your group again is biomes? (FSM: Yeah) And an ally you want- you think you have and a group you want to talk to? (FSM: Native plants) Native plants. And an adversary? Somebody you want to talk to but you might not have a

> good relationship with? (FSM: Fossil fuels) Fossil fuels. [FSB], what's your resource again? (P4, 54:52-57:35)

Shila went through five other groups, asking which resource they were and having them report-out an ally and an adversary. She then framed for transfer to Day 2 one last time before the class ended:

> You guys, I want you to come in prepared to talk to the other groups. Prepared to talk to the other groups. That's where we're starting from tomorrow. (P4, 58:34)

The addition of an end of class report out encouraged resource groups to complete at least part of Side 2 of their Document, helping the students prepare for the Day 2 activity. It also reinforced students' authority as resource managers for their particular resources, making them accountable to other resource managers to be prepared for their interactions on Day 2 (in lieu of accountability to the teacher, since Shila was not going to collect the completed Document).

Day 2

On Day 2, Shila continued to use the media provided by the PBL curriculum and co-edited with Terry: PowerPoint slides and writing on the board to remind students of what was due in class and orient them to the day's activities, fact sheets (to be referenced if needed and ready to turn in at the end of the day), a PowerPoint slide with an example Day 2 Map (see Appendix G), and Map-making supplies (blank sheets of paper, colored markers and post-it notes). The class was 55 minutes long, with class times broken down as indicated in Table 5. Each of the main class segments are described in more detail in the following sections.

Table 5. Time Table: Shila Day 2

Day 2: Shila	Time	Media
1. Beginning of Class	**8 min 25 sec**	PowerPoint/Board
- Students organized things that were due	3 m 15 s	Document
- Teacher talked about upcoming salmon panel	2 m 35 s	Fact Sheet
- Review	2 m 35 s	
2. Map Activity	**46 min 25 sec**	PowerPoint/Board
- Teacher introduced Map	10 m 45 s	Document, Paper, Markers, Post-its
- Student groups worked on Map	35 m 40 s	

Note. Shila's class on Day 2 was 55 minutes long. The class time was broken down as indicated in the table, proceeding from the beginning of class to the Map activity.

Beginning of Class

At the beginning of class on Day 2, Shila oriented the whole class twice to the PowerPoint slide telling them which assignments to take out and reminding them to sit with their resource partner(s). She took attendance and fielded a few questions while they got settled. She then reminded the students about an upcoming panel of salmon scientists, orienting them to the project's larger goal and how it was connected to the panel, and then handing out passes the students would need in order to attend. Finally, Shila reviewed naming conventions for students submitting assignments online before getting started on the day's primary activity.

Map Activity

Instead of reviewing the Day 1 Document as a whole class, Shila initiated work on the Day 2 Map right away. She had students write their resource name and management goals on post-its to put on the center of their Map, framing the activity expansively in terms of the prior day's work:

> This is why I had you guys do the work yesterday. Write it in one sentence. This is the work that you did yesterday, intellectually on the tool, you're summarizing it right now on one post-it. (P8, 12:28)

Shila set a timer for 2 minutes, during which she walked around the classroom showing groups of students an example post-it. She then asked students if they needed more time, added two minutes to the timer, and walked around the room checking off homework while the students worked. When the timer went off the second time, she had a few groups of students read their post-its out loud to the class and then spent about 4 minutes explaining how to do the rest of the Map activity, referring to it as a "concept map" or a "Map."

Making up.

After giving directions, Shila walked around the room answering questions about the Map. She told the second person she talked to not to make up the Document from Day 1 (she had been absent):

> Shila: So you're going to have a quick catch up on-
>
> FS2: So, [FSO] told me kind of what to do - insects, predatory birds, trees, native plants. So I can just do this. Do I have to fill this out? (shows Shila a piece of paper)
>
> Shila: No, that was just to help you structure your thinking. It's not anything that's due.
>
> FS2: So is this due?
>
> Shila: It's to structure your conversation. It's a mental exercise.
>
> FS2: Okay. (P8, 22:59)

This move to not have the student make up the assignment is consistent with the curricular goal of the Document activity (as a tool to help students prepare for the Day 2 Map), and completing it at a later date would not serve to prepare the student for the Map activity. This framing move suggests that Shila's goals for the students in relation to the Document align with the curricular goals, reinforcing students' accountability to each other for being authorities on their resource rather than accountable to the teacher because she would be grading or assessing them in some way.

At the end of class, another absent student approached Shila regarding making up work from Day 1:

> FS: I wasn't here in class yesterday so I didn't do the sheet. So do you want me to-
>
> Shila: No. It doesn't mean anything to do the sheet now because it was just to structure your thinking for this. (P8, 58:12)

Shila reiterated what she told the other absent student: That there was no reason to complete the Day 1 Document after the Day 2 activity since the entire purpose of it was to prepare students for making connections with other resource groups. This consistency in her responses demonstrates that she had a clear vision of the purpose of the tool from Day 1, a purpose that did not include collecting and evaluating it.

Moving on.

Many groups, including the focal group, appeared to start working with other resource groups right away, since they had completed their Documents during class the previous day. However, a few minutes into working on the Map, Shila came across one group that appeared to be making changes to their Document from Day 1. She quickly stopped them, telling them they were going to need to adapt the content depending on who was available to talk with them that day:

> You don't need to change anything on that. That was just a tool to get you to think about it. And you can quickly mentally adapt who you're going to- [talk to]. (P8, 26:30)

Before they even started talking with other resource groups, Shila encouraged these students to adapt their ideas, explaining the role of adaptation in this activity:

> You might end up having to talk to other allies and adversaries because those people might be occupied, right? This helped you go through a lot of mental exercise and you can probably quickly adapt it (MS: Oh) to the allies and adversaries that you have. (P8, 27:06)

In these excerpts, Shila not only stopped students from making changes to their Day 1 Document, but also reiterated the goals of the assignment as focused on the development of students' thinking about their resources. In other words, the Document activity was intended to support the students' roles as authorities on their resources in a way that would facilitate their adaptive use of that knowledge.

Accountability as authors.

During her 31 conversations with individuals and resource groups throughout the Map activity, Shila kept the students focused on the task of creating shared management goals and resolving conflicts with other resource groups, with the details of these conversations captured on their Maps so she could make sense of their thinking. Shila's focus on capturing the unique detail of student conversations supported student authorship, as she valued the contributions that each student had to make and was not only looking for particular, scripted answers on their Maps. She emphasized capturing the quality of conversations over completing every assigned part of the Map:

> It's more important to probably capture the detail that you haven't captured right now than having one more conversation because there's only about 5 minutes left in class. (P8, 52:10)

She wanted students to author content and take on the roles of local experts, explicitly telling a few groups of students that she wanted to know what was in their minds because she already knew what was in hers:

> I've got all sorts of thoughts in my mind because I've been studying this for a long time, but I need to know what you have found out. (P8, 43:29)

Shila fostered authorship by encouraging students to express answers that she did not think of:

> I never would have even thought along those lines so it's really great that you came up with that. (P8, 48:34)

She positioned this kind of authoritative thinking as valuable, saying to another group less than 1 minute later:

> Talk to fossil fuels. She came up with a good resolution. (P8, 49:15)

Shila also oriented students toward the discipline of environmental science by focusing on the quality of their ideas rather than common school goals such as grades:

> I just want to see your thinking. No, I'm not grading. I just want to see your thinking. (P8, 54:43)

Attuning students to their contributions as authors in lieu of her role as an authority figure was one more way Shila supported student authorship in her classroom.

Problematizing management strategies.

As they neared the end of class, Shila checked in with multiple groups to see if they were making connections and resolving conflicts:

> What are some of the resolutions you heard from some of your adversaries? (P8, 49:25)

While looking at a student's paper, Shila checked that their group was including resolutions to conflicts and not just common goals:

> Okay, so you're making sure, so I see common goals- great. And, you're- got the goals and resolutions and how they rely on each other? (P8, 52:57).

Conflict resolution was a critical part of the curriculum, as it was the primary source of problematizing in the activity (Engle & Conant, 2002). By emphasizing conflict resolution, Shila supported both the problematizing of students' management goals (and their understanding of their resource), as well as positioning students with the authority to resolve those problems on their own. The students were also held accountable to each other for coming up with agreeable resolutions. All of these framing moves Shila made, connecting settings and positioning students as authorities (and as accountable to other resource managers), encouraged students to not only

transfer-in prior knowledge about their resources, but also to continue to adapt that knowledge in order to address the problems that arose during moment-to-moment interactions with other resource groups.

Students

During both days of data collection, Shila expansively framed for transfer within the multi-day project and provided support for students' productive engagement in the discipline of environmental science. The students responded to her support by making progress, engaging with disciplinary ideas and practices, and transferring disciplinary content in both routine and adaptive ways.

Following Shila's expansive framing of the Document as a tool to prepare students on Day 1 for their Day 2 conversations, the students focused their discussions on the relationships between their resource and other resources of the state rather than on how to complete the Document correctly. Besides a few clarifying questions about the intentions of Side 2, students largely discussed disciplinary content with Shila on Day 1. This focus on content was especially noticeable when (multiple) groups of students asked more questions about how to complete the Map on Day 2 than they did about how to complete the Day 1 Document. While completing the Document may have been an easier task than making the Map, it is likely that the students were more concerned about how to complete the Map correctly because the teacher would be collecting it.

The following excerpts demonstrate differences in the interactions between some of the students and Shila on Day 1 and Day 2. On Day 1, Female Student L from the insects group did not mention the Document at all, focusing on their need to control some insect populations. In turn, Shila made recommendations about which groups to talk with on Day 2:

FSL: Some insects, I think they need to kind of keep populations up, but a lot of them- I mean some of them are good for the environment, but there are like- we did the weevil like I said and there's a lot on how they like get numbers down.

Shila: Right, so that might be the most important ecological goal is to keep the numbers down (FSL: Ok) and so you might want to- it like- would um, is it- is there a certain type of native plant that- would you want to talk to the native plant group because they would help- they might have management strategies that would help, or is there like the small- the songbirds?

FSL: The songbirds (?)

Shila: Exactly.

FSL: Ok. (P4, 43:03)

In contrast, when they talked to Shila on Day 2 the insect group was more concerned with articulating the resolutions (part of the Map guidelines) they came up with while talking with the songbirds group:

Shila: Where are you guys filling in details?

FSL: Yeah, we just have to- yeah-

Shila: What are some of the resolutions you heard from some of your adversaries?

FSL: Um, Okay, so from predatory songbirds, I'm just writing this down right now, basically, they eat our predators and, so, if-

FS2: Oh, you mean predatory birds.

FSL: Yeah

FS2: They eat- yeah, our predators.

Shila: So, predatory birds eat songbirds.

FSL: So, if we keep the environment intact and biodiversity up, then they can have a wider variety of things that they prey on (Shila: Mmhmm) and, so then, that in turn will keep our population from being too abundant because there's going to be a greater amount (Shila: Cool) of things that are eating us.

Shila: Cool. Thinking through the food web. Good. Thanks. (P8, 49:21)

In this excerpt, the insects group explains the complex connections they made between insects and predatory birds to Shila; predatory birds are friends to insects because they eat songbirds who are insects' predators (in other words, eating our predators and not us makes you our friend). The insects group took up the content suggestion Shila made on Day 1 (to talk to songbirds), enacted it on Day 2, and then used that interaction to meet the requirements of the Map activity as well as to articulate a more developed understanding of their resource (in comparison to Day 1). Even with an increased focus on assignment completion on Day 2, both excerpts show the students meeting the guidelines of both assignments and thinking about the content in disciplinary ways (i.e., thinking through the food web). Shila helped students use the Map activity to continue to adapt and deepen their understanding of their resources, using the guidelines of the Map activity to focus their attention on capturing detail and asking students about their resolutions.

Based on analysis of the other interactions filmed, such as the above excerpts from the insects groups, the focal group was typical of student groups in Shila's class. The available data from other resource group interactions (Greg and Nate interacted with five other resource groups on Day 2), in triangulation with the conversations Shila had with students as she interacted with various resource groups on both days, indicate that the detailed data I have on the focal group largely captures the student experience in this classroom.

Disciplinary Practices

Conflict was built into the Map activity as a way of problematizing students' knowledge of their resources (Engle & Conant, 2002), and Shila's students frequently used scientific practices, such as the "Roles of Contributor and Critiquer" or the use of nature-based evidence (Ford & Forman, 2006), to address or resolve the conflicts. Rather than always accepting the

knowledge claims made by other students, they willingly engaged in drawn-out debates about the validity of claims or requested evidence to support those claims.

As far as the productivity of problematizing was concerned, critiquing each other's knowledge claims seemed to foster students' productive engagement in the discipline of science (Engle & Conant, 2002; Ford & Forman, 2006). This critique showed up for Terry's students in their discussion of predatory birds on Day 1, as well as their interactions with numerous groups on Day 2 (trees, insects, native plants, and watersheds). These sections contain evidence demonstrating how the focal group continued to challenge each other from Day 1 to Day 2, as well as being challenged by (and challenging) other groups.

Early in their Day 1 work on the Document, Nate contributed the claim that forest fires were allies with predatory birds because they made it easier for the birds to find prey:

> Nate: So, predatory birds love forest fires because where there's a forest fire, all the animals are like (makes sound) and so they run.
>
> Greg: And the biiiiirds-
>
> Nate: Are like, oh yeah, that's what's up.
>
> Greg: Going insane.
>
> Nate: And they swoop down, they-
>
> Greg: They're like dang. (P3, 35:44)

This first time predatory birds came up in conversation, Greg appears to have accepted Nate's claim that they were allies to fires. However, when they came up again in a later conversation, Greg challenged the claim and Nate responded by talking Greg through an example of what the fire–predatory bird relationship might look like in nature:

> Greg: Predatory birds-
>
> Nate: What's up friends. (flips paper over)
>
> Greg: Find prey in fleeing mamm[al]s. Is that true or did you just make that up?

Nate: What? It's completely true.

Greg: Like hell(?) (laughs)

Nate: It's a little weird, though. I don't really see how that would happen.

Greg: What? The mammals just like dip in-

Nate: I would just imagine like at the edge of a forest fire just like- I guess it would kind of work, just animals just like stampeding (gestures with his hands) like away. They're like freaking out because there's like a fire up on them. (Greg: Yeah) And then the predatory birds are like are like (makes swooping sound and gestures down). That'd be so scary. Imagine if you were like a small mammal just running away from a fire (both laugh). Huge fire behind you. Just birds everywhere (?) just trying to kill you. Like your habitat is destroyed. That'd be horrible.

Greg: Alright Pete.[8] (P3, 45:55)

This use of nature-based evidence appears to convince Greg to accept Nate's argument for their positive relationship with predatory birds. He even lists predatory birds as one of their allies on his Document and then brings the relationship back up at the end of class on Day 2, saying: "I still like the predatory birds angle" (P7, 52:19).

This example shows how Greg and Nate challenged each other during their interactions with just each other on Day 1, but they continued to use these scientific practices of critiquing each other (and other groups) and asking for nature-based evidence to support knowledge claims with other groups on Day 2. Their use of scientific Roles and evidence will continue to be evident in further excerpts used in the following sections.

Routine and Adaptive Transfer

Greg and Nate completed the Document on Day 1 and used it to jumpstart their Map activity on Day 2. They each referred to their Documents briefly at the beginning of the Day 2 Map activity before approaching the tree group:

[8] Greg's reference to Nate as "Pete" is likely an expression. Pete was not Nate's real name.

> Nate: We've got to talk to salmon, they're (?)
>
> Greg: Do we have to talk to salmon?
>
> Nate: Yeah, they're our foe(?). Salmon and small mammals, they hate us.
>
> Greg (looking at paper): I said small mammals, predatory birds, trees, plants.
>
> Nate (looking at paper): I said trees, plants, salmon, small mammals. Salmon are better because- what one did you say? Predatory birds? Oh I guess we help predatory birds.
>
> Greg: We love predatory birds.
>
> Nate: The predatory birds don't really depend on us, they're just like, there's a fire, that's what's up. (P7, 19:29)

This interaction was the only instance on Day 2 where it was apparent that Greg and Nate were referring to the physical Document they filled out on Day 1. While this could be interpreted as them not using the Document during their Day 2 conversations, I believe it is evidence of their strong propensity to continue developing their arguments and adapting their knowledge rather than repeating it in the way it was preserved (statically) on the Document.

While Greg and Nate did use information routinely on Day 2, in the manner it was captured on their sheet (in the above excerpt, for example) or similarly to how it was discussed on Day 1, they also added to their knowledge and frequently adapted it by critiquing each other and other groups and asking for evidence. The final statement Nate made in the above excerpt does not particularly indicate an adaptation of Nate's knowledge, but it does show a shift in his approach to choosing ally and adversary groups to talk with. After being introduced to the requirement on the Day 2 Map to track the relationship both directions (from birds to fires and from fires to birds), Nate chose to pursue some relationships over others, likely because some were easier to explain than others.

The following sections show how the focal group interacted repeatedly on Day 2 in ways that involved both routine and adaptive transfer of content discussed on Day 1.

Managed fires are good fires.

The focal group's primary position on fires as a valuable natural resource started as a disagreement on Day 1 with Nate defending how useful fires were for trees and Greg challenging him:

> Greg (reads from the handout): Look at the list of resources bolded above and blah blah blah blah blah. Um (starts writing). Trees provide fuel (looks over at what Nate is writing)
>
> Nate: Nope
>
> Greg: For the fires
>
> Nate: Nope
>
> Greg: For number 3?
>
> Nate: So, (looks at paper) Oh. Oh yeah. Except, we did- say native plants, because they don't really burn down trees very much.
>
> Greg: Yeah they do.
>
> Nate: No, they don't.
>
> Greg: Have you seen a wildfire happen?
>
> Nate (looks up from paper): I've seen wildfires. What happens is they just burn down like everything underneath them and all the trees live. And the trees are like, oh yeah, that's what's up. (points to Greg's paper) Only like 1 like to 10 are major stand-replacement fires.
>
> Greg: The thing about the major stand-replacement fires is that those 1 to 10 fires are like equal in size to like all 8,000 small fires.
>
> Nate: I mean, kind of, but like think about all the fires that we wrote down, those were like all the major fires, and those were ones that actually like burned down trees 75-80% of the- or 75% of the- But yes, they can burn down trees, but rarely.
>
> Greg: But you're- but those are all the major fires. Again. All those major fires are equal to like thousands and thousands of the understory ones. Those other ones are puny.
>
> Nate: It's true, I mean it can go either way (breaks eye contact). They both help and destroy trees. So-
>
> Greg: Ok. Trees provide fuel for the- or (shakes head) I'll just say plants (erases paper). Plants. (P3, 37:51)

This excerpt shows Greg and Nate developing their shared position on the relationship between fires and trees by using scientific practices on Day 1, critiquing claims and asking for nature-based evidence (Ford & Forman, 2006). When Greg proposed that trees provide fuel for fires, but Nate critiqued this claim repeatedly, responding to Greg's bid for evidence (asking if he's seen a wildfire) by providing evidence from his (supposed) experience with wildfires, in addition to statistical evidence likely gathered from a science text. After going back and forth a few times with claims, counter-claims and evidence, Nate conceded that some fires burn trees, but did not back down overall. In the end, Greg reluctantly changed the answer he wrote on his Document, but when they met with the first group (trees) on Day 2, Greg was still hesitant to call fires useful:

> Nate: All right, so that's why we're your friends and not your foe. (Female Student T: Ok) Uh, but if you want to write us down as your foe- There are like 1 to 10 fires yearly that burn over a thousand acres (Male Student T: Yeah) and those fires-
>
> FST: That's like a lot, a thousand acres, how many trees can you fit in a thousand-
>
> Greg: Disclaimer, those 10 fires are like equal to the other 8,000 fires in terms of like area damage.
>
> Nate: It's cool man.
>
> MST laughs.
>
> Nate: So, we're trying to manage our fires (laughs). We're trying to manage our fires, but you know, you never know.
>
> Greg: It sounds a lot better than it actually is. (P7, 21:54)

By the time they met with their third group on Day 2, Greg did not let go of his knowledge about stand-replacement fires, but he had largely adopted Nate's position that fires were valuable as a natural resource:

> Nate: What're you guys?
>
> Female Student LM: We're large mammals.

Nate: Oh. Are we bad? We're not bad to you.

FSLM: No, you're definitely bad.

Nate: No we're not, trust me.

Female Student SI: You like kill our homes.

Nate: I know (Greg: Sort of). We also rejuvenate your house.

Female Student HT: And some of our like food source, too, because some of the mammals that require (?) (Greg: Yeah) like deers, so, you kill off our food source.

Greg: Yeah, sometimes- if forests are not controlled, they're just-

FSLM: Fires just like ruin everything

Greg: Ehhh

Nate: No, they don't (arms crossed).

Greg: They're good for ecosystems.

Nate: They're like good for trees.

FSHT: They're good for like new trees to grow.

Nate: They're good for old trees.

Greg: Yeah, they're good for standing trees. (P7, 43:20)

These excerpts show how Greg and Nate developed their primary goal as resource managers of fires: Using controlled burns that would provide nutrients to the soil without destroying trees. However, this argument was challenged by an interaction with the insects group that forced them to adapt their understanding of their resource (that even controlled, understory burns would destroy trees if the trees were already damaged by insects).

Insects encourage fires.

Greg and Nate continued to develop their primary argument when they discussed their relationship with insects on Day 2. The following excerpt shows the limited extent of their conversation about insects on the previous day:

Nate: I don't think insects can run away from fires. Insects probably die, right?

Greg: They can fly away.

Nate: Not all insects. Maybe like grasshoppers. (Greg looks up at Nate)

Greg: They can hop away. (Nate: Ok) Are there grasshoppers in forests? (P3, 40:39)

While they had not planned to talk with the insects group on Day 2, they were summoned by them during their first meeting with the trees group. Female Student L quickly explained that they saw a clearly adversarial relationship with fires in terms of how the fires impacted insects:

FSL: So for forest fires- so you basically burn plant life and trees, which we like need to survive.

Greg: Oh damn. (FSR laughs) Shit.

FSL: Obvi. The obvi. Um (Greg: Um) I'm trying to think of another more like-

Greg: I don't know how like insects affect fires. (P7, 34:02)

Greg quickly agreed with the insects group that fires would kill plant life that the insects needed to survive, taking FSL's claim at face value (not critiquing it or asking for further evidence). He may have easily accepted their claim because of how similar it was to their claim from Day 1, where they had discussed fires burning the insects themselves.

However, both groups struggled to explain how insects could impact fires (something the fires group had not discussed on the previous day). Using the scientific practice of making contributions and critiquing them (or making claims and counter-claims) (Ford & Forman, 2006), they came to an agreement that trees damaged by insects would burn more easily, leading to fires that were hard to manage:

Greg: Well, if you eat all the plant life then the fires can't burn it.

…

FSL: If we eat plant life, I'm trying to think of like- there's like less- that doesn't really make sense. Because overall, I mean, if we eat all the plants, there's just going to be like less animal life and just like everything in a certain area, is that like- (Greg: Yeah) because that could be mark- a spot that's

more likely to provide a fire? Like, it's just dead basically? Like if all the animals had left?

Nate: Um, like some insects like cause trees to be like diseased. And then the trees, like, are more prone to like being on fire. I don't know. Because they're all dead.

FSL: Yeah, there we go. See, that's what I'm trying to say.

Nate & Greg: Yeah.

FSR (looks up from writing on the Map): Sorry, what was-?

FSL: So insects can kill trees (FSR: Oh, can spread-) or can cause disease in trees and they're more likely to catch on fire.

(Greg nods) (P7, 34:37)

In this excerpt, Greg and Nate appear to adapt their argument that trees are positively impacted by managed fires, by recognizing how insects could interfere with that argument if they weakened the trees to the extent that they would burn in any type of fire. This adaptation of their understanding of their main argument in light of the impact of insects aligns with the curricular goal of problematizing students' understanding of their resources by working through adversarial relationships with other resources, as well as aligning with Shila's goals for students to be flexible regarding who they talked to on Day 2 (using the Document to prepare to talk with a variety of groups on Day 2). This honing of their argument also aligned with science goals, where prior knowledge should be adapted and built upon when new information is available.

Native plants.

Both Greg and Nate adjusted their understanding of their relationship with native plants on Day 2. Initially, they stuck with their argument on Day 1 that understory fires were good for trees but not for plants:

Greg: It's sort of like, we have weird relationships because like plants- (Shila: Mmhmm) plants are helpful to fires, but fires aren't necessarily helpful to small plants, they get burnt.

Shila: Well, is there a way that you can sell, like, nutrients going back into the soil? (Nate: We can kind of-) Or clearing off of the area because there's a new successional states? Or (Nate: Yeah), is there ways that you can sell like (Greg: I mean, you can sell that to-), no really, fires are great for you because-

Greg: They're good for trees, but not for plants. (P3, 42:27)

However, they were quick to agree with the native plant group (that fires could be both harmful and helpful) when they pointed out the usefulness of fires to control invasive species and to clear areas for the growth of huckleberries:

Nate: What are you guys? (FS?: Native plants) Oh yeah, we're your enemy.

FS1: Yeah. (laughs)

FS2: Not really, actually. (FS1: Really?) (Nate: Yeaaaah) We were listing you as an ally.

Nate: It's both. (FS1: Wait) It's definitely both. Because we burn down all the native plants.

FS2: Yeah, but then that like helps us (?) invasive species.

Nate: I mean, it could go either way. (P7, 48:22)

…

Nate: Yeah, the whole idea is that we want to burn you guys-

Greg: That's the thing, like with trees, the like- that argument makes sense, but even controlled burns, they're meant to burn the plants.

FS?: Right.

FS2: But they're useful for like huckleberries which (?) the areas-

FS3: Yeah. (points to FS2)

Greg: That's true.

Nate: Unless they get, yeah, burnt.

FS1 (turns to FS3): Wait, what?

FS3: Huckleberries need open areas-

FS2 (finishes sentence): which result from burns. (P7, 49:54)

Unlike their interaction with the insects group, this example primarily shows Greg and Nate routinely adding to their knowledge, but not adapting it. While they did provide nature-based evidence, the groups did not critique each other's knowledge claims, which might have been linked to their more adaptive use of knowledge.

Fire and water.

One final way Greg and Nate adapted their ideas on Day 2 was by continuing their arguments from Day 1, such as debating the relationship between fire and water while interacting with the watersheds group. They had initially claimed (during the Day 1 warm-up) that ash from fires could negatively impact salmon populations, but Greg extended this to impacting the whole watershed negatively, which Nate did not agree with:

> Greg: It's like chemicals get in the water?
>
> Nate (raises his eyebrows): Chemicals get in the water?
>
> Greg: Yeah.
>
> Nate: Or how about nutrients get in the water? (raises eyebrows)
>
> Greg: No. Water doesn't absorb dirt and like get nutrients.
>
> (MS laughs off screen)
>
> Nate: But all the sediments that like wash down from being eroded?
>
> Greg: You're wrong.
>
> Female Student BL (tries to interrupt): We need you guys- we're just going to write you down as an adversary.
>
> Nate (ignores FSBL): Why is that, why is that (?) (Greg ?)
>
> Nate: It's definitely not harmful, it's neutral.
>
> Greg: You're neutral. I would say it's more. (P7, 45:08)

While they did not come to a consensus in this example, Greg and Nate did continue to adapt the way they articulated their claims about the relationship between fires and water.

In these examples, it is clear that the focal group transferred disciplinary knowledge in productive ways from Day 1 to Day 2. However, it is also clear that they did not only transfer knowledge routinely, in an identical form or additively, from one activity to the next, but that they continued to adapt that knowledge in ways that were reflective of the practices of scientists.

Overall, Shila's students appeared to engage productively in terms of completing the tasks assigned to them (the Document at the end of Day 1 and the Map at the end of Day 2) and in terms of making progress in their understanding of the discipline. By the end of Day 2, after expanding and adapting their arguments from Day 1, the focal group demonstrated a better-developed understanding of the relationship between fires and other resource groups (especially insects and native plants) than they had at the start of the activity. This understanding appeared to develop as they both considered the conflicting management goals of other groups and continued debates from Day 1.

Summary

Shila not only expansively framed the Day 1 Document in terms of time, place, participants and roles (students as resource managers who were preparing to meet with other resource managers in class on the following day), but she also made moves to frame the Document expansively as a material resource. She referred to the Document as a tool and told the students she would not be collecting it, emphasizing its intended goal of facilitating preparation for the Day 2 Map activity rather than as an assignment that would be collected for evaluation. Shila also positioned the students so they were accountable to each other for their responses on the Document by facilitating a share out at the end of Day 1. She stopped students from adding to the Document on Day 2, reminding them of its function as a tool, and told

students who were absent on Day 1 not to make it up (continuing to avoid treating it as an assignment typical of schooling).

All of these framing moves around the Day 1 Document, paired with a consistent use of dialogic discourse during her interactions with students, provided the conditions for the orientation of Shila's students toward the practices of science and an adaptive use of knowledge (Scott et al., 2006). Students in her class, Greg and Nate, not only interacted with each other using the roles and evidence practices of science on Day 1 (Ford & Forman, 2006), but also interacted with five other student groups on Day 2 in these similar ways. The role of critiquing each other's knowledge claims and prompting each other for nature-based evidence set Shila's students up to adapt their knowledge on both days of data collection, and Shila continually supported this adaptive transfer through her expansive framing that promoted student authorship and encouraged students to be accountable to each other and the discipline of science.

CHAPTER 5.

Case 2: Terry's Classroom

The following chapter is a single case analysis of Terry's classroom, beginning with a focus on the teacher and description of events in consecutive order over the course of the 2-day lesson. This section orients around how Terry framed the material resources that were either provided by the curriculum or co-planned with Shila, as well as Terry's role as an authority figure in her classroom. The teacher analysis is followed by a focus on Terry's students, especially the focal students Bree and Rae. The student section is organized according to findings regarding students' use of disciplinary practices and transfer. This chapter wraps up with a summary of findings that segues into a comparison between the two cases in the next chapter.

Day 1

Terry used the material resources provided by the PBL curriculum and co-edited with Shila: PowerPoint slides and writing on the board to remind students of what was due in class and orient them to the day's activities, scratch paper for a warm-up, fact sheets created by the students as homework, PowerPoint slides to introduce the Day 1 Document, and printed Document sheets of paper (see Appendix B). The class was 55 minutes long, with approximately 4 minutes at the beginning of class taken up by whole school (loud speaker) announcements not described below. The remainder of class time was broken down as indicated in Table 6, and each of the main class segments are described in more detail in the following sections.

Table 6. Time Table: Terry Day 1

Day 1: Terry	Time	Media
1. Beginning of Class	**9 min 45 sec**	PowerPoint/Board
- Welcome (pleasantries)	1 m 5 s	
- Teacher introduced researchers	1 m 30 s	
- Teacher reviewed	7 m 10 s	
2. Warm-up Activity	**13 m 20 sec**	PowerPoint/Board
- Teacher introduced warm-up	1 m 45 s	Scratch paper
- Student groups worked on warm-up	3 m 15 s	Fact Sheet
- Teacher introduced share out	1 m 25 s	
- Groups shared out	6 m 55 s	
3. Document Activity	**27 min 20 sec**	PowerPoint/Board
- Teacher introduced Document	12 m 45 s	Document
- Student groups worked on Document	14 m 35 s	

Note. Terry's class on Day 1 was 55 minutes long. The class time was broken down as indicated in the table, proceeding from the beginning of class, to the warm-up activity, and finally to the Document activity. Approximately 4 minutes at the beginning of class were taken up by whole school (loud speaker) announcements that are not described in the table.

Beginning of Class

Terry started the day with questions and comments to the students about their weekends and the school musical, followed by a brief introduction of the two researchers who were collecting video data in the classroom. She then told the students how confused the prior class period had been about the same assignments, and that she was:

> Going to do some damage control with you to ensure that you're not similarly confused. (P2, 4:50)

This introduction led to a 7-minute long explanation of the fact sheet, connections between the activity and the larger project (the "end goal"), how to submit assignments online, and several student questions about these topics, prior to her introduction to the day's warm-up activity.

Warm-up Activity

The Day 1 warm-up built on prior individual research conducted by students regarding their group's state resource (e.g., watersheds, trees, water) and recorded on a "fact sheet." The fact sheet contained information about students' resources such as its importance, potential conflicts with other resources and its importance to salmon. Terry framed the warm-up in relation to previous work (the fact sheet), and checked that the resource groups completed and remembered their fact sheet via a warm-up:

> So you were supposed to come up with a bunch of information about where your resource is in the state, right? The importance of your resource, the potential conflicts that you might have with other resources. Right? And then the importance to salmon. And I'm just rattling those things off, but you had a sheet that talked about the things you needed to find about your particular resource. And then you were to take that information and put it on the template that I gave you that we called the "fact sheet." (P2, 6:51)

The prompt for the warm-up was as follows:

> (1) Describe your resource in 1 to 2 sentences.
> (2) What's the most important aspect of this resource to our state? Is it economic, ecological or cultural?
> (3) What's the most important aspect of this resource as it relates to salmon? (P4)

Students worked on answering these questions with their resource partner(s) for a few minutes, using scratch paper to keep track of their ideas. Terry walked around the room answering questions while the students worked.

After about 3 minutes of working with their resource partner(s) on the warm-up, Terry had 5 out of the 14 groups share with the whole class. Before calling on groups, she oriented students on what to listen for, framing for transfer between the warm-up and the upcoming Document activity:

> I just want to hear from five groups. Ok? Really loud. Here's what you're listening for: Is Laura's group a group that I should talk with? Does my resource

> interact with Laura's resource in a way that really matters? Or, is my resource so not related to hers that I shouldn't waste my time talking to her? There are like 13 or 14 groups of resources in the state, and you want to home in on: what are the most important resources? Which ones interact with mine the most to contribute to a healthy environment for salmon? Ok? So you're listening for: Who do I need to talk to? Ok? (Students don't appear to respond) Because remember the end goal is that you have an understanding of how- how all the resources work together to promote healthy habitats for salmon or not. So everyone, do listen to this part ok? (P2, 17:00)

This excerpt shows Terry expansively framing for transfer to not only the Day 2 Map activity in terms of talking to other resource groups, but also the larger project where salmon habitats were a primary focus.

When the five groups shared their responses to the three warm-up questions, Terry used primarily authoritative discourse to check and correct student answers (Scott et al., 2006, p. 628), spending an equal time restating what the students said and allowing the students to report about their resource. Sometimes Terry used a less evaluative form of revoicing (Engle et al., 2012, p. 219):

> Ok, so watersheds are- important to our state. What did you say? Economically? Ecologically? (FSL: Ecologically) Ecologically important for our state. (P2, 20:35)

Other times, Terry reshaped or reformulated what the students had said:

> I'm just going to take what you said and twist it around a little bit. (P2, 21:07).

She also used the share out time as an opportunity to evaluate the correctness of groups' answers (Scott et al., 2006, p. 628; teacher "checks and corrects"):

> The only thing is, let's you and I talk about the biomes that you've identified? Ok? Because I would argue that we're mainly temperate rainforest, (MSW: right right) and did you mention that? (MSW: I did, yeah.) Ok. (P2, 23:54)

Overall, Terry seemed to use the warm-up activity, including the share out time, to prepare the students for the following Document activity and subsequently the next day's Map activity.

While she used primarily authoritative discourse during this time, she still allowed students to share their ideas in a whole class setting, making some dialogic moves such as "seeking clarification and further elaboration" (Scott et al., 2006, p. 628). However, this was one of only a few times Terry was observed positioning students as authors (Engle et al., 2012). This share out was a rare opportunity for students to learn directly about resource groups from the students who were acting as their managers (until their conversations on Day 2), and even then, they only heard from 5 of the 14 groups (listed on the Document, see Appendix B).

Document Activity

Right after the fifth group's share out, Terry introduced the Document activity:

> I'm now going to give you a sheet that will help you with your thinking, that will begin to guide your thinking about, well, who is it that I need to talk to? What are the relevant groups out of the 13 or 14 groups, who are the most relevant players in managing my resource? (P2, 26:59)

Here, she added to the expansive framing she had begun prior to the five groups sharing, framing the Document in terms of relationships between different resource groups.

Terry segued into the Day 1 Document activity by reminding students of their roles as resource managers (expansively framing roles) and giving examples about the content of the Document:

> So now, you guys here's what we're going to do. Now we're going to start identifying, alright, well out of the different resources in the state, which are the resource groups that you, as the resource manager of biomes, or you as the resource manager of mammals- small mammals, or you as the resource manager of trees, what are the other resource groups that you are going to be in conflict with. Right? (P2, 24:22)

She spent about 9 minutes going through the Document with the students (P2, 24:22-33:11), taking questions along the way. She made sure to remind students that they would be talking to

other resource groups on the following day (expansively framing for time, place and participants):

> Now you want to think about some of the other resources being represented in class, and I would pick six, I'd circle six that are imp- it doesn't say this, but I would pick six that you want for sure to talk to today and tomorrow, okay? (P2, 29:26)

Critical thinking.

Another primary focus of Terry's while she introduced the Document was to encourage students to think critically, which might have been an attempt to promote student authorship:

> Use your best critical thinking skills here to figure out what you should do. As long as you're critically thinking through it, you will not do it wrong. (P1, 29:20)

However, even when encouraging critical thinking, Terry used language that oriented the students toward a "right" or "wrong" dichotomy:

> So again you guys, don't get yourself all stuck up in doing this right, if you're critically thinking about it, you'll do it right, okay?... As long as you're critically thinking through it, you will not do it wrong. (P2, 30:01)

It is difficult to tell in these excerpts whether Terry is challenging the traditional right–wrong dichotomy that is part of the grammar of schooling (Parker et al., 2013) or if she is actually reinforcing it by suggesting that a right or wrong answer exists. In either case, this move to encourage critical thinking and the partial class share out during the warm-up could be considered evidence of Terry attempting to promote student authorship (Engle & Conant, 2002; Engle et al., 2012); the rest of her introduction to the Document activity was focused on how to complete each part of what she referred to as the "handout" or "sheet" correctly.

Answering questions.

While students worked on the Document with their resource partner(s), Terry checked in with groups and answered questions. During this time, multiple student groups asked Terry for

help with both the content and goals of the Document. Terry frequently gave students direct answers to their questions about content:

> MS: So for the resources that are important to us, do we want- like because the salmon pretty much all- do the animals that eat the salmon, do we care about those? Or do we only care about the things like affect us that are like-
>
> Terry: You're salmon right? (MS: Yeah.) Ok, so I wouldn't choose the animal groups to be talking with tomorrow. (P2, 38:25)

Interactions where Terry provided direct answers to questions were consistent with both authoritative discourse (where the teacher checks for correctness) and schooling practices where the teacher is the authority or source of knowledge. These traditional teacher–student roles, where students seek to provide the answers the teacher is asking for, show up in interactions on Day 2 as well, where students use Terry as the source of critique and evidence for their claims rather than critiquing each other or looking for evidence in nature (explored further in the following "Students" section).

Assignment completion.

After explaining the Document and answering questions, Terry led the students into the group work time with a reminder about the purpose of the Document, both focusing on completion of the Document and preparation for the Day 2 Map:

> So the goal is that this be complete by the end of the period so that tomorrow when you walk in, you can actually have those interactions. Alright? So go ahead and get this completed please. (P2, 32:50)

In this excerpt, Terry appears to be treating the Document as both a tool, where the focus is on preparation for another activity (its intended purpose as part of the 2-day lesson), and as a traditional classroom assignment, where the focus is on completion. She had also referred to the Document as a "handout" or "sheet" (rather than "tool") a number of times, terms that could be considered part of the grammar of schooling in addition to a focus on assignment completion.

Following this introduction, the remainder of the class time (about 15 minutes) was spent with resource groups working together on the Document.

Near the end of class, Terry noticed that students were not completing Side 2 of the Document:

> Terry (to small mammals group): Ok, gentlemen, are you all fine? (MS: Yeah) Squared away? Do you have a plan to get the rest of it done before tomorrow?
>
> Male Student BK: Yeah.
>
> Male Student BL: We have our stuff picked out (flips paper over).
>
> Terry: Ok great. (Walks away) (P2, 47:57)

She seemed to take the students' word for it that they would complete the Document before Day 2 and did not follow up with the whole class. However, it was apparent on Day 2 that at least the focal group and the small mammals group had not completed Side 2 of the Document before class. The following is an excerpt from their conversation about the Day 1 Document while they were supposed to be working on the Day 2 activity:

> Male Student BK: I have to write my questions on this worksheet(?)
>
> Rae: Yeah, I did that(?). I don't think that this was-.
>
> MSBK: I think the top- this whole thing is just the name (Rae laughs) and the bottom one is the question. (Rae: All right.) Pretty sure that's what it says to do.
>
> Rae: (?)good for now(?) (P5, 29:47)
>
> …
>
> Rae (referring to the Document): Ok wait, catego- this one is what? What questions we have? This one is what question they have?
>
> MSBL: She did say, that doesn't matter really. She said that she's not even grading it.
>
> Bree: But she asked us to turn it in.
>
> MSBL: Yeah, but she says she's not even grading it. (P5, 34:19)

This excerpt demonstrates that at least two of the groups still felt compelled to finish Side 2 before the end of Day 2, but it also shows that Terry's framing of the Document on Day 1 was not sufficient to convince all of the students to actually complete the Document. One potential explanation for this is that many of Terry's students seemed unclear about how to complete the assignment correctly, continuing to ask basic questions such as who they were supposed to be talking to during class, even during the last few minutes of class on Day 1:

> FS: Um, was it necessary that we talk to other groups for this [Document]?
>
> Terry: You're going to talk to other groups tomorrow. So the point here is, here are my talking points for each group. I know I'm going to talk to this group, here are my talking points. And then here's the questions I'm going to ask. (P2, 50:21)

While this interaction occurred about a minute before the bell rang to indicate the end of class, Terry continued to explain the goal of the assignment without checking with the group if they had completed the Document or were in fact prepared for the Day 2 activity. Terry's strategy for convincing students to complete the Document seemed to be repeated explanation of either the assignment's goals or how to complete specific parts of the assignment. Since many students did not complete the Document on Day 1, her attempts to appeal to their accountability to other students (resource groups) or their accountability to her as the teacher (when she asked them to complete Side 2 of the Document) were at least partially unsuccessful, perhaps because she did not clearly explain on Day 1 that the students would be turning the Document in for her to evaluate. On Day 2, Terry continued to frame the Document in ways that might convince students to complete it and turn it in to her by the end of class.

Day 2

On Day 2, Terry continued to use the material resources provided by the PBL curriculum and co-edited with Shila: PowerPoint slides and writing on the board to remind students of what

was due in class and orient them to the day's activities, fact sheets (to be referenced if needed and ready to turn in at the end of the day), a PowerPoint slide with an example Day 2 Map (see Appendix G), and Map-making supplies (blank sheets of paper, colored markers). The class was 55 minutes long, with approximately 4 minutes at the beginning of class taken up by whole school (loud speaker) announcements not described below. The remainder of class time was broken down as indicated in Table 7, and each of the main class segments are described in more detail in the following sections.

Table 7. Time Table: Terry Day 2

Day 2: Terry	Time	Media
1. Beginning of Class	**7 min**	PowerPoint/Board
- Students organized things that were due	50 s	Document
- Teacher talked about upcoming salmon panel	2 m 30 s	Fact Sheet
- Teacher reviewed	3 m 40 s	
2. Map Activity	**43 min**	PowerPoint/Board
- Teacher introduced Map	7 m 30 s	Document
- Student groups worked on Map	35 m 30 s	Paper, Markers

Note. Terry's class on Day 2 was 55 minutes long. The class time was broken down as indicated in the table, proceeding from the beginning of class to the Map activity. Approximately 4 minutes at the beginning of class were taken up by whole school (loud speaker) announcements that are not described in the table.

Before Class

Before class started on Day 2, Terry instructed a student who had been absent on Day 1 to complete the Document at a later time:

> Terry: Um, so what we did is (takes out a sheet of paper) this handout. The whole purpose of it was to prepare you for what we're going to do today, okay? So, I think you're going to be okay cuz you have a partner you've been working with, right?
>
> Female Student: Yeah.
>
> Terry: Great. (Terry looks up at the classroom) Yeah and she's here and she was here yesterday too. Ok, so go ahead and do the activity today, and then when you have extra time, fill this in (hands FS the paper). Okay?

FS: Awesome.

Terry: Yeah, you'll be okay.

FS: Thanks. (P6, 1:16).

This move to have the student make up the assignment is contradictory because she both explains the goal of the Document assignment (as a tool to help students prepare for the Day 2 activity) and tells her to complete the assignment in a way that will not fulfill this goal (as completing it at a later date will not serve to prepare the student for the Map activity). Even though completing the Document at a later time would not help the Female Student prepare for the Day 1 Map activity (which was the curricular purpose for the Document), Terry still asked her to submit it as an assignment at a later date. This framing move suggests that Terry may have had goals for the student outside of the curricular goals surrounding the Document, such as wanting the student to be accountable to her as a teacher and/or using the Document similarly to other assignments where the purpose was primarily the assessment of students by the teacher.

Beginning of Class

After a few minutes of loudspeaker announcements, Terry asked the students to stop copying each other's homework:

> How are you all? Copying each other's homework I see. Y'all, you won't get anything out of copying anyone else's homework, okay? Other than credit. But that doesn't do any good. And there are like seven of you doing it, so no problem. Just, I want you to know, I don't care. You just won't get anything out of doing it. Okay? Because you won't ~~learn~~ the material. So I got that you're insuring that your grade looks a certain way, but I want you to be learning the material, okay? (P6, 4:40)

This explicit attempt to orient students away from a typical "doing school" practice (copying assignments), along with her repeated mentioning of "critical thinking," clashes somewhat with other moves Terry made that oriented students toward doing school practices such as focusing on

assignment completion. She made a similar point about focusing on students' thinking during her beginning of the year interview:

> When I was in school you had to look stuff up in a card catalog, and it was cumbersome, and so it really was helpful to have a whole bunch of stuff memorized. But now I think that the most important thing is that students learn how to think because they can access information easily. And I also think that- you know, so critical thinking and problem-solving skills I think are the most important. (Terry, beginning of the year interview)

These excerpts demonstrate Terry's goal of facilitating students' learning by impacting their thinking, both self-professed and communicated in two different ways to her students. These three instances are counter-examples to Terry's more frequent tendencies to orient students toward schooling practices such as telling her the answer she was looking for or submitting assignments for her to evaluate.

At the same time, even though she mentioned critical thinking and not copying work, the manner in which she communicated these goals to the students still reflected authoritative discourse, where she *told* the students her goals for them (critical thinking, learning and not copying) rather than positioning their work in ways that would facilitate these goals. In other words, despite her clear expression of learning goals for students that emphasized their thinking, she positioned the material resources (especially the Day 1 Document) in primarily bounded rather than expansive ways (Engle et al., 2012), especially by collecting the Document and calling it a "handout" and Day 1, and then asking students to make it up, and repeatedly going over the directions on how to complete it on Day 2. These bounded framing moves contradicted the expansive goal of the Document as a tool for the Day 2 Map, and offer a possible explanation for the students' focus on completing the Document on Day 2 as well as asking Terry for answers when working with other groups rather than critiquing each other's knowledge claims.

After asking the students to stop copying the assignment, Terry greeted them briefly and talked about the upcoming winter break. She then reminded the students about an upcoming panel of salmon scientists, orienting them to the project's larger goal and how it was connected to the panel, and then handing out passes the students would need in order to attend. Before launching into the Day 2 Map activity, Terry reviewed assignments that the students needed to turn in, reminding them about the Day 1 Document:

> Also today, you want to have this handout that we filled out yesterday completed. Okay? And, then the assignment that we do today is going to build on this handout. (P6, 8:20)

When a student asked a question about the Document, Terry spent about 3 minutes reviewing it with the whole class, going over how to answer the questions on Side 2:

> Female Student: I just have a question about the sheet (Terry: sure). So, in the top like set of boxes you write down questions that you have for the other group and then the second boxes they have (?)
>
> Terry: Yeah, let me go through this with you, okay? And I know that there was some confusion about it yesterday. So why don't you- everyone, why don't you take this out? Because you're going to be using it today anyway, okay, so it will be helpful to have it out. (Students rustle papers)
>
> [Terry spends about 3 minutes explaining how to complete Side 2 of the Document without interruption.]
>
> Terry: Ok, any other questions about this handout? No. Ok. Alright. Fantastic. So you are going to turn this in today, after you complete the work for today. (P6, 8:49-11:39)

Not only did Terry re-explain how to do Side 2 of the Document on Day 2, but she also instructed students (who she knew had not completed the Document yet) to turn it in by the end of class that day. This seems to imply that she expected students to work on the Document during class at some point, although she did not provide time for them to do so, which led to students working on their Document during the Map activity time. Neither of these framing moves (reviewing how to complete the Document or telling the students to turn it in at the end of

the day) aligned with the Document's purpose (in relation to the 2-day lesson as a whole) as a tool to prepare students for the Day 2 Map activity. Instead, Terry seemed to be making sure the students were getting their work done and giving it to her so she could check it for correctness (Scott et al., 2006, p. 628).

Map Activity

After re-explaining how to complete Side 2 of the Document, Terry moved on to explaining the Day 2 Map activity, where students would use different colored markers to map connections between their resource and four other resources on a large piece of paper:

> You're going to be making a little poster on this piece of paper. And what you're going to be doing is a graphic organizer that looks pretty complicated up there and I just want to explain it because it's not meant to be complicated. (P6, 11:39)

Terry instructed the students to talk to two ally and two adversary groups, sharing their goals and management strategies with the other groups. In addition, conflict resolution was meant to be a big part of their focus when talking with adversary groups:

> And then finally, in this situation, rather than talking about your common goals, because you may not be having any, you're going to say, alright, well there has to be some way we can meet in the middle or resolve the conflict. Okay? Here's what I propose, and I want you to come up with some ideas for the conflict mediation, or to resolve the conflict. I think this will be the most challenging part. (P6, 16:05)

After fully explaining the assignment and taking a few questions, Terry reminded the students to turn in their Document at the end of class along with their Map, specifying that both she and the researcher from the university were going to look at it:

> I'm not grading this sheet and I am going to look at it, and [Researcher 2] will look at it, so please do turn in this sheet as well. Alright? (P6, 19:00)

At this point, Terry stopped referring to the Document's curricular purpose (as a tool for preparation for the Map), instead framing the Document as an assignment intended for evaluation by an authority figure (teacher or researcher).

Problematizing management strategies.

Similar to Day 1, Terry walked around the room answering questions while the students worked on their Map. She answered many procedural questions about how to complete the Map, such as how to use different colors and where to write things on the paper, as well as questions related to relationships between the groups, such as recommendations for ally and adversary groups to talk to or potential management strategies for conflict resolution. Despite its central role in the lesson as a source of "problematizing" (Engle & Conant, 2002), she did not particularly emphasize the act of conflict resolution:

> Female Student ST: Oh, the question was just- we just didn't know if we were just like finding out each other's stances or actually making comments and stuff?
>
> Terry: You're looking for strategies- they don't have to agree with your compromise, but if you see it as a possible compromise, you would write it down.
>
> FSST: Ok.
>
> Terry: Yeah, we're not duking it out.
>
> FSST: Ok. (P6, 35:17)

In this excerpt, Terry asked students to write down possible resolutions, whether or not other groups agreed with them, orienting the students away from having the type of scientific discussion that would include critique of each other's knowledge claims (Ford & Forman, 2006). She seemed to be de-emphasizing the "problematizing" (Engle & Conant, 2002) aspect of the Map activity by asking students to write down strategies without coming to a consensus with other groups. In this particular example, Terry may have directed the students away from

debating with other groups since this group was asking Terry basic questions about how to complete the assignment 16 minutes into the work time and 20 minutes before the end of class. Even if this was the case, Terry only brought up conflict resolution with one other group before the end of class, the fossil fuels group whose interactions were wrought with conflict, suggesting that conflict resolution was not a facet of the assignment that was particularly important to her.

Answers and authority.

During her 19 conversations with individuals and resource groups during the Map activity, Terry oriented the students toward completing the Map and frequently offered direct answers or recommended solutions when groups asked for them. Terry's focus on students' use of particular answers seemed to make her authority as the teacher clear during these interactions. She occasionally even rejected students' ideas, constraining the direction of the groups discourse in an authoritative way (Scott et al., 2006, p. 628):

> Terry: How would you know what was there in the first place? Before you mined, before you dug anything up, what could you do to be responsible for what was there in the first place?
>
> [Students are all quiet for a few moments.]
>
> MS: Like, make sure animals can't get in.
>
> Terry: Make sure animals can't get in where?
>
> MS: To the mine.
>
> Terry: Ok, sure. So, if you were talking to an animal group, then that might be a compromise, right? If you're going to like, proof the mine so that no one's getting in there. But my question was, how are you going to know what's there in the first place? (P6, 36:53)

In this excerpt, Terry asked a question with a particular answer in mind, redirecting the students' answers until they came up with the answer she was looking for, enacting an initiation–response–evaluation pattern of talk common in authoritative discourse (Scott et al., 2006, p. 612). Many of the interactions between Terry and her students were consistent with an

authoritative, teacher-centered approach to instruction common to the grammar of schooling (Parker et al., 2013), where Terry was the authority and students were accountable to her for doing assignments and figuring out the answers that she deemed to be correct. This more traditional classroom structure did not necessarily make Terry unsuccessful as a teacher: her students were engaged and productive in terms of completing both their Document and Map by the end of class on Day 2. However, her more bounded framing of the material resources, especially in terms of students' authority and accountability to her as the teacher, may have detracted attention from students using practices that aligned more with the discipline of science rather than just schooling (Ford & Forman, 2006).

End of Class

Terry talked with Researcher 1 briefly at the end of class, mentioning how she thought the students were bogged down by the details of the assignment:

> Researcher 1: So how do you think it went?
>
> Terry: Um, (laughs), I think it went- I think that this worked in the groups sharing their ideas (Researcher 1: Mmhmm). Right? I think that [the Document] was a good way to structure them saying their ideas. I think that my kids get really bogged down in details. Like: but I don't have three. (Researcher 1 nods) Or, I don't have two groups that I conflict with.
>
> Researcher 1: Yeah yeah.
>
> Terry: Right? Even though I can say it a hundred times, you should do what makes sense to you (Researcher 1: right), you might not get three, I just want you to be shooting for it (Researcher 1 nods: right), you may not have two groups you conflict with, it might only be one, they get really (Researcher 1: Yeah yeah) bogged in the details. (P6, 54:53)

Even though Terry spent a lot of time in class explaining both the Document and Map in detail, she did not seem to consider that her students were trying to include the level of detail that she had specified during these detailed assignment descriptions. Such detailed explanations may have oriented students toward completing assignments in way the teacher desired, rather than

orienting them to their own authority in relationship to the assignment (despite Terry asking them to think critically and not copy each other's work).

Students

Terry's students all seemed to get their work done on Day 2, both the Document and the Map. However, some groups (at least the focal group and the small mammals group) spent a lot of their time on Day 2 filling in Side 2 of their Day 1 Document and completing the written Map, rather than deepening or expanding their understanding of their resource (trees) and other state resources.

On Day 1, Bree and Rae both contributed to the completion of Side 1 of the Document before the end of class, encountering just two problems they asked Terry about (the definition of watersheds and the issue of whether or not to address logging). At the beginning of the Day 2 Map activity, Bree and Rae spent 10 minutes deciding who to talk to, talking to Terry, and then adding logging to their management goals before a group approached them to talk about the Map. Bree and Rae talked with four groups and wrote about all of them on their Map while also completing Side 2 of the Day 1 Document. These activities appeared to be common among other students groups, as witnessed in the interactions between the focal group and the other four groups, as well as the interactions between groups and the teacher captured on the teacher mic.

Disciplinary Practices

While conflict was built into the Map activity as a way of problematizing students' knowledge of their resources (Engle & Conant, 2002), Terry's students did not commonly use scientific practices, such as the "Roles of Contributor and Critiquer" or the use of nature-based evidence (Ford & Forman, 2006), to address or resolve the conflicts. Instead, they seemed to

accept most knowledge claims coming from the teacher or other students at face value, avoiding drawn-out debates about the validity of claims or requests for evidence to support those claims.

As far as the productivity of problematizing was concerned, not critiquing each other's knowledge claims seemed to reduce the usefulness of conflicts as a way to support students' productive engagement in the discipline of science (Engle & Conant, 2002; Ford & Forman, 2006). This lack of critique showed up for Terry's students as conflict with no critique, contribution with no critique, minimal critique and teacher critiques. For the focal group, the strongest source of problematizing (via critique) was via the teacher (who challenged Bree and Rae to address logging) and not the other resource groups.

Conflict with no critique.

The following excerpt is an example of students addressing conflict with an adversary group, but not using critique or requests for evidence (two scientific practices) as strategies to resolve the conflict. Bree and Rae encountered the conflict with the mining group, but neither group shows any indication of critiquing each other's knowledge claims (even when Rae switches to discussing animals, a different resource group, instead of trees):

Rae: But we dislike you coming in and wiping out our forests and suspicion that-

Bree: Yeah, clear-cutting is not our thing-

FSL: But you guys let us use the land, don't you?

Bree: No (looks at Rae)

FSR: Ok. Land disputes.

FSL: Ok, yeah.

Bree: Ok (drops pen).

Rae: See by mining, you- yeah, no more trees can be planted because you destroy it.

FSR: Yeah, but there's no- we need to mine. Because it's like-

Rae: And animals need to live.

FSR: It's a huge economic-

FSL: Washington needs money.

Rae: And, you know, we kind of need oxygen to breathe.

FSR: Ok, yeah, but we need to mine anyway. (P5, 41:59)

The two groups shared their management goals and realized they had a conflict (land disputes) in terms of countering with their own claims that were not in agreement, but they did not critique any of the claims or ask for evidence. This example of encountering conflict between resource groups does not really seem to fulfill the role of problematizing in a way that was supportive of disciplinary engagement because the students were not using disciplinary practices to address the problem.

Contribution with no critique.

Even within their group, Bree and Rae typically both contributed, but neither student provided critique or focused on providing evidence from nature. In the following episode from Day 1, Bree and Rae both contributed to a discussion involving the relationship between salmon and trees:

Bree: Habitats for other animals (Rae writes), and biodiversity in forests, and for salmon, they shade river beds so it's cool enough and um, they prevent erosion and filter out, like, so sediments don't go in the river and like pollute it.

Rae (writing): Ok, shade to help salmons and roots stop erosion and dirt falling in the river.

Bree: Sediment. (Rae: sediment sediment) So much more scientific.

Rae: Sediment. In river. Okay. (P1, 13:00)

…

Rae: Ok, salmon. Give trees nutrients (writes). What is it? Marine-derived oxygen- I mean nitrogen?

Bree: Nitrogen.

Rae (laughs and writes): Nitrogen.

Bree: Ok, (writing) and then trees, um, keep sediment out of river and um (looks up and sighs) and shade whatever. Ok, so that's good.

Rae: Ok. (P1, 38:56)

While this conversation was productive in terms of helping the students complete their Document, it demonstrated an undisputed transfer-in of knowledge claims, likely from their prior work on the fact sheet. The few examples of Bree and Rae disagreeing with each other in even a minor way are addressed in the next section.

Minimal critique.

There were a few instances in this dataset where Terry's students critiqued each other, but none of these instances were followed up by back and forth discussions between a contributor and critiquer (Ford & Forman, 2006). They all involved a one sentence critique that is immediately accepted by the other party as true, and the conversation then moved on without requests for any type of evidence to support the claims. Here, Bree and Rae were discussing which resource groups they should consider adversaries:

Bree: Could it be insects could kill trees?

Rae: But they also benefit trees

Bree: Ok, so let's do fossil fuels (P5, 28:45)

In the next excerpt, Rae made a claim unrelated to the resource group they were interacting with, so Bree responded by redirecting her:

Bree: I'm just going to say (writing) small animals will need trees for habitat. (looks up at others) trees need small mammals-

Rae: For like, you know like, without nothing eating it, we'll just overpopulate

Bree: But small mammals don't eat trees

Rae: Small mammals don't eat trees (P5, 35:04)

Bree and Rae were not the only resource group who did very little critiquing. The following is an example of a brief moment during their interaction with the small mammals group where students other than Bree and Rae briefly critiqued each other:

MSBK: Oh yeah, we need one more strategy though.

Rae & MSBL: No, we have three.

Rae: Maybe you just didn't write them down? (Bree: yeah)

MSBL (points to post-it): No, preserve forest is not a strategy.

MSBK: Yeah, it is.

Bree: Yeah it is. That's like the main goal.

MSBL: Oh, ok. that's like the ultimate strategy. (P5, 35:26)

Like the interactions between Bree and Rae, MSBL is quickly convinced to follow the lead of others, even when they do not provide nature-based evidence or even other knowledge claims to back up their position. It is hard to tell if the students are avoiding conflict with one another or they just do not see a compelling reason to get into an argument and so they quickly cede their position. However, the fact that interactions with groups outside of their own also involved very little critique or evidence use suggests that the focal group interactions were representative of the class as far as types of (science or school-based) practices used by the students.

Teacher critique.

As seen in the above examples, Terry's students did little to critique each other or expand upon each other's knowledge claims, and they interacted with other resource groups in the same way on Day 2, contributing to the completion of the Document and Map by making largely unchallenged claims about nature and scientific practice (Ford & Forman, 2006). While largely

ignoring nature-based evidence, the students did turn to Terry for answers and critique of their claims about their state resource and its relationship to other resources.

Bree and Rae's primary struggle was the question of whether or not they needed to address logging as the tree group. This question was resolved by both students agreeing to do what the teacher told them to do. On Day 1, 3 minutes before the end of class, Bree and Rae asked Terry about logging and she encouraged them to consider it:

> Bree: Mrs. Terry? (pause) Do you think, for fossil fuels, is- would like logging be included with that? Is that? No?
>
> Terry: No, are you looking for people to talk to about logging?
>
> Rae: Yeah
>
> Terry: You'd talk to the tree people.
>
> Bree: Well, that's us (laughs).
>
> Terry: Oh (raspberries with her lips).
>
> A female student next to them asks if they're talking about logging. Bree and Rae laugh.
>
> Terry (to the other FS): Yeah, yeah, because they're going to manage the trees, right? Which we cut down. (looks back at Bree and Rae) (P1, 44:51)

Before talking to Terry on Day 2, Bree and Rae briefly discussed logging:

> Rae: Um, are we just ignoring the fact that- Do we want to log any of our trees?
>
> Bree: Yeah, I'm not- I feel like we should be promoting like- (pause) Selective logging? (P5, 21:20)

Soon after this conversation, when they called her over, Terry told the focal group (again) not to ignore logging:

> Rae (to Terry): Um, so we had a question. We're trees, and we have like, environmentally we really want to save the forest, but like, economically like logging- (Terry: Yes) Do we just like kind of ignore logging, or do we have to like add that in there and be like-?
>
> Terry: Well I wouldn't ignore it, right? Because it's a big economic thing for our state. I mean, it's a- it rubs me wrong every time I drive into further west

> and I see the areas that have just been completely deforested- and yet, I'm using the products that are made every time, right? Like paper, the desk, things in my home- it would be silly to say I'm not pro wood, you know? So I would consider it. It makes yours a little complicated, but it's okay to be 2-headed about it.
>
> Bree: Ok. (P5, 23:22)

In this excerpt, Terry essentially instructs the students to address logging, providing nature-based reasons for including it. Following this conversation with Terry, Bree and Rae return to their discussion of their resource's primary importance (part of the Map activity):

> Rae: We like- we are the forest. Like, that's like- we provide the habitat and keep the soil in place.
>
> Bree: Yeah, but I mean, I think like what she said, we can't ignore the economic.
>
> Rae: Yeah, so we should say, um-
>
> Bree (writing): My primary importance is to maintain the forest habitats, while still-
>
> Rae: Um, while still maintaining a balance of economic (Bree: Yeah, so) by responsibly logging with like regulations that require you to regrow like after you log.
>
> Bree: Or something, yeah, ok, and then so- (looks up at board & writes) Management goals. (P5, 25:00)

After Bree and Rae called on the teacher when they were unsure about the role of logging, they then adopted that critique in their group interactions. Bree used the teacher as both evidence and the source of the critique (attributing the critiquer role to the teacher), rather than drawing on evidence from nature or coming up with her own reasons for critiquing Rae's focus on ecological rather than economical claims.

After the above conversations, Bree and Rae's Day 2 interactions with other resource groups all addressed logging:

> Bree: Yeah, how- so we do need to do some logging for the economic side of things. Um, where would be best, like if it had to happen for you?

> Male Student R: Hmm you guys need to log? Isn't that- isn't there like a logging specific group?
>
> Bree: (shakes head) No.
>
> MSR: Oh, so you guys cover logging? (Bree: yeah) Ok. Um, I guess logging would be best probably-
>
> Male Student L: In areas that aren't by rivers.
>
> MSR: Yeah, in areas that aren't by rivers and probably around Western Washington because there aren't that many trees and they're all really dry in Eastern Washington. (Bree nods) (P5, 49:14)

This take-up of the teacher's critique may be viewed as Terry subtly dictating the content of the focal students' discussions, where the teacher authoritatively "prescribes the direction of discourse" and "acts as a gatekeeper to points of view" (Scott et al., 2006, p. 628).

Routine Transfer

On Day 2, Bree and Rae used content they discussed on Day 1, but they did little to adapt it and only marginally added to it. For example, on Day 1 Bree and Rae talked about the relationship between trees and small mammals, emphasizing small mammals' use of trees for homes:

> Rae: I said (reads from paper) small mammals use trees for shelter slash, I meant to say like homes but I said live (laughs) uh and (Bree: oh yeah) bring salmon for nutrients. (P1, 36:00)

On Day 2, Bree and Rae met with the small mammals group, coming to the same conclusion from Day 1:

> I'm just going to say (writing) small animals will need trees for habitat. (P5, 35:04).

No transfer.

In addition to this type of routine transfer of knowledge, occasionally Bree and Rae did not transfer knowledge at all. Even though they had access to more information about the

relationship of their resources, the two resource groups struggled to come up with common goals enough to ask the teacher for help:

> Rae (to Terry): Ok, so small mammals and trees, what else do we have in common besides just wanting to preserve the forest? (P5, 31:11)

If either of the groups had thought to look at Bree and Rae's Document from Day 1, they would have been reminded that small mammals contribute nutrients to the soil. Instead, nutrients from small mammals did not come up once during their 8-minute long conversation with the small mammals group, indicating a missed opportunity for transfer.

Adding not adapting knowledge.

When faced with entirely new information that they did not discuss on Day 1, Bree and Rae added to their knowledge, but did not appear to adapt it to accommodate the new knowledge. One example of this was their discussion with the biomes group regarding where it would be best to log. When Male Student RT suggested logging in Western Washington would be preferable to Eastern Washington, Bree could be seen and heard writing MSRT's suggestion verbatim, without even responding to it directly much less questioning its validity or asking for evidence to support the claim (P5, 49:30).

Another example of adding but not adapting knowledge was when Bree and Rae learned about mining in streams from the mining group, but did not use the new information to adapt their thinking about mining, logging or trees in general. Their conflict resolution was exactly the same as the one they decided with the small mammals group, one that came up again with the biomes group (i.e., not logging by rivers). In this case, it was apparent that the solution of "not logging by rivers" addresses the mining group's concerns about erosion, but not their need to mine for gravel in the streams:

> Bree: Where mostly is your mining? Like, is it-

FSR: We're streams and open pit (Bree: streams?) streams (laughs)

Bree (shakes her head): That's just not going to happen.

FSR: open pit. We've got a lot of shit going on. (FSL: surface mining) surface mining (FSL: underground mining)

Rae: Yeah, we just don't want you guys anywhere near our forests (P5, 44:02)

…

FSR: We have to be in streams which are in forests.

Bree: Not really.

Rae: Ok, so if you made like-

Female Student L: Why do you have to be in streams? (question directed toward FSR)

FSR: Because we have to get like the gravel.

FSL: Oh (?) ok

Bree: Ok well-

FSR: Yeah, gravel is Washington's main thing. For like construction.

Bree: Really? And doesn't that like kill all the salmon? (P5, 44:28)

…

FSR (looks at paper): Oh yeah, uh, will there be erosion effects?

Bree: Oh um, yeah if you take out all the- you take out the trees

FSR: Because yeah that could be a conflict that you guys would cause us (Bree: how would-) because we need stable soil

Rae: But we are already not mining [sic - means logging] by rivers because that would hurt our small animal friends

FSR: Ok. (starts to write) not mining-

Rae: So not mining by the rivers will cause the erosion-

FSR: Or, do you mean not logging?

Rae: Or yeah, sorry, not logging by rivers will keep the soil in place so the sediment doesn't go into the rivers

Bree: (looks at Rae) Should I write that?

> Rae: Yeah write that down. no mining by rivers, that means we have an agreement with mining (P5, 45:15)

Female Student R appeared to be using Side 2 of the Day 1 Document to remember their question about erosion effects, leading to some much needed conflict resolution between the two groups. However, Bree and Rae appeared to only agree with recommended solutions that safely mapped onto more than one of their resource partnerships rather than adapting any of their knowledge claims. They seemed to stick with safe conflict resolutions that spanned several of the groups and did not appear to show any accountability to the mining group in terms of resolving conflicts in ways that benefited them.

Summary

Terry expansively framed the Day 1 Document in terms of time, place, participants and roles (students as resource managers who were preparing to meet with other resource managers in class on the following day), but the framing moves she made around the Document as a material resource were bounded. She referred to the Document as a "handout" or "sheet" instead of a tool, eliciting the grammar of schooling around completing assignments to achieve an evaluation. She told the student numerous times that she would be collecting the Document, going so far as to remind students how to complete it at the beginning of Day 2, and did not stop students from finishing it while they were supposed to be working on their Map. She also told an absent student to make up the Document, treating it like an assignment that students needed to submit for evaluation from the teacher in addition to a tool intended to facilitate participation in class on Day 2.

All of these framing moves around the Day 1 Document, paired with her frequent use of authoritative discourse during interactions with students, was linked to Terry's students being oriented more toward typical schooling practices than those of science, accompanied by routine

transfer of knowledge from 1 day to the next (Scott et al., 2006). Students in her class mostly interacted with each other by contributing ideas and agreeing with each other rather than challenging each other or using evidence-based practices of science (Ford & Forman, 2006). They interacted with other student groups on Day 2 in the same way that they interacted with each other, largely avoiding the typical scientific practices of critiquing each other's knowledge claims or prompting each other for nature-based evidence. These types of interactions meant Terry's students were engaged in some routing transfer and the practices of "doing school" (Pope, 2003), but did little to adapt their knowledge from Day 1 to Day 2. Even though Terry framed for transfer by connecting settings, she did little to promote student authorship, focusing the students more on her authority as a teacher who was looking for particular answers and who intended to evaluate their classwork.

CHAPTER 6.

Comparing the Cases

The previous two chapters included detailed descriptions of each of the classrooms, including evidence of teachers' contributions and students transferring and engaging in more or less disciplinary ways (see Appendix J for a comparative table of events across the two days). This chapter identifies two broad claims about how each teacher's moves may have been linked to the types of transfer and engagement their students exhibited, findings that become more visible when comparing the two classrooms and their material resources.

In these cases, it is apparent that Shila and Terry framed some aspects of the social context differently, including the material resources that were the same across the two classes. The teachers framed material resources as part of the context of their classroom in more expansive or bounded ways, suggesting that resources be considered in addition to time, place, and participants as an aspect of the social setting worth considering when exploring how framing affects transfer (an extension of Engle et al.'s, 2012 work). The moves the teachers used to frame material resources aligned with the method of "connecting settings" outlined by Engle and her team.

While students in both classrooms engaged in schooling tasks that involved the use of science content or knowledge claims, as well as the science-based role of "resource manager," they did not all engage in the practices of science associated with adaptive transfer, specifically the role of critiquing each other's knowledge claims in light of nature-based evidence (Ford & Forman, 2006). A potential explanation for differences in students' adaptive transfer between the two classrooms was differences in the teachers' use of methods of expansive framing involving the "promotion of student authorship" and disciplinary-appropriate accountability (Engle et al.,

2012). The two teachers appeared to orient their students toward using more science or more schooling practices by either framing only through the connection of settings or by also promoting student authorship. Findings from this dataset suggest that students with support for authorship and disciplinary-appropriate accountability transferred both routinely and adaptively, while students without this support from the teacher transferred mostly routinely.

Chapter Outline

Claim 1 marks the first section of this chapter, oriented around the finding that the teachers framed material resources in more expansive or bounded ways that oriented students toward or away from using scientific practices in the classroom. This claim is supported through an explanation of the elements of Engle and her team's (2012) "framing for transfer" theory, with Table 8 outlining the aspects of contexts that can be framed and extending those aspects to include material resources, and Table 9 outlining the five framing moves the teachers used to frame the Day 1 Document (material resource), followed by explanations of all five moves. Claim 1 segues into Claim 2 with an explanation of how authority and accountability are part of the five moves the teacher made, which map onto the two methods for framing expansively outlined by Engle and her colleagues.

Claim 2 marks the second section of this chapter, oriented around the finding that some students transferred more adaptively than other students, while all students transferred routinely. A proposed explanation for this difference stems from the methods teachers used to frame social contexts expansively, especially with regards to their promotion of students' authority and disciplinary-appropriate accountability, which appeared to impact how adaptively the students transferred knowledge claims.

Claim 1: Framing Material Resources

Framing material resources in more expansive or bounded ways is an important aspect of teacher framing for student transfer in project-based classrooms. Previous analyses using the "framing for transfer" theoretical lens (Engle et al., 2012) focused on time, place, participants, and roles as the aspects of contexts that could explain whether or not teachers were using the expansive framing methods of "connecting settings" and "promoting student authorship" in their classrooms. Using these elements alone did not explain differences in the nature of student transfer in these two classrooms. Broadening the Engle team's framework to include the framing of material resources provides a plausible explanation for differences in transfer and engagement.

Framing for Transfer

During observation, both teachers appeared to be expansively framing time, place, participants, and roles for transfer across the 2 days of the lesson, yet the students in Shila's classroom seemed to engage in more disciplinary ways, including continuing to adapt knowledge claims in addition to using or adding to them, on Day 2 than the students in Terry's classroom. This difference was interesting given that the two teachers worked closely together, co-planning the lesson and using nearly identical classroom resources—even the amount of time each group of students had to work on each task was highly similar. It was likely a difference in the way that the teachers were presenting, explaining, and facilitating the lesson that could explain differences in how adaptively or routinely the students were using their knowledge.

Table 8 demonstrates the similarities and differences between the teachers' framing in the two classrooms.

Table 8. Expansive and Bounded Framing of Aspects of the Context

Aspects of Context	Expansive Framing	Bounded Framing
Time	**Day 1**: Both teachers framed forward in time to Day 2. **Day 2**: Both teachers framed backward in time to Day 1.	
Place	**Day 1**: Both teachers framed the place as inclusive of both the Day 1 and Day 2 classrooms. **Day 2**: Both teachers framed the place as inclusive of both the Day 1 and Day 2 classrooms.	
Participants	**Day 1**: Both teachers framed the participants as the students, their resource partners, and resource groups the following day. Terry additionally framed the Document as involving the teacher. **Day 2**: Both teachers framed the participants as the students, their resource partners, different resource groups, and the teacher. Terry additionally framed the Map as involving one of the researchers.	
Roles	**Day 1**: Both teachers framed students' roles as *resource managers* in preparation for Day 2 (authoring the content of a tool for use the next day). They also framed students' roles as *students* who were responsible for recording content on a Document. **Day 2**: Both teachers framed students' roles as *resource managers* who were resolving conflicts with other resource managers and *students* who needed to complete the Map.	**Days 1 & 2**: Terry emphasized completing and submitting the Document to be evaluated by others, which emphasized the *student* role more than in Shila's classroom and seemed to impinge slightly on the expansive role of *resource manager* encouraged in the curriculum.
Material Resources	**Day 1**: Shila framed the Document as a tool (to be used to facilitate the Day 2 activity) by repeatedly calling it a tool, telling the students she would not be collecting it, and reviewing it with the whole class before the students left for the day. **Day 2**: Shila continued to frame the Document as a tool (to be used to facilitate completion of the Map on Day 2) by telling absent students they did not need to make it up, and by telling groups of students not to continue working on it.	**Day 1**: Terry framed the Document as a school-based assignment (a product to be assessed by others) by calling it a handout or sheet (not a tool) and telling the students she would be collecting it. **Day 2**: Terry continued to frame the Document as an assignment by reviewing the instructions on how to complete the Document again on Day 2, by asking absent students to make the assignment up, and by allowing students to work on the Document during class on Day 2.

Note. This table demonstrates the similarities and differences between the teachers' framing in the two classrooms.

According to Engle and her colleagues (2012), the aspects of a social context that can be framed are: time, place, participants, and roles. It was apparent in this dataset that the teachers were framing the context differently, but the framework Engle and her team provided was insufficient for explaining how. Despite the teachers giving the students the exact same Document and expansively framing it as something that would prepare them for the following day, the students in the two classrooms responded differently to the completion of the Document. Shila's students largely finished the Document in class on Day 1 and were ready to begin the Map activity right away on Day 2. In contrast, at least two of Terry's groups did not complete the Document on Day 1 and spent the first 10 minutes of the Map activity discussing features of the Document that should have been completed on Day 1. This difference suggests that the some of the students were more focused on completion of the Document (part of the "grammar of schooling") by recording knowledge they already had, than they were on the Map where they would continue to build on and adapt their knowledge.

These differences appear to stem from differences in framing of material resources briefly introduced in Table 8, as the teachers made at least five moves to frame the Document more expansively as a material tool or more bounded-ly as a school-based assignment (not a tool). Table 8 illustrates how similar the classrooms were, as the teachers planned the classes together and used the same material resources, including the PowerPoint slides, Document and Map design. However, the few areas where the teachers began to diverge, in addition to differences in how the focal students interacted on Day 2, suggested that there was more to the picture. A key aspect of the context in these classrooms, the material resources, was not captured in the table provided by Engle and her colleagues (2012, p. 220). Because the students in the classrooms clearly transferred content from Day 1 to Day 2 differently, I tracked the differences

between the two classrooms in terms of the teacher's moves around the aspects of the context defined by Engle and her team, demonstrating how framing material resources was where the teachers exhibited the most differences in framing.

Resource Framing Moves

Table 9 identifies the five framing moves the teachers used to orient students to the material resources in particular ways. The table includes a brief description of the five ways the teachers differed in how they framed the material resources, which is followed-up with more detailed descriptions of each move and a summary of the means by which teachers were framing.

Table 9. Teacher Framing Moves Related to the Document

Teacher Framing Moves	Teacher 1: Shila	Teacher 2: Terry
1. Naming the Document	Mostly "tool"	"Handout" or "sheet"
2. Collecting the Document	Not collected	Collected
3. Reviewing the Document	End of Day 1	Start of Day 2
4. Making up the Document	Not made up	Made up
5. Prolonging work on the Document	Not prolonged	Prolonged

Note. This table identifies the five framing moves the teachers used to orient students to the Document in more or less expansive ways.

Naming.

As she handed out the Document on Day 1, Shila called it a "tool" and told the students right away that they were going to be using it to structure their conversations on the following day. Shila named material resources in ways that oriented students more toward science practices (away from the "grammar of schooling"), calling the Document a tool most of the time and the Map a "concept map" or a "poster." Shila referred to the Document as a tool seven times on Day 1 (one time as "worksheet") and four times on Day 2. In contrast, Terry called the Document a "handout" four times on Day 1 and four times on Day 2, and a "sheet" three times on Day 1 and four times on Day 2, but never a "tool." Written on top of the paper itself (used by both

teachers), the Document was referred to as a "material tool," the researchers called it a material tool, and the PowerPoint slide both teachers used said "tool": "This tool will help you structure your ideas and guide the conversations you need to have" (P2). And yet, the only time Terry referred to the Document as a "tool" was in conversation with Researcher 1 after class on Day 2. On Day 2, Terry referred to the Map as "poster" once and "graphic organizer" once, but never a "concept map" or "tool;" when interacting with students, she frequently just called it the "paper." While the board mentioned "mapping",[9] Terry never used this terminology.

It is likely that both teachers meant something in particular when they labeled the Document as a tool, handout, or sheet. Whether these meanings were apparent to, communicated to, or understood by the students is a question I cannot answer with this dataset. However, there is evidence that both teachers were using the terms intentionally. Shila responded to a students' question about how to fill out the Document by saying: "this is a tool for you to use." She did not explain it any further or answer the student's question directly, suggesting she expected the student to know what she meant when she said it was a tool for her use. Terry never used the word tool with the students, but she did use it with the researcher, suggesting that she understood it as a part of the work of the project, in relation to the researchers, and potentially made a choice to not use the word with the students. It is unclear why she made this choice, whether she wanted to use the Document differently than the research team had intended, or just did not think the students would understand the label "tool," or some other reason. However, their use of the word "tool" does suggest that both teachers understood the intention of the curricular role of the Document (as a tool).

[9] "Share out: Mapping your resource and finding connections with others in the state" (P6).

Collecting.

The teachers explicitly told students whether or not to turn the Document in so the teachers could look at it. Terry not only told students that she was going to look at it, but also that the researcher (who was filming the class) planned to look at it as well (suggesting that the Document had an evaluative purpose). In contrast, Shila stopped students from making changes to their Document during class time, refocusing them on using it as a tool to complete the Map. Additionally, Shila mentioned how she expected the students to adapt the content for use in their conversations on Day 2, explicitly emphasizing adaptive transfer of the content.

To use the Document appropriately as a tool on Day 2, the students needed to finish it on Day 1. To support this goal, Shila coordinated an impromptu share out at the end of Day 1 to take advantage of students' accountability to other "resource managers" (student groups) for being prepared for the following day's activities (since she did not position the students as accountable to herself for finishing the Document). While she asked students to "fill this in," she did not use words like "complete" or "turn in" when asking the students to prepare to share their ideas from the Document, instead orienting students toward articulating the content of the tool:

> An ally you want- you think you have and a group you want to talk to?... And an adversary? Somebody you want to talk to but you might not have a good relationship with? (P4, 57:09)

In contrast, Terry communicated the same goal of finishing the Document (on Day 1) to her students, but she did not position the students to be accountable in any way for finishing on Day 1. She did position them as accountable to her on Day 2 for submitting it by the end of class, asking students to "turn this in today" (P6, 11:21) and then again to "please do turn in this sheet" (P6, 19:00) right before they started the Map activity.

Reviewing.

While Terry repeatedly told her class that the Day 1 Document was intended to prepare them for the Day 2 activity, she treated the Document like an assignment that could be completed and turned into the teacher whenever it was done. On Day 2, Terry reviewed the instructions for how to fill out Side 2 of the Document, a teaching move that only made sense if Terry was viewing it as an assignment to get done rather than as a tool to support the Day 2 activity. Terry used Day 2 class time to go over the directions (again) on how to complete Side 2 of the Document, while Shila only mentioned the Document in passing, asking the students to refer to it as they summarized their management goals on post-it notes as the first step toward completing the Map. Students, used to complying with teacher directives, may have assumed that the activities emphasized by the teacher were the ones that they should work on during Day 2, leaving Shila's class with a clear message to focus on the Map and Terry's students with the task of completing both the Document and Map.

Making up the document.

Both teachers talked to students who were absent on Day 1 about the Document, but while Terry asked a student to still complete the Document, Shila told two students not to complete it. Terry did not elaborate on why she wanted the student to still complete the Document (implicitly framing it as a school-based assignment), but Shila clearly communicated the role she thought the Document played in structuring their thinking for the Day 2 activity (explicitly framing it as a material tool).

Prolonging work on the document.

Shila stopped a group from modifying their Document at the beginning of the Day 2 activity, refocusing them on adapting the ideas that they had already recorded on the tool. Terry allowed her students to use Day 2 class time to complete their Day 1 Document.

Framing Moves and Methods

These five resource framing moves were made by the teachers through a mix of meditational language and other positioning moves. They frequently used discourse to position the resources in relation to science or schooling contexts, relevant to practices typical of classroom-related tasks (such as completing work on time or getting the answer the teacher was looking for) or practices related to making scientific claims (critiquing knowledge claims in pursuit of nature-based evidence). For example, the teachers used different language to identify the Document: a "handout" was more likely to remind students of schooling tasks (as handouts are a more rare occurrence outside of the school context), whereas "tool" was more likely to orient students to a variety of contexts and practices (as tools are used in various situations in addition to the context of school, for example, a tool to style your hair, a tool to repair the TV, or a tool to measure the acidity of a substance).

In addition to framing resources discursively, the teachers positioned material resources in relation to the relevant actors in the social context, especially students (self and other "resource managers"), teachers, and the scientific community. These framing moves oriented the students to whom the authority was in that context, as well as to whom they were accountable. Terry primarily framed the Day 1 Document in terms of students' accountability to her (and her authority as the teacher), while Shila framed material resources in terms of students' accountability to other disciplinary actors such as other "resource managers" or critiquers (as

well as student authority). Table 10 tracks the relationship between the five framing moves made by the two teachers around the Document and the way these moves positioned whether the teacher or student had authority and to whom the students were accountable.

Table 10. Framing Moves and Teacher Supports

Framing Moves	Teacher 1: Shila	Teacher 2: Terry	Positioning Authority and Accountability
1. Naming	Mostly "tool"	"Handout" or "sheet"	**Authority**: A tool might be a place where students record their own disciplinary ideas, in contrast to a handout, which contains factual information from a text or teacher that has a measure of (in)correctness. **Accountability**: If a tool is for the students' personal use, it emphasizes accountability to the self, resource partner(s), and other resource managers.
2. Collecting	Not collected	Collected	**Authority**: Collecting the Document implies that it will be evaluated by someone in a position of authority, detracting from the student's authority over the content. **Accountability**: Material resources that are collected by the teacher fulfill an obligation to that teacher, potentially detracting from students' accountability to themselves or others.
3. Reviewing	End of Day 1	Start of Day 2	**Authority & Accountability**: By reviewing with the students in a whole class setting, a teacher might position students with authority and accountability. While the students are authoring content by exercising intellectual authority, they are accountable for sharing that content with their peers and the teacher during periods of review, where they can be reined in if their ideas do not make sense.
4. Making up	Not made up	Made up	**Authority & Accountability**: Making up an assignment for which the purpose was to prepare for another activity primarily serves to emphasize the teacher's authority and the accountability of the student to the teacher (in lieu of emphasizing students' authority or accountability to anyone other than the teacher), as the make-up will have little to do with the task itself (its function as a tool) or other members of the class.
5. Prolonging	Not prolonged	Prolonged	**Authority**: Prolonged how-to explanations of material resources may serve to reiterate the teacher's authority. **Accountability**: Repetitious explanations from the teacher may remind the students of their accountability to the teacher for achieving correctness on the task rather than accountability to themselves or others for learning, creating, or contributing valuable knowledge claims.

Note. This table tracks the relationship between the five framing moves made by the two teachers around the Document and the way these moves positioned whether the teacher or student had authority and to whom the students were accountable.

Table 10 illustrates how each of the framing moves the teachers made were associated with authority and accountability, either expansively (in ways that supported student authority and accountability outside of the typical schooling student–teacher dyad) or bounded-ly (in ways that oriented students to the teacher's authority and their accountability to the teacher). Shila framed material resources more expansively, promoting student authorship (in addition to connecting settings through discourse), while Terry framed material resources more bounded-ly, rarely promoting student authorship (but still connecting settings through discourse). These methods for supporting student transfer are further explored in Claim 2.

Connection to Claim 2

The findings detailed in this section regarding how the teachers positioned material resources as part of the social context suggests that the teachers' framing did not just facilitate more or less transfer from Day 1 to Day 2, but also different *types* of transfer. Framing for student authority and accountability to others (besides the just the teacher) was not only related to how Shila's students used the material resources on Day 2, but how adaptively they used them. This connection between framing material resources and participants expansively in terms of authorship and accountability meant not only more disciplinary engagement, but also more adaptive transfer, a finding that is explored in more depth in Claim 2.

Claim 2: Framing for Adaptive Transfer

In this dataset, framing (for transfer) in ways that oriented students toward scientific practices (and/or away from the "grammar of schooling") meant the promotion of student authorship and accountability, which was linked with students' use of adaptive transfer. Shila's students, who were engaged in more adaptive transfer, were also more productively engaged in the discipline of science than Terry's students, who were primarily engaged in routine transfer.

The difference between the expansive and bounded conditions for material resources and roles (as aspects of the social context) shared a similarity that brought light to the problem of defining how Shila framed for both adaptive and routine transfer while Terry framed for mostly routine transfer: disciplinarity. The moves Shila made to frame the Document as a tool oriented the students toward the discipline of environmental science, where students had more authority and accountability to people besides the teacher, rather than to the "grammar of schooling" (Tyack & Cuban, 1995).

Productive Disciplinary Engagement

Engle and Conant (2002) and Engle (2012) identified four supports for productive disciplinary engagement (PDE), two of which (authority and accountability) are also important for expansively framing for transfer (Engle et al., 2012). This section outlines how Shila and Terry fostered (or did not foster) PDE, breaking down the components so they can be referenced in the next section when explaining a connection between promoting student authorship and fostering adaptive transfer.

Table 11 shows how Shila provided all four characteristics of contexts (authority, accountability, problematizing, and resources) fostering PDE, while Terry provided resources, which were provided either by the curriculum or co-created with Shila.

Table 11. Supports for Productive Disciplinary Engagement

Supports for PDE	Teacher 1: Shila	Teacher 2: Terry
Authority: "authority is a matter of students having an active role, or agency, in defining, addressing, and resolving such problems…. In addition, authority includes teachers and other members of the learning community positioning students as stakeholders" (Engle & Conant, 2002, p. 404).	**Strong.** Shila provided supports for student authority by using dialogic discourse and framing material resources in ways that oriented students away from the "grammar of schooling."	**Weak.** While there was a curricular expectation for giving students authority, Terry used authoritative discourse and framed material resources to establish the primacy of her authority as the teacher.
Accountability: "a norm developed within a learning environment that learners are responsible for regularly 'accounting' for how their ideas make sense, given the relevant work of others" (Engle, 2012, p. 172).	**Strong.** Shila had all of her students share with the whole class near the beginning of Day 1, and many of the groups shared again at the end of class (orienting students toward their accountability to other students). They were also held less accountable to the teacher (when Shila did not ask them to submit their Document for her to evaluate) making room for more disciplinary accountability.	**Weak.** Terry only had five student groups share with the whole class at the beginning of Day 1, during which time she evaluated the accuracy of the students' knowledge claims (orienting students to the teacher's accountability). She also held the students accountable to her by submitting their Document for evaluation by the end of class on Day 2.
Problematizing: "problematizing is any individual or collective action that encourages disciplinary uncertainties" (Engle, 2012, p. 168)	**Strong.** Shila emphasized making connections and resolving conflicts between groups on Day 2, the main part of the curriculum designed to problematize the discipline.	**Moderate.** While problematizing happened somewhat through the curricular resources (as conflict between resource groups), Terry sometimes un-problematized things by giving students answers.
Resources: "a learning environment must provide learners with access to the necessary resources for that work" (Engle et al., 2011, p. 174)	**Strong.** Both teachers provided the same resources of time, space and material resources as they were co-planned and provided to some extent by the PBL curriculum.	**Strong.** Both teachers provided the same resources of time, space and material resources as they were co-planned and provided to some extent by the PBL curriculum.

Note. This table shows how Shila provided all four characteristics of contexts (authority, accountability, problematizing, and resources) fostering PDE, while Terry provided resources, which were provided either by the curriculum or co-created with Shila. These supports were rated weak, moderate, or strong according to how strongly they support students' productive engagement in the discipline of science (see Chapter 2 for an explanation of this rating system).

The results from Table 11 predictably map onto the PDE-related outcomes for the two classes (shown in Table 12), where Shila's class rated strong for PDE and Terry's class did not.

Table 12. PDE-related Outcomes

PDE-related Outcomes	Teacher 1: Shila	Teacher 2: Terry
Engagement: "a group of learners is more engaged to the extent that more of them are participating in an interaction, that participation has greater intensity, and each learner's participation is responsive to that of others" (Engle, 2012, p. 164)	**Strong.** Shila's students met all six criteria for engagement laid out by Engle & Conant (2002) and Engle (2012).	**Strong.** Terry's students met all six criteria for engagement laid out by Engle & Conant (2002) and Engle (2012).
Productive Engagement: "they make intellectual progress, or, in more colloquial language, 'get somewhere'" (Engle & Conant, 2002, p. 403)	**Strong.** Shila's students transferred science knowledge both adaptively and routinely from Day 1 to Day 2, using science practices to critique and expand evidence foundations for some of their knowledge claims, as well making visible progress in their thinking about the relationship between fires and other State resources.	**Moderate**. Terry's students transferred science knowledge routinely, but not adaptively from Day 1 to Day 2. They also added to their knowledge claims on Day 2, but did little to adapt them, making little progress in their thinking about how trees relate meaningfully to other State resources.
Disciplinary Engagement: "there is some contact between what students are doing and the issues and practices of a discipline's discourse" (Engle & Conant, 2002, p. 402)	**Strong.** Shila's students used disciplinary practices to contribute scientific knowledge claims, critique them and request or provide nature-based evidence.	**Weak.** Shila's students used knowledge claims about science, but did not use scientific practices or ways of adapting knowledge claims based on new evidence.
PDE: "students' deep involvement in, and progress on, concepts and/or practices characteristic of the discipline they were learning about" (Engle, 2012, pp. 163-164).	**Strong.** Shila's students were productively engaged in science because they engaged in both schooling and disciplinary practices that oriented around the students having authority and being accountable to people besides the teacher.	**Weak.** Terry's students were not productively engaged in science because they primarily engaged in non-disciplinary schooling practices that oriented around being accountable to Terry as an authority figure.

Note. This table defines how strongly each class of students: (a) engaged, (b) engaged productively, and (c) engaged in the discipline of environmental science. Shila's class rated strong for PDE and Terry's class did not (see Chapter 2 for an explanation of this rating system).

Each aspect of PDE and the four supports is explained in more detail in the following section.

Engagement.

Part of the challenge of this dataset is apparent in the finding that both focal groups demonstrated strong engagement, but Terry's class was not as strong in terms of productivity,

and markedly weaker in terms of disciplinarity. The table in Appendix K displays evidence of focal groups from both classrooms meeting the criteria for "engagement" outlined by Engle (2012).

Productive engagement.

The teachers' five different moves for framing the Document appeared to have an effect on how quickly the focal students were able to begin working on the Day 2 Map, as well as how much flexibility or adaptability they had when it came to making connections between their resource and the other resource groups. Students in Terry's class were unprepared to begin talking to other resource groups right away on Day 2: the focal group (Bree and Rae) spent 10 minutes discussing what they were supposed to be doing and who they wanted to talk to before they were approached by another group to start the Day 2 activity. In contrast, students in Shila's class started meeting with other resource groups right away. The focal group (Greg & Nate) spent less than 2 minutes briefly reviewing the groups they wrote to talk to on their Document before seeking out the tree group.

Disciplinary engagement.

Shila primarily supported students' engagement in the discipline of environmental science by conversing dialogically (Scott et al., 2006) with students (a type of discourse used in scientific practice), while Terry primarily supported students' engagement in "doing school" by using authoritative discourse that is typical of schooling. Additionally, students in Shila's class engaged in the disciplinary practices of science outline by Ford and Forman (2006): taking on the roles of contributor and critiquer, and referring to nature as evidence for knowledge claims.[10]

[10] Ford & Forman (2006) also referred to the practice of addressivity to the scientific community, but this dataset does not contain evidence one way or the other if this is the case (just-in-time interview data is likely needed).

As part of her authoritative discourse, Terry told the students answers, telling the focal group that they needed to talk about logging and the biomes group that they should focus on riparian zones. Using authoritative discourse, Terry critiqued the biomes group in a whole class setting, modeling the "correct answer" (Scott et al., 2006, p. 628): "If the teacher's charge is to evaluate student responses, one can infer that he or she has assumed some role of authority over the subject matter content" (Cornelius & Herrenkohl, 2004, p. 471).

Related to her authoritative role, Terry tended to encourage routine transfer, where students directly applied knowledge they demonstrated on Day 1 (while working on the Document). While constructing the Map, they sometimes added their knowledge to information from other groups, but they did little to adapt it. Terry's tendency to answer student requests for direction with content-based direct answers did nothing to disrupt the typical schooling pattern of completing assignments to the teacher's direction. By using this "grammar of schooling," Terry missed opportunities to encourage student authorship or ownership of their knowledge of their resource.

In contrast, Shila tended to use dialogic discourse, where she was "open to different points of view" rather than "focusing on a single perspective, normally the school science view" (Scott et al., 2006, p. 628). During interactions with students, Shila either did not respond evaluatively to their report-outs or she followed up with a question. Shila avoided telling students answers and she encouraged students to have answers she did not think of. Shila encouraged students to adaptively transfer their knowledge, "to build on and apply new ideas through talking with others" (p. 628).

Engle and Conant (2002) and Engle (2012) described four characteristics of contexts fostering PDE. While not all of these supports are directly relevant to the current analysis, they

do provide further evidence for why Shila's students were more productively engaged in the discipline that Terry's students, which is an important foundation to establish in connection with adaptive transfer.

Resources.

Resources, primarily time, space, and material resources, were largely the same (physically) across the two classrooms, as the teachers co-planned the 2-day lesson. However, material resources were not framed the same way by the two teachers (as discussed in Claim 1).

Problematizing.

Built into the curriculum. Shila emphasized making connections and resolving conflicts between groups on Day 2. Terry de-emphasized connections and resolutions, calling them the most difficult part of the assignment. Additionally, students who took up the science disciplinary "Role of Critiquer" (Ford & Forman, 2006) problematized their peers' knowledge claims, while students who only took up the "Role of Contributor" did little to problematize the discipline. In this dataset, Shila's students critiqued each other's knowledge claims, while Terry's students did not critique each other, but turned to the teacher multiple times for critique of their knowledge claims (including their definition of watersheds, the role of logging for their resource and management strategies that would align with the small mammals group).

Authority.

Authority was connected to how disciplinary the classroom was; a teacher who used primarily authoritative discourse (Scott et al., 2006) would struggle to promote "intellectual authority" in students, the foundation of all of the other types of authority (Engle, 2012, p. 170; Figure 3).

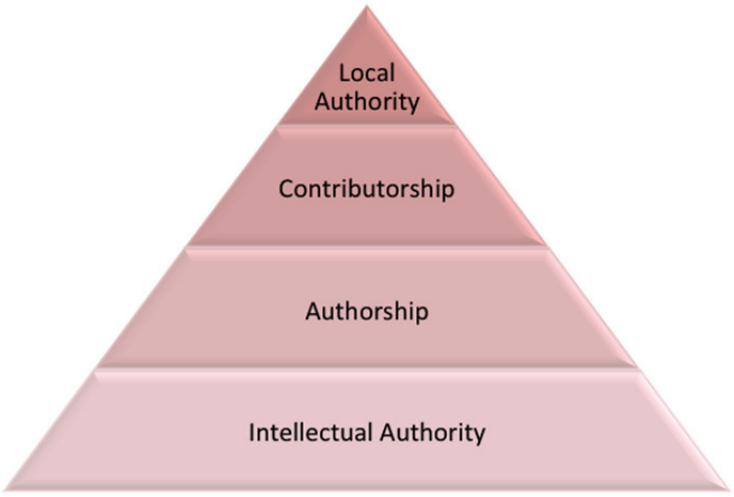

Figure 3. The four kinds of intellectual authority. These authorities were laid out by Engle (2012) so that they appear to be building upon each other from the bottom to the top.

Through their use of different types of discourse (Scott et al., 2006), Terry emphasized finishing the Day 1 Document correctly (using words like "complete", getting it "right," and not getting it "wrong"), while Shila emphasized using the Document as a tool to facilitate adaptive conversations about the Day 2 Map (telling students they would need to "adapt" and telling them their thinking and Maps should be "messy"). For example, even though Greg and Nate pushed Shila hard to give them a direct answer to their question about the goals of wildfires, she maintained her focus on process (narrowing down) and asking probing questions (why do we need to burn things?). These teaching moves seem very intentional, considering how easy it would have been to just directly answer the group's question, strengthening my hypothesis that Shila wanted the students to author their own ideas and answers rather than receive them directly from the teacher.

Accountability.

The teachers used different forms of discourse and different methods of framing resources in order to encourage their students to be accountable to the teacher or accountable to other actors in the discipline of science (such as other "resource managers," critiquers, nature

itself, or the scientific community). Terry used mostly authoritative discourse to orient her students toward their accountability to her as the teacher. Shila oriented her students to disciplinary-appropriate accountability by using more dialogic discourse and challenging students to share with more people (the whole class) more often (warm-up share out and end of class on Day 1).

In addition to the five resource framing moves outlined in Claim 1 (tracked in terms of their support for accountability and authority in Table 10), the teachers' contrasting methods of introducing the Day 1 Document was one example of the differences in support for authorship and accountability across the two classrooms. Instead of explaining the Document instructions from front to back for almost 9 minutes as Terry did, Shila gave the students a minute to look over the Document after she handed it out, then brought the students back together to clarify and ask questions about how to complete the Document. She used examples of questions in the whole group discussion that had come up while she talked to individual groups as they looked at the Document for the first time. These two strategies for introducing the Document promoted authorship by having the students generate questions about the Document, unlike directly instructing the students on how to complete the assignment. The strategies also promoted students' accountability to other resource managers rather than Shila as the teacher.

Methods of Framing

Engle et al. (2012) discussed two "methods for expansively framing learning contexts" (p. 228): connecting settings and promoting student authorship. Figure 4 demonstrates how teacher framing moves are associated with these two methods of framing.

Mapping the data from the two classrooms onto this framework, shown in Figure 5 and Figure 6, it became clear that Shila was framing by both connecting settings and promoting student authorship, while Terry was primarily just connecting settings.

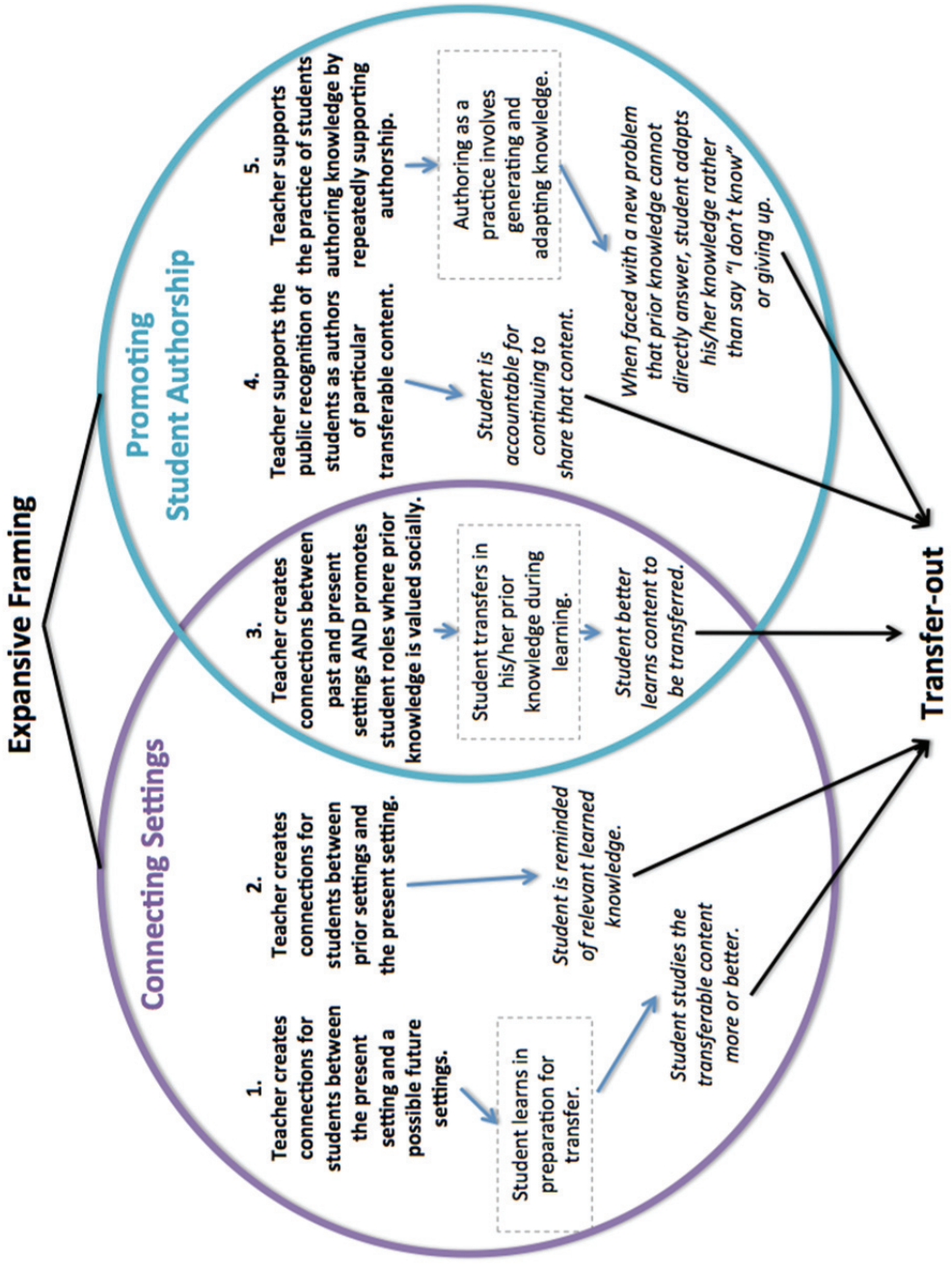

Figure 4. Expansive framing (Figure 1 repeated). This is a modified version of "Figure 2" from the Engle et al. (2012) article, designed to demonstrate: "Five potential explanations for how expansive framing may foster transfer" (p. 220).

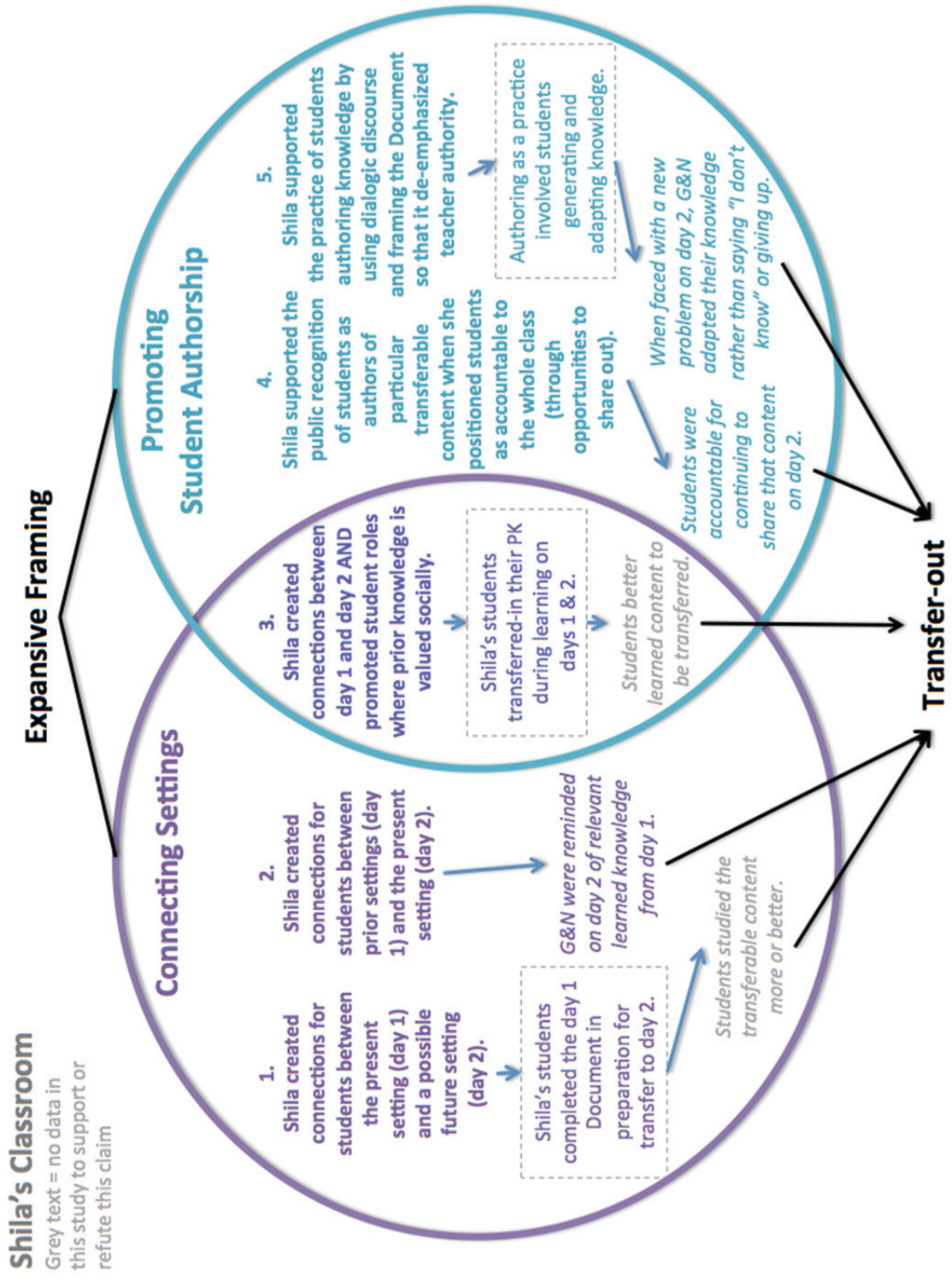

Figure 5. Expansive framing (Figure 1 modified): Shila's classroom. This figure demonstrates how Shila framed expansively for transfer by both connecting settings and promoting student authorship.

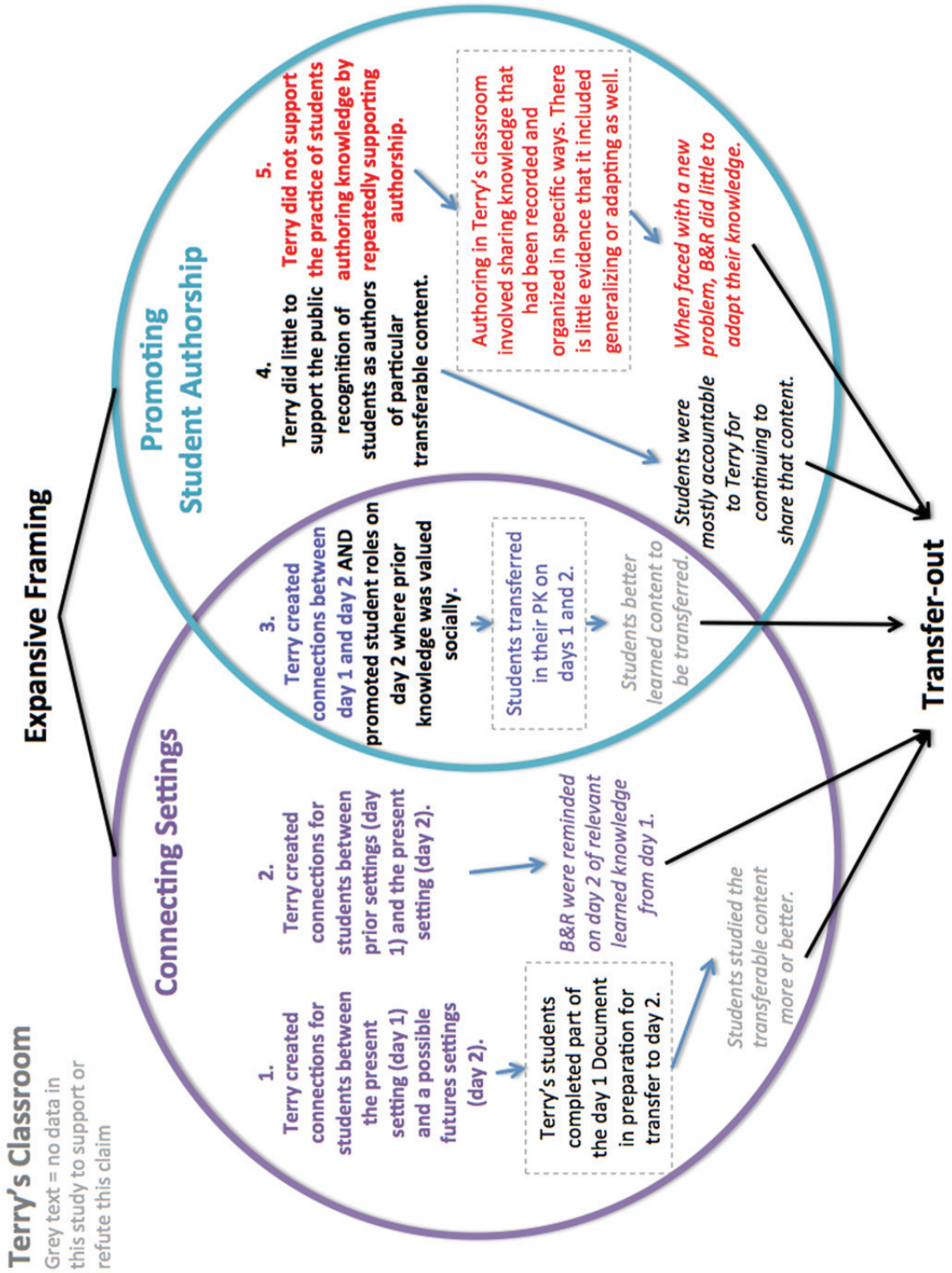

Figure 6. Expansive framing (Figure 1 modified): Terry's classroom. This figure demonstrates how Terry framed expansively for transfer by connecting settings but did little to promote student authorship. The red denotes areas where Terry did not support for transfer, and black denotes where she did little to support for transfer.

While Table 8 in Claim 1 demonstrated how the teachers expansively framed time, place, participants, and roles, these framing moves were largely associated with connecting settings rather than promoting students' authorship. By using primarily dialogic discourse and positioning material resources, Shila seemed to orient her students toward science and away from schooling practices, encouraging them to engage in the scientific practices of critiquing unsupported knowledge claims and continually adding to and adapting their knowledge. In contrast, Terry positioned material resources and used primarily authoritative discourse to orient students to practices of routine transfer and engagement in task-related procedures (such as getting correct answers and completing tasks on time). These different framing methods likely explain the different types of transfer in this dataset: Connecting settings and promoting student authorship (Shila) promoted both routine and adaptive transfer while just connecting settings (Terry) promoted routine transfer.

Adaptive and Routine Transfer

In this dataset, the focal students from Shila's class (Greg and Nate) showed more adaptability than Terry's focal group (Bree and Rae). Following their largely routine or rehearsed conversation with the tree group (practiced on Day 1), Greg and Nate were requested by three groups they had not planned to talk to (insects, watersheds and large mammals). They adapted their plan to include insects, and spent time talking with the other groups even though they did not add them to their Map. Greg and Nate had barely discussed insects at all on Day 1, and yet when they met with the group, they were still able to adaptively transfer their knowledge about fires, combined with prior knowledge about insects, to make a claim about how the two resources could be connected. While Bree and Rae also talked to many groups they had not prepared to meet with, they struggled to adapt their knowledge of trees, sticking to broadly

applicable statements such as “trees provide habitats” (P5, 30:07) or “they maintain balance in ecosystems” (P5, 36:18), often waiting for or probing other groups to suggest ideas about how their resources might be connected:

> Bree: Yeah, but like for native plants, like would you want a place where that has like too many native plants or like, or like-
>
> Female Student 1: We want to- well we would like have you go in and like-
>
> Female Student 2: Log in an area that had- that is invaded by invasive plants (FS1: non-native) that are like killing the native plants. (P5, 40:05)

Bree and Rae appeared to use mostly routine transfer, where they would repeat information they had gathered from sources such as the fact sheet or the teacher but did not generate much new knowledge on Day 2. This could be because they were working on completing both the Document and the Map at the same time, so they had fewer resources to draw from when trying to generate new ideas. In contrast, Greg and Nate appeared to use both routine and adaptive transfer, using the knowledge they had prepared when applicable, but also adapting this knowledge or creating new knowledge when faced with resources or challenges they had not foreseen. This adaptability could stem from their focus on the Map activity rather than completing the Document from Day 1, freeing the students to take up arguments about their resource from Day 1 (such as whether or not fires damage the watershed) or discuss new problems with resources they had not yet discussed.

Even with consideration of these alternative explanations, this dataset demonstrated a striking connection between (teachers) promoting student authorship and (students’) adaptive transfer, making promoting authorship a very likely explanation for why some students transferred more adaptively than others. The methods teachers used to frame social contexts expansively (either connecting settings or promoting student authorship), especially with regards to their promotion of students’ authority and disciplinary-appropriate accountability, appeared to

impact how adaptively the students transferred knowledge claims. While students in both classrooms engaged in schooling tasks that involved the use of science content or knowledge claims, as well as the science-based role of "resource manager," they did not both engage in the practices of science associated with adaptive transfer, specifically the role of critiquing each other's knowledge claims in light of evidence from nature-references (Ford & Forman, 2006). The two teachers appeared to orient their students toward either science or schooling practices depending on their framing of and support for student authorship and accountability. Analysis of these classrooms reveals what it looks like for groups of students to routinely and adaptively transfer in the context of a PBL-APES class, and demonstrated that the students with support for authorship and disciplinary-appropriate accountability transferred both routinely and adaptively, while students without this support from the teacher transferred mostly routinely.

CHAPTER 7.

Discussion and Conclusions

The primary goals for students in this design-based implementation research (DBIR) project were adaptive transfer and engagement in environmental science (Parker et al., 2013; Nolen et al., 2014). Using a small slice of this larger DBIR project, I dug deeply into the literature on transfer and engagement to find ways to qualify the differences between the types of framing, engagement and transfer evident in two classrooms with access to the same resources and teachers who had co-planned their lessons. This microgenetic analysis (Chapters 4 and 5) and comparison (Chapter 6) of the implementations in the two classrooms has led to claims of different types of transfer and engagement in both classrooms, fostered by teachers who used particular framing moves and discourse practices to promote types of transfer and engagement that were valued in their classrooms.

This chapter includes a discussion of my findings, a follow-up of my original research questions, a discussion of this study's significance, including contributions to theory and practice, as well as limitations and future research recommendations.

Discussion

While this dataset only included video from two consecutive days of class during the fourth month of the school year, consistencies in the behavior of the teachers and students (especially their distinctiveness when compared across the two classrooms) suggest that the teachers had been using particular types of discourses (especially dialogic and authoritative) and positioning moves (especially positioning students as authors or not) since the beginning of the school year. In this case, the differences in engagement and transfer between the two classrooms were less likely explained by *only* the teachers' framing of the social context during these

particular days, and likely *also* explained by discourse patterns and other positioning moves that they had established with the students over time.

For example, over the course of the 2 days of video recordings, Shila never instructed her students to critique each other's claims or request evidence in support of claims, but many of her students made these moves that were consistent with science disciplinary practices. It is likely that a consistent modeling of dialogic discourse and support for student authorship over time led to these types of interactions between Shila's students, suggesting that the findings in this study may not only be insights about the 2-day segment, but also may demonstrate outcomes of practices that had developed over time. The framing of material tools may, in fact, be an indicator of teachers' general approaches to framing project-based work in science classrooms. Future, longitudinal research on material resources as aspects of the social context that can be framed to support adaptive transfer may provide a more detailed picture of the effect of teacher framing on students' behavior. Such research would allow exploration of connections between teachers' framing and students' transfer and engagement, along with related discourse practices.

Research Questions Follow-up

The following section directly addresses the research questions that I proposed prior to my analysis of this dataset. These questions served as a guide for my initial analysis, informing my choices of theoretical codes based on literature addressing student engagement and transfer. While the claims in Chapter 6 represent the natural, qualitative process of adapting focus in light of insights during data analysis, they still align with my research questions in terms of shedding light on the relationships between material tools, teacher's framing moves, and students' engagement and transfer. All of my original research questions were answered to some extent

through the process of analysis, although in some cases this meant not finding the evidence I expected.

Question 1:

How did the implementation of material tools as a learning resource support or impede students' PDE in a PBL setting?

A detailed analysis revealed that some of the material resources in these classrooms were framed (implemented) in particular, more or less expansive ways by the teachers. Shila framed the Day 1 Document as a material tool that was intended to structure thinking and prepare students for adaptive conversations where critiquing other students' claims made sense in pursuit of more scientifically accurate, evidence-based claims. Shila prepared the students to reference and adapt the Document on Day 2, but actively discouraged students from continuing to fill it out on Day 2. In contrast, Terry framed the Day 1 Document as a school-based assignment that was intended to be submitted and assessed by the teacher. She asked that the Document be referenced and completed by students on Day 2, but not necessarily adapted in light of new knowledge claims or evidence. Terry did not stop students from continuing to work on their Document during class on Day 2, directing the students to complete both the Map and the Document by the end of the day.

Shila's students, who used the Document as a tool and adapted its content on Day 2, exhibited stronger engagement in the discipline of science and more adaptive transfer than Terry's students, who were still working to complete the Document as a school-based assignment on Day 2, using primarily routine transfer. These findings, building on previous theories regarding disciplinary engagement and transfer, suggest that framing material resources expansively in ways that support near transfer (especially by supporting student's authority and

discipline-appropriate accountability) is an important consideration for teachers who want to foster adaptive transfer in PBL science classrooms.

Question 1a:

Using positive transfer and PDE as measures for learning, in what ways did the curricular material tool from Day 1 come to function in the activity on Day 2?

Because the two teachers framed the Document in five different ways on Day 1, it functioned differently for the two groups of students on Day 2. For Shila's students, it functioned as a tool that they adapted as they worked on their Day 2 Map, serving as a jumping off point to build upon ideas and arguments from the previous day while accommodating new knowledge from other groups. In contrast, Terry's students continued to work on completing the Document during class on Day 2, and either routinely transferred the content from Day 1 to Day 2 or did not transfer it at all. These differences between the two classrooms could be tracked in terms of both transfer and PDE, where Shila's students were more productively engaged in the discipline and transferred more adaptively on Day 2 than Terry's students.

Question 2:

When not focused solely on the teacher, what resources did framing involve in a classroom? What was the relationship between the teachers and the material resources?

In this dataset, some of the material resources were not explicitly framed by the teachers, especially PowerPoint slides and the whiteboard at the front of the classroom. While they may have been framed by the teachers earlier in the school year, during the two days of data collection, these resources primarily served to provide students with constraints and affordances during the process of completing the Day 1 Document and Day 2 Map. When drafting this research question, I had hypothesized that elements of the classroom context besides the teacher

would take a more central role in framing for transfer in a PBL setting where a teacher was expected to be a "guide on the side" rather than a "sage on the stage" (Greeno, 1998, p. 19). While in some ways this was the case in the classroom that had the less authoritative, more dialogic teacher (Shila) because the students had fewer content- or answer-driven discussions with the teacher, the curricular materials and peers served mostly as reminders of the teacher's goals and directions (framing), rather than acting as a distinct source of instruction or framing. For instance, the positioning of the Day 1 Document as a tool by one teacher and as a school-based assignment by the other had little to do with the features of the medium itself, but rather how the teacher positioned the Document in relation to the activities of the classroom and project.

Question 3:

Was there a relationship between the figured worlds (scientific practices versus the practices of schooling) with which students were engaged and the productivity of students' engagement in the discipline?

During analysis, I decided not to frame the classrooms in terms of figured worlds (Holland et al., 1998), as this framework added complexities to the analysis that were not necessary to explain my primary findings. Also, the differences between expansive and bounded framing, as methods teachers use in classrooms to impact students' transfer, sufficiently captured the distinction between disciplinary practices or contexts outside of the classroom (expansive) and classroom practices (bounded).

Despite adapting my analytical frame, this question was largely addressed in my analysis through a contrast of disciplinary practices with classroom practices ("doing school" or the "grammar of schooling"). The real or imagined contexts of science and schooling were prevalent

to different degrees in the two classrooms. Students' engagement with science practices (and teachers' use of dialogic discourse and framing for student authorship) was linked with PDE more than engaging with mostly schooling practices. Terry's students were engaged in fewer science practices when they were concerned with completing the Day 1 Document as a school-based assignment for Terry to assess. A focus on assignment completion (in terms of getting correct answers) and the teacher's point of view in lieu of building on and adapting their ideas about scientific concepts meant Terry's students were less productively engaged in the discipline of science and transferred less adaptively than students in Shila's class. Shila's students were more engaged in science practices when they built on the knowledge they had recorded on the Document, adapting their knowledge based on new evidence during the Day 2 Map activity, and consequently engaging productively in the discipline of science.

Implications for Theory and Practice

This dataset was particularly valuable in terms of understanding the role of classroom resources in supporting student engagement and transfer, since Shila and Terry co-planned the 2-day lesson and used nearly identical resources of time and space to work, as well as the material resources needed to do that work. Most of the students across the 2-day dataset worked on and completed both the Document and Map by the end of Day 2. However, analysis revealed that the ways the teachers framed the Document in the two classrooms differed significantly, leading to differences in how their students worked on the Document during class on Day 1 and the connected Map activity during class on Day 2.

Even though both teachers made connections (framed expansively) between Days 1 and 2, linking the Document and Map activities in terms of time, place, participants and roles, other framing moves they made encouraged students in one classroom to transfer knowledge claims

more adaptively from Day 1 to Day 2. Shila's framing moves oriented her students toward the productive use of scientific practices (especially critiquing one another using nature-based evidence) and adaptive transfer, while Terry's framing moves oriented her students toward assignment completion and routine transfer. The differences between these framing moves was largely a difference in the source of authority and accountability in the classrooms, orienting students either toward their responsibility to the teacher or toward their accountability to each other and the authority of nature and the scientific community (Ford & Forman, 2006). These relationships were likely developed over the course of the school year.

Shila's framing of the Document as a *tool* not only facilitated a connection between the 2 days of the activity, but also seemed to encourage students to critique each other's knowledge claims and continually adapt them across the 2 days. While this type of framing is typical in the discipline of science, through the use of dialogic discourse (Scott et al., 2006), it is not as common in science classrooms where authoritative discourse is part of a grammar of schooling (Parker et al., 2013). This research contributes to a body of work in the learning sciences that recommends bringing disciplinary practices (Ford & Forman, 2006) into the classroom and changing the discourse practices (Scott et al., 2006) that perpetuate an outdated grammar of schooling (Parker et al., 2013) that encourages students to "do school" (Pope, 2003) rather than become more central participants in a scientific community (Lave & Wenger, 1991; Wenger, 1998). It also contributes to research on how teachers can facilitate learning, transfer and engagement in project-based classrooms (Krajcik & Blumenfeld, 2006; Nolen et al., 2014; Parker et al., 2013; Parker et al., 2011), by using disciplinary-related discourse and framing material resources in ways that orient students to sources of authority and accountability outside

of the classroom teacher (Engle, 2012; Engle & Conant, 2002; Engle et al., 2012; Etherington, 2011; Windschitl & Thompson, 2006).

Contributions to Theory

Because this dataset was part of a DBIR study where the teacher preparation practices and curriculum had already been altered based on feedback from 2 years of project implementations, it was already thick with theory and practices imprinted by researchers, teachers, and content experts when I designed my research questions and began my analysis. To the best of my ability, I analyzed the data with a consideration of these theories, especially the focus on teacher practices in terms of expansive framing and student outcomes in terms of disciplinary engagement and adaptive transfer.

This research primarily contributes to theory on project-based learning, productive disciplinary engagement, framing for transfer, and the role of material tools in science classrooms. The 2-day lesson in this dataset emphasizes the need for teachers to provide supports for near transfer across multiple-day projects, including material tools (such as the Day 1 Document) that tie multiple contexts together. Also, the effectiveness of material resources in this dataset (especially the resource intended to be used as a "tool") was largely determined by how expansively the teachers framed that resource, which was connected with how teachers supported for students' authority and accountability. Additionally, analysis of this dataset contributed to an expanded definition and role of resources in both productive disciplinary engagement (PDE) (Engle & Conant, 2002) and transfer literature (Engle et al., 2012), adding *material resources* to the list of aspects of the context (Engle et al., 2012) that are important to consider when exploring the expansiveness of teachers' framing.

My findings suggest a connection between support for students' PDE and expansiveness of their framing for transfer. A connection between PDE (Engle & Conant, 2002) and framing for transfer theory (Engle et al., 2012) makes sense in light of the two frameworks sharing a primary author (Engle), but this connection remains largely unexplored in the literature. In this analysis, support for PDE and framing for transfer were linked in the sense that the teacher (Shila) who provided more support for student authority and accountability and more expansive framing had students who were more productively engaged in the discipline of science and who transferred knowledge claims both adaptively and routinely. The other teacher (Terry), who provided less support for student authority and accountability and more bounded framing of material resources, had students who were engaged less productively in the discipline of science and who routinely transferred knowledge without adapting it.

The five framing moves around material resources I found when analyzing this dataset are clearly connected with the support the teachers were or were not providing for their students' PDE (see Table 10). These two theories were linked in the article by Engle and her colleagues' (2012), but not at this level of analysis. Engle's team used the data from Engle and Conant's (2002) work as an example of how "authorship promotes accountability to particular content" (pp. 224-225), but did not address the similarities between the conceptual components of the articles. While sharing a primary author (Engle), the articles discussed two different outcomes (transfer and PDE), and yet the focus of both on the importance of authority and authorship suggests not only a similar meaning across the two works, but also emphasizes the central importance of student authority in the classroom (for both outcomes of adaptive transfer and productive disciplinary engagement).

Finally, adaptive transfer as a theoretical concept was developed in this research, connected to science practices (Ford & Forman, 2006), discourse practices (Scott et al., 2006), and supports for engagement (Engle 2012; Engle & Conant, 2002). This dataset provided evidence for what adaptive transfer of knowledge claims looks like in a PBL science context. While this evidence is heavily tied to the discipline of science and the supports for student authority and accountability in relation to science practices (including discourse), it builds a foundation for further research on the role of different types of transfer in classroom environments.

Contributions to Practice

The PBL-APES curriculum implemented in these two classrooms was specifically designed to support students' engagement in environmental science and deep, adaptive learning and transfer (Parker et al., 2013). However, this research demonstrates that even an experienced teacher such as Terry—who had well-developed disciplinary knowledge, was using a PBL curriculum, and was motivated to learn how to teach effectively using the PBL curriculum—can end up encouraging students to transfer routinely by framing material resources in bounded ways that are reflective of "doing school" practices (Pope, 2003).

An analysis of this dataset revealed that in order to support learning through projects, expansive framing across the aspects of the context outlined by Engle and her colleagues (2012) may not be sufficient, especially if features of the classroom such as material resources are orienting students toward "doing school" rather than disciplinary practices. Intentional, expansive framing of material resources as tools may help teachers support students in making connections across multiple parts of a project in ways that facilitate students building on and adapting their knowledge over time. In other words, even if a curriculum provides resources

intended to support student engagement and transfer, the way teachers frame those resources still matters for the types of transfer and engagement the students experience.

Overall, this research contributes to an understanding of what PBL looks like in the classroom, and that using a PBL curriculum does not guarantee particular types of student transfer or engagement. Teachers may choose to frame material resources as tools instead of as school-based assignments (using moves like the five framing moves identified in Claim 1 that support student authorship) when they want to encourage connections between multiple activities or contexts, and encourage both near and far transfer in order to help students make sense of learning through projects and make connections with contexts other than the classroom. Additionally, teachers may practice providing supports for adaptive transfer by encouraging students to use the scientific practices of critiquing knowledge claims and providing nature-based evidence (Ford & Forman, 2006), and by fostering student authority and disciplinary-appropriate accountability (Engle & Conant, 2002), moves that are likely to promote increased disciplinary engagement as well.

Limitations and Future Research

All of the following suggestions for future research are born out of either limitations of this study, especially in terms of access to certain types of data, or moves to restrict the scope of this project. While this analysis only focused on a 2-day lesson segment of a year-long PBL curriculum, the classrooms were rich with complex student and teacher interactions that have the potential to yield numerous, layered analyses. At the same time, these particular classrooms were only recorded for a few sections of project work, so access to the additional data needed to answer broader research questions is limited. These limitations and ideas for different types of analysis are reflected in the following recommendations for future research.

Learning as Cognitive Change

While transfer and PDE stand at the forefront of student outcomes worthy of pursuit in the learning sciences, "learning" in the cognitive sense still holds a place amongst these more situative concepts. Learning defined in terms of changes to an individual's mind is incredibly hard to define and measure, yet when we observe students transferring disciplinary knowledge or engaging productively with specific disciplinary practices, we might also make claims about the ways they are using that knowledge and how that is connected to individual cognitive change. This is especially true in the case of tracking routine and adaptive transfer, where an exploration of the implications of adaptability for a student's mind has the potential to greatly contribute to an understanding of connections between cognitive change and types of transfer. I chose not to actively make these connections in this paper, as the situative theories I used for analysis were complex enough on their own, and adding a cognitive analysis to the scope of this work was not feasible. Also a cognitive analysis would have benefitted from more just-in-time interview data from the individual students, which was not a part of this project's data collection scheme. However, I hope to either conduct or enjoy reading future research that explores the differences between adaptive and routine transfer through a cognitive lens.

Project-Based Learning

There were indications that knowing and using specific science teaching discourse moves facilitated the goals of PBL in this sample. Further study is needed, perhaps with a more longitudinal dataset, on the role of framing in PBL classrooms, especially as related to making recommendations for teachers on the best ways to frame for transfer and adaptive transfer. In general, PBL literature could benefit from additional research that addresses the connections

between framing for transfer and projects as lesson units that extend across longer periods of time than many traditional schooling tasks.

The AP Vet Challenge

Although not extensively discussed in this paper due to lack of student interview data, it is possible that the students in these two classes, as AP vets, were so entrenched in the traditional, "doing school" model of schooling in their other courses and in their schooling histories that they were easily reminded to fall into the roles associated with doing school (Pope, 2003). In this case, the teachers had to make a great effort to break students out of the habits of getting assignments done, regurgitating information from books and teachers, and completing tasks in isolation from each other. If the teachers had been working with a group of students who were well-versed in the expectations of project-based work, teaching moves such as telling the students to "think critically" (Terry) may have been more effective in directing the students' engagement (as having more intellectual authority) during group work. It seems that this group of high-achieving students were exceptionally tuned-in to the expectations of the teacher as far as getting credit and good grades for their work, and were only secondarily interested in learning the content due to either interest or desire to do well on the AP exam. If I had access to more data from the first four months of the school year in these classrooms, I might be able to show how Terry and Shila differently built-up the expectations of their students for doing certain types of work in their classrooms, especially work that included intellectual authority and accountability to people besides the teacher. Hopefully, future project research will provide more insight this issue of working with AP vets as well as other populations of students with more diverse schooling histories.

Diversity

During Year 3 of the Design-based Implementation Research project, the same year that this dataset was collected, implementation was expanded from suburban to urban schools where there was more diversity in the communities being studied, especially with regards to students having fewer prior experiences with AP curricula: "the expansion to two urban districts provided an opportunity to test the robustness of the curriculum while investigating local differences in context and implementation that could affect its success" (Nolen et al., 2014, p. 3). Data is already being analyzed regarding the implementation of the PBL-APES curriculum with students outside of the "AP vet" population included in this study. These studies will contribute to our understanding of how students with more diverse literacy skills, social skills, and knowledge bases respond to and engage with learning AP content through projects.

Preparing Students for Scientific Practices

In this dataset, I did not have access to data that would explain *how* students learned to use the scientific practices used by students in Shila's classroom. Because these 2 days of class activity were not recorded until the fourth month of the school year, I do not know whether Shila explicitly taught the practices earlier in the year or the students transferred them into Shila's class as previously developed repertoires of practice (perhaps from a previous science class). However, it is possible that the teacher preparation the teachers experienced influenced their use of science practices in the classroom.

In this dataset, Shila and Terry demonstrated similar degrees of content knowledge. Across the 2 days, all of what the teachers told the students was scientifically accurate, and neither of them encountered a situation with students where they were not able to address a content-based question. While the teachers demonstrated similar levels of content knowledge,

they did not have the same pedagogical content knowledge. Terry was a more experienced science teacher. Shila had participated in an ambitious science methods course at the university based on principles of PDE (Windschitl & Thompson, 2006). While Terry had interacted repeatedly with student teachers and coaches from the secondary science teacher education program, she had not participated in the classes herself. She stated in her end-of-year interview:

> I didn't learn how to do project based learning. I've had three student teachers from the University. They've all been immersed in like big questions and how to teach through big questions. I think it's great. (Terry, end of year interview).

Consequently, Shila had recent experience learning practices designed to support PDE, while Terry continued to hope that she could improve her knowledge of ambitious teaching. When asked, "Is project-based learning a good fit for your teaching style?," Terry responded: "If I could learn how to do it well" (Terry, end of year interview).

Several research studies have already started down the path of addressing this question about how students learned to use the scientific practices—especially Cornelius and Herrenkhol (2003), Berland and Reiser (2011), and Windschitl and Thompson, (2006)—and I believe the field of the learning sciences would benefit from further studies that explore the connections between authentic disciplinary practices (including but not limited to the sciences) and traditional classroom practices.

Revoicing versus Reshaping

With access to more student interview data, another potential direction for analysis of this dataset would have been clarifying (or challenging) the value of teachers "revoicing" students' explanations for expansive framing (Engle et al., 2012, p. 219). In this dataset, Terry's attempted to revoice easily devolved into reshaping into what she believed to be true. There also seemed to be a very real danger of revoicing being misinterpreted by students as reshaping whether or not

this was the teacher's intention, especially if students were accustomed to IRE or authoritative discourse patterns (Scott et al., 2006). Perhaps future "framing for transfer" (Engle et al., 2012) research will be able to add more insight into the impact teaching moves such as revoicing or reshaping have on student's perceptions of their own authorship and accountability.

Types of Transfer

As this is one of the first research projects that describes and documents what adaptive transfer look like in classrooms, I hope that future research will add further evidence and insights to these first steps toward defining what could be useful ways to measure deep learning in the sciences. Beyond the transfer/no-transfer divide, there are subtleties in types of transfer that I believe are left unexplored, and yet could be beneficial outcome measures for disciplines with widely varying value systems (just as adaptive transfer aligns with the values of the scientific community).

Summary

While sufficient for case-based analyses, this dataset was limited in terms of longitudinal scope, whereby further claims about student transfer could be made as well as claims about teachers' and students' changes over time. Transfer has only recently caught the attention of situative researchers, and there is plenty of room for further research on topics such as types of transfer and the role of transfer in PBL curricula. Engle and her colleagues (2012) outlined a set of recommendations for framing and transfer-related studies to follow their lead:

> We suggest three kinds of studies that are likely to be especially fruitful: (a) experiments focused on disentangling the effects of different aspects of framing, (b) comparative studies in classroom settings, and (c) microgenetic investigations that provide data-grounded explanations of how each set of processes unfolds, separately or in concert, to foster transfer. (p. 226)

While this dissertation responds to their call for both comparative classroom settings and microgenetic investigations of the processes involved in framing for transfer, there are still many stones left unturned in these areas. In addition to their recommendations for these three kinds of studies, I believe more research on adaptive and routine transfer, only briefly mentioned in their paper, has the potential to contribute greatly to the field of the learning sciences. As outcome measures related to student learning, routine and adaptive transfer are a fresh way to frame the recurring battle between traditional methods of schooling and methods that more closely mimic the practices of authentic disciplines. More qualitative studies that include rich descriptions of classroom contexts would contribute both to the further development of transfer theory and to teaching practice, as they would allow teachers compare their own practices to those in the case studies.

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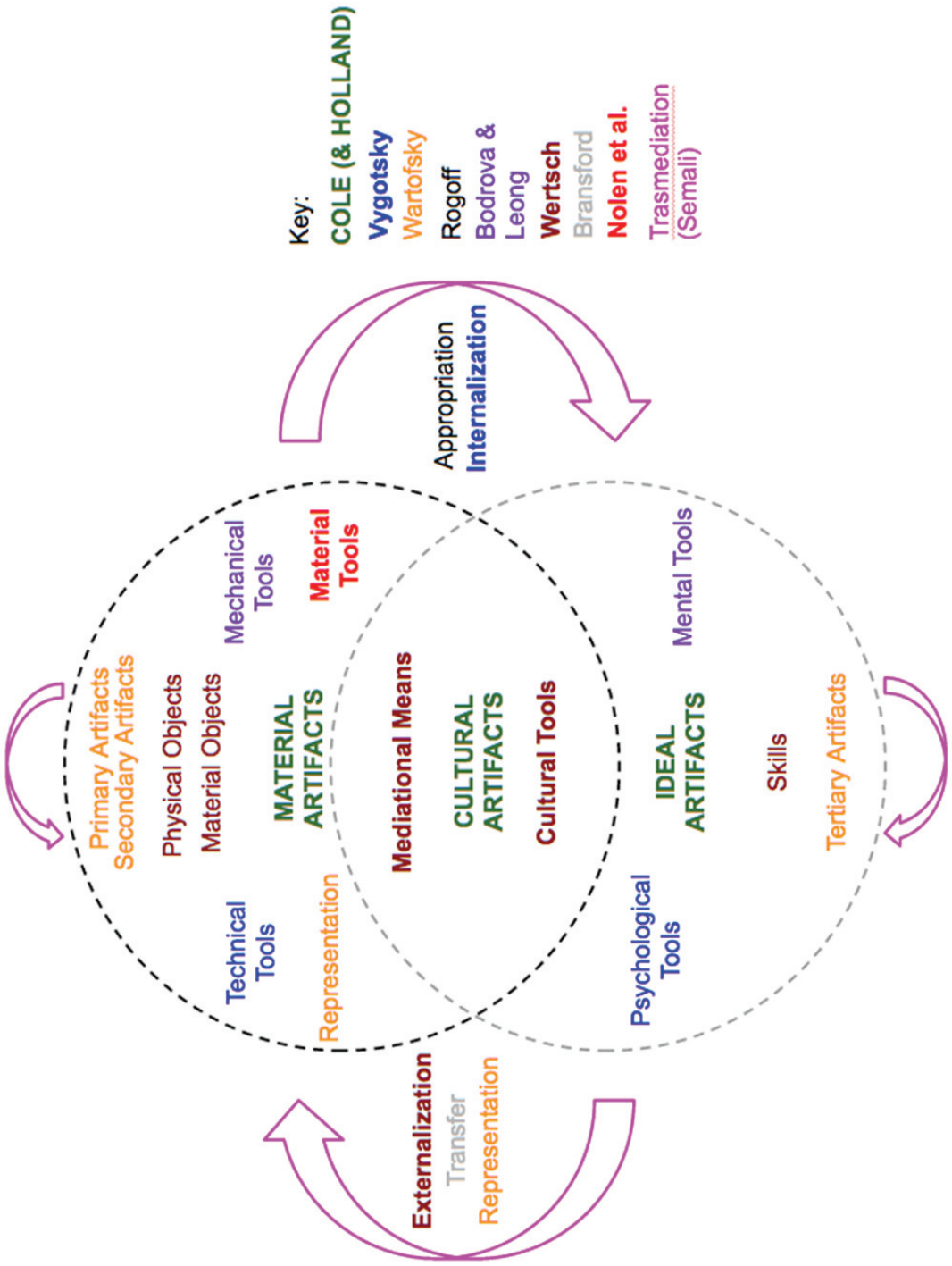
Appendix A.

Media Diagram and Explanation



The media terminology in the above diagram falls into one of three main categories: **external** to an individual's mind (black, dashed circle), **internal** to an individual's mind (grey, dashed circle), or **both** internal and external to an individual's mind simultaneously (overlap of the two

dashed circles). Media researchers express a variety of relationships or movements between the external and internal planes demonstrated in the figure above: external to internal, internal to external, external to external and internal to internal (shown as large, pink arrows). Most of these movements express media-production, and can be defined as either transmediation, the movement from one sign system to another (Semali, 2002; Siegel, 1995; Suhor, 1984), or semiosis, the representation of one medium by another (Sebeok, 1994). These terms often have the suffix "tion," indicating an action turned into a noun; for example, internalization is the act of internalizing. All of these processes hint of movement between media or sign systems. The concepts of media, transmediation, and semiosis seem to capture both the stationary and moving parts of the above diagram.

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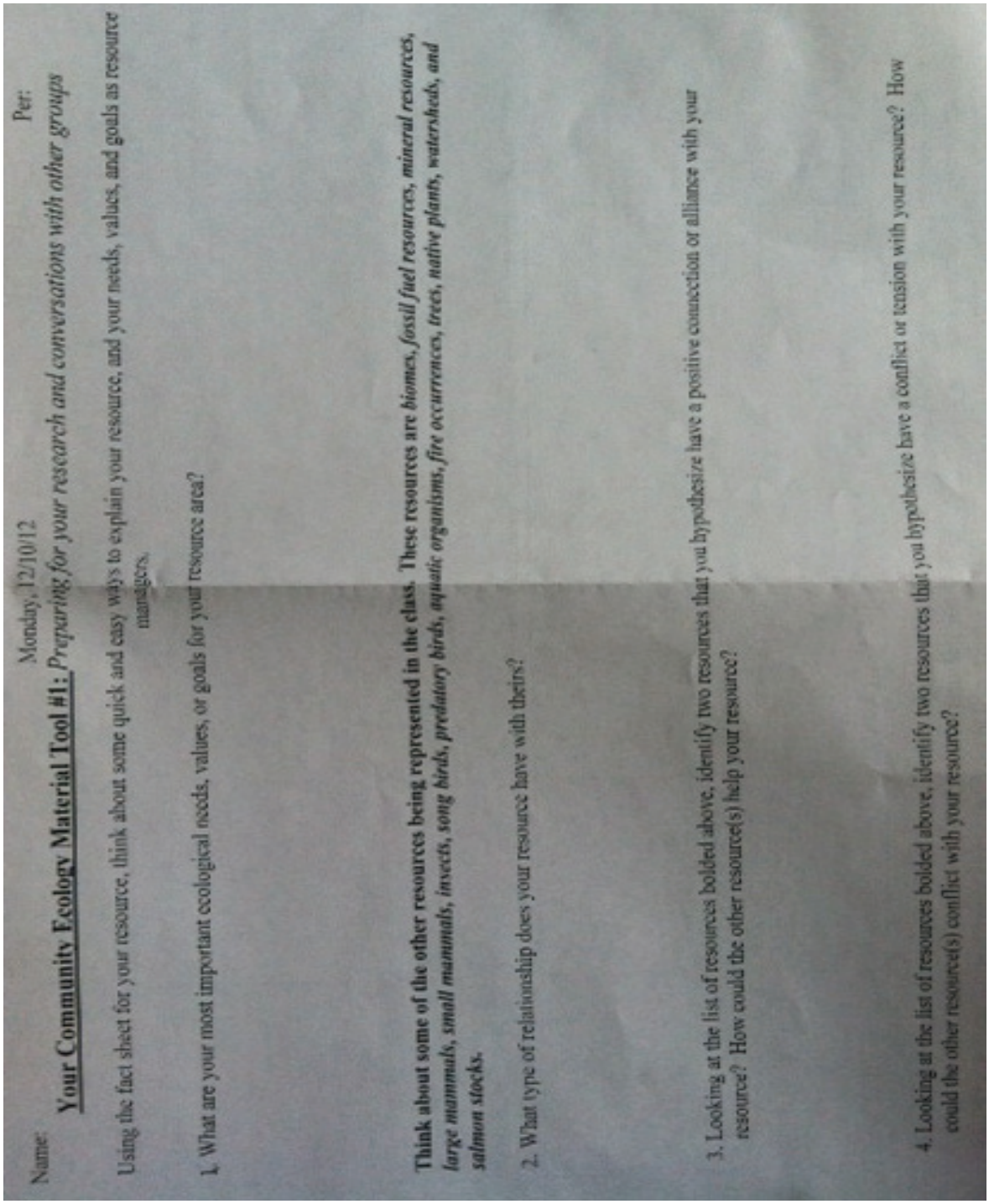
Appendix B.

Day 1 Document Template[11]



Name: Monday, 12/10/12 Per:

Your Community Ecology Material Tool #1: *Preparing for your research and conversations with other groups*

Using the fact sheet for your resource, think about some quick and easy ways to explain your resource, and your needs, values, and goals as resource managers.

1. What are your most important ecological needs, values, or goals for your resource area?

Think about some of the other resources being represented in the class. These resources are *biomes, fossil fuel resources, mineral resources, large mammals, small mammals, insects, song birds, predatory birds, aquatic organisms, fire occurrences, trees, native plants, watersheds, and salmon stocks.*

2. What type of relationship does your resource have with theirs?

3. Looking at the list of resources bolded above, identify two resources that you hypothesize have a positive connection or alliance with your resource? How could the other resource(s) help your resource?

4. Looking at the list of resources bolded above, identify two resources that you hypothesize have a conflict or tension with your resource? How could the other resource(s) conflict with your resource?

[11] This material tool was co-created by the KIA research team prior to implementation Year 3.

Name: Monday, 12/10/12 Per:

Before talking with the other resource managers in the state, do the work now to distill your information down to what other resource managers may be interested in. Remember, we are looking at the relationships between resources and salmon. What might the other groups want to know about the facts, needs, values, and goals of your resource in relation to their own resource? Think through how your resource impacts other resources. Do the work now to identify the resource managers you know you need to speak with (or you know need to speak with you). Write specific resource below, and write what you anticipate needing to say to those resource managers.

Name of Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Resource 6

Now think about what questions you might want to ask to help you understand how your resource area interacts with other resource areas in the state?

Name of Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Resource 6

Text from the Day 1 Document Template

Monday, December 10, 2012

Your Community Ecology Material Tool #1

Preparing for your research and conversations with other groups

Using the fact sheet for your resource, think about some quick and easy ways to explain your resource, and your needs, values, and goals as resource managers.

1. What are your most important ecological needs, values, or goals for your resource area?

Think about some of the other resources being represented to the class. These resources are biomes, fossil fuel resources, mineral resources, large mammals, small mammals, insects, song birds, predatory birds, aquatic organisms, fire occurrences, trees, native plants, watersheds, and salmon stocks.

2. What type of relationship does your resource have with theirs?

3. Looking at the list of resources bolded above, identify two resources that you hypothesize have a positive connection or alliance with your resource? How could the other resource(s) help your resource?

4. Looking at the list of resources bolded above, identify two resources that you hypothesize have a conflict or tension with your resource? How could the other resource(s) conflict with your resource?

Monday, December 10, 2012

Before talking with the other resource managers in the state, do the work now to distill your information down to what other resource managers may be interested in. Remember, we are looking at the relationships between resources and salmon.

What might the other groups want to know about the facts, needs, values, and goals of your resource in relation to their own resource? Think through how your resource impacts other resources. Do the work now to identify the resource managers you know you need to speak with (or you know need to speak with you). Write specific resource [sic] below, and write what you anticipate needing to say to those resource managers.

Name of Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Resource 6

Now think about what questions you might ask to help you understand how your resource area interacts with other resource areas in the state?

Name of Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Resource 6

Appendix C.

Teacher Interview Protocol (Beginning of the School Year)[12]

University of Washington
Knowledge in Action Project

Beginning of the Year Teacher Interview Protocol
New Teachers to Project
2012-2013

Thank you for agreeing to participate in this interview. We are interested in hearing your thoughts about teaching and this course. Everything you share with us is confidential. This interview will be audio-recorded. You may ask me to stop recording at any time or to stop the interview at any time if you ever feel uncomfortable.

1. Have you taught AP Environmental Science before? Comparing the approach of how you taught the course previously to this PBL course, can you share how you think it may be different or the same?
    a. Do you think it may require you to change your instructional approach at all? How?
    b. Can you describe for me the AP culture in your district?
    c. Can you describe the student population that you expect to have in your class?

2. Given all the information you have received this week, tell me your thoughts on Project-Based Learning.
    a. What does Project-Based Learning mean to you?
    b. What are your expectations for teaching PBL this year?

3. Tell me a little bit about your teaching philosophy in science courses.
    a. Describe for me your understanding of how science works/is done.
    b. What should students learn from a science course?
    c. How do you think a science class should be taught?

4. Given what you've learned about the course this week, tell me about your goals and expectation for this course.

5. What struggles and challenges do you anticipate you will face in teaching this course?
    a. How do you think you will approach these challenges?

6. What do you think of the course master question?
    a. Do you think it will be useful in framing the course content?

7. Talk about the depth of learning you think students will achieve by taking this course.
    a. How well do you think the course will prepare students for the AP Exam?
    b. How well do you think the course will prepare student to be able to apply knowledge from the course to other situations in life?

[12] This protocol was co-created by the KIA research team before implementation Year 1 and edited before implementation Years 2 and 3.

   c. In the past we've seen students struggle with the perceived disconnect between the AP Exam and the projects, what strategies do you think you will use to help address this issue?

8. How do you see the parts of the course fitting?
   a. What parts fit together well?
   b. What parts of the course don't make sense?
   c. Are there any important gaps in course content coverage?
   d. What kind of supports will you need to be a co-designer of the course?

9. How do you see subject matter experts fitting into the course?
   a. In what ways would you want subject matter experts add to the course?
   b. What will help make working with subject matter experts easier?

10. In general, how do you think students will respond to the level of reading, writing, and amount of homework expected in the course?
    a. Reading – how many/what proportion of students will find the reading difficult?
       i. Are there strategies that you will use to help students to be more successful in reading for the course? What are they?
    b. Writing – how many/what proportion of students will find the writing difficult?
       i. Again, are there strategies that you will use to help students to be more successful with the writing for the course? What are some of them?

11. Can you talk about the level of student engagement you expect for this course?
    a. Do you think students will be more or less engaged compared to when you've taught this course before or to other classes you've taught?
    b. What kinds of things will support engagement or trigger engagement? (probes: particular cycles, activity characteristics) Why?
    c. What kinds of things will get in the way of engagement? Why?

12. Did you find the summer institute useful for orienting you to the course and the research project? What could we have done differently to make it more useful for you?
    a. If yes, what did you find useful?
    b. If no, what kinds of support would be useful for you? (i.e. instructional strategies, materials, coaching, identifying subject matter experts, literacy and student engagement strategies?)

13. Is there anything else that you would like to add?

Appendix D.

Teacher Interview Protocol (End of the School Year)[13]

University of Washington
Knowledge in Action Project

End of Year Teacher Interview Protocol
2013

Thank you for agreeing to participate in this interview. We are interested in hearing about your experience with this class this year and getting your suggestions on how we can improve the course. Everything you share with us is confidential. This interview will be audio-recorded. You may ask me to stop recording at any time or to stop the interview at any time if you ever feel uncomfortable.

1. What were the biggest surprises that you had this year?
    a. Share a little bit about your goals and expectations for this course. Were those goals and expectations met?
    b. Thinking back to the concerns you had about the course at the beginning of the year, did any of those things come up? How did you deal with them?

2. What did you think of the course master question?
    a. Was it useful in framing the course content?
    b. How did you introduce that question to the students?
    c. How did you use the question as a teaching tool?

3. How well did the looping back of concepts work in the course?
    a. Were you able to use the looping process to build on learning for students? In what ways did you do this?
    b. Were students able to loop concepts and information from previous cycles?
    c. Talk about the depth of learning you think students achieved by taking this course. How well do you think the course prepared student to be able to apply knowledge from the course to other situations in life?

4. At the outset of each project cycle, how did you convey the aim of the cycle to your students?
    a. Was the cycle driving question useful?

5. Can you talk about student engagement in this course?
    a. Were students more or less engaged compared to when you've taught this course before or to other classes you've taught?
    b. What kinds of things supported engagement or triggered engagement? (probes: particular cycles, activity characteristics) Why?
    c. What kinds of things got in the way of engagement? Why?

6. In general, how did students respond to the level of reading, writing, and amount of homework expected in the course?
    a. How did the texts support of hinder students' learning?

[13] This protocol was co-created by the KIA research team before implementation Year 1 and edited before implementation Years 2 and 3.

   b. Were there strategies that you used to help students to be more successful in reading and writing for the course? What were they?

7. How well do you think the course prepared students for the AP Exam?

8. Have you taught this course before? Comparing the approach of this course to the way you taught the course previously, can you share how it is different or the same?
   a. Did it require you to change your instructional approach at all? If so, how?
   b. Now that you've taught the course, what are your thoughts about Project Based Learning (PBL)?
   c. How would you describe PBL?
   d. If you were to walk into a teacher's classroom, how would you know that they were using PBL?
   e. Is PBL a good fit with your teaching style, or is it difficult for you?
   f. What kinds of skills do teachers need to implement PBL successfully?

9. Are there resources of support structures in your district or school that supported you in teaching this year (formalized or informal collaborations, coaches, curriculum coordinators, etc.)?
   a. If no, what kinds of support would be useful for you?
   b. Did you get the support you needed from UW to teach the course this year?
      i. If no, what kinds of support would be useful for you?
      ii. If yes, what support did you find useful?
      iii. Did you find the (*fill in blank with each of below items*) useful and productive?
         1. Summer Institute orientation
         2. PD Days
         3. Learning Logs
         4. Other material tools
         5. Feedback Week
      iv. What could we have done differently to make these things more useful for you?

10. If you were going to teach this course again next year, would your goals be different? Tell me about those goals.
    a. What advice would you have for other teachers thinking of using this course?

11. How, if at all, has this experience changed you as a teacher?
    a. What are you personally taking away from this experience that is of value to you?

12. Is there anything else that you would like to add?

Appendix E.

Teacher Survey Template (Beginning of the Year)[14]

Teacher Survey **2013-2014**

Tell us about yourself

Thank you for taking the survey today. We use your answers to help us make decisions about the course for future teachers like you. Your answers are confidential.

Name_____ **School**_____

1. How many years have you been teaching?	
2. What type of degree/s do you hold and in what subject areas?	
3. What teaching certifications/credentials do you have?	
4. Have you attended the AP College Board training?	
5. Have you been a scorer for the AP exam?	
a. If yes, how many times	
6. Have you taught an AP class before?	
a. IF Yes, what AP class(s) have you taught before? How many times?	
7. Have you taught our PBL AP class before?	

ABOUT AP Please answer for the course that you are teaching: APGOV or APES.

1. Has your school offered APGOV/APES before?	YES NO
2. Has your school offered our PBL APGOV/APES before?	YES NO
3. Does your school require prerequisites for APGOV/APES?	YES NO
a. If so, what?	
4. Does your school require students take the AP test?	YES NO
5. Do students receive a grade boost for taking the AP test?	YES NO

[14] This survey template was co-created by the KIA research team before implementation Year 1 and edited before implementation Years 2 and 3.

Teacher Survey **2013-2014**

Tell us about yourself

Thank you for taking the survey today. We use your answers to help us make decisions about the course for future teachers like you. Your answers are confidential.

6. **Tell us in general about your school's culture around AP classes and taking the AP test:**

7. **What is your philosophy around teaching an AP class and the AP test?**

8. **Do you give incentives for your students to take the AP test? If yes, what do you do?**

For example: Extra credit, GPA boost…

Appendix F.

Student Survey (Beginning of the School Year)[15]

Beginning of the Year Student Survey, 2012-2013 1

Tell us about yourself

Thank you for taking the survey today. We use your answers to help us make decisions about the course for future students like you. Your answers are confidential.

Name: _____ Teacher: _____ Class Period:____

1. There are many different opinions about humans' responsibility towards the environment. Some people value their own needs more than the needs of the environment while others believe that it is important to take care of the whole planet. We can represent these different opinions on a scale ranging from concern for yourself to concern for the whole planet. **Circle the answer that best represents where your responsibility lies.**

Sustaining yourself only	**Sustaining all human beings**	**Sustaining all living things**	**Sustaining all living and non-living things in a community**	**Sustaining the planet as a whole**

2. Why are you taking this class? Rate each reason from 1 (not important) to 5 (very important)

	Not Important				Very Important
I want to earn college credit for passing the AP test	1	2	3	4	5
I am interested in this subject	1	2	3	4	5
I think taking this class will help me in college	1	2	3	4	5
It is important for me to know this information	1	2	3	4	5
It is a required class	1	2	3	4	5
Other (please write in your reason/s below) _____	1	2	3	4	5

3. Are you planning to take the AP test?

- ○ Yes
- ○ Probably
- ○ Probably Not
- ○ No

[15] This survey template was co-created by the KIA research team before implementation Year 1 and edited before implementation Years 2 and 3.

Beginning of the Year Student Survey, 2012-2013 2

Tell us about yourself

4. Rate each reason for how important it is in your decision to take or not take the AP Test

	Not Important				Very Important
Earning college credit to save money on tuition	1	2	3	4	5
Earning college credit to get through college faster	1	2	3	4	5
I'm required to take the test	1	2	3	4	5
The cost of the test	1	2	3	4	5
Whether or not the college I want to go to accepts AP credit	1	2	3	4	5
My parent wants me to	1	2	3	4	5
My teacher wants me to	1	2	3	4	5
Whether or not I plan to go to college	1	2	3	4	5
How well I think I will do on the test	1	2	3	4	5
I want to test how much I learned	1	2	3	4	5
Other (Please write in your reason/s below) _____	1	2	3	4	5

5. Have you taken other AP classes before this year? If so which ones?

6. What are your plans after you graduate? Check all that apply:

- Get a job
- Go to college
- Join the military
- I don't know
- Other: _____

Beginning of the Year Student Survey, 2012-2013 3

Tell us about yourself

7. How many people do you know have gone to or are in college?

- ○ 0
- ○ 1-5
- ○ 6-10
- ○ More than 10

8. Who do you know who has gone to college or is in college now? Check all that apply:

- ○ Parent or Grandparent
- ○ Brother or Sister
- ○ Cousin or other relative
- ○ Close friends
- ○ Other people I know

9. How many students in your school do you think will attend college?

- ○ Almost everyone
- ○ More than half
- ○ Half
- ○ Less than half
- ○ Almost no one

10. Does your school help students prepare for college? If so, how?

13. I think this class will prepare me for after graduation by:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Helping me earn college credit	1	2	3	4	5
Teaching me skills and knowledge needed for college	1	2	3	4	5
Preparing me to handle a college workload	1	2	3	4	5
Helping me learn to read and write at a college level	1	2	3	4	5
Helping me to make informed decisions about the environment	1	2	3	4	5
Helping me understand how the environment works	1	2	3	4	5
Teaching me how to live more sustainably	1	2	3	4	5

Beginning of the Year Student Survey, 2012-2013 4

Tell us about yourself

11.Have any of your teachers talked about college in your classes? If so, share some examples.

12. Have any of your teachers talked with you personally about college? If so, share some examples.

14. Rate the following statements from 1 (Strongly Disagree) to 5 (Strongly Agree):

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I will use the things I learn in this class in the real world.	1	2	3	4	5
This class will help me learn things I need for college.	1	2	3	4	5
I am good at answering questions on tests where I have to write out answers.	1	2	3	4	5
I learn best when I get to discuss ideas with other students.	1	2	3	4	5
I learn best from lectures and PowerPoints.	1	2	3	4	5
I learn best from textbooks.	1	2	3	4	5
I like to read outside of school	1	2	3	4	5
I learn best through doing real-world projects	1	2	3	4	5
Most kids in my school talk a lot about college .	1	2	3	4	5
Most of the teachers in my school talk to students about college.	1	2	3	4	5
Most of my high school science textbooks are hard to understand	1	2	3	4	5

More About You

15. To the best of your knowledge, what is the highest level of schooling that your mother has completed?

- No school
- Elementary school
- Middle school/Junior high school
- Some high school
- Graduated high school
- Some college or technical school
- Graduated college
- Advanced degree (for example, MA, MS, PhD, MD, JD)

16. Were your parents born in the United States or another country?

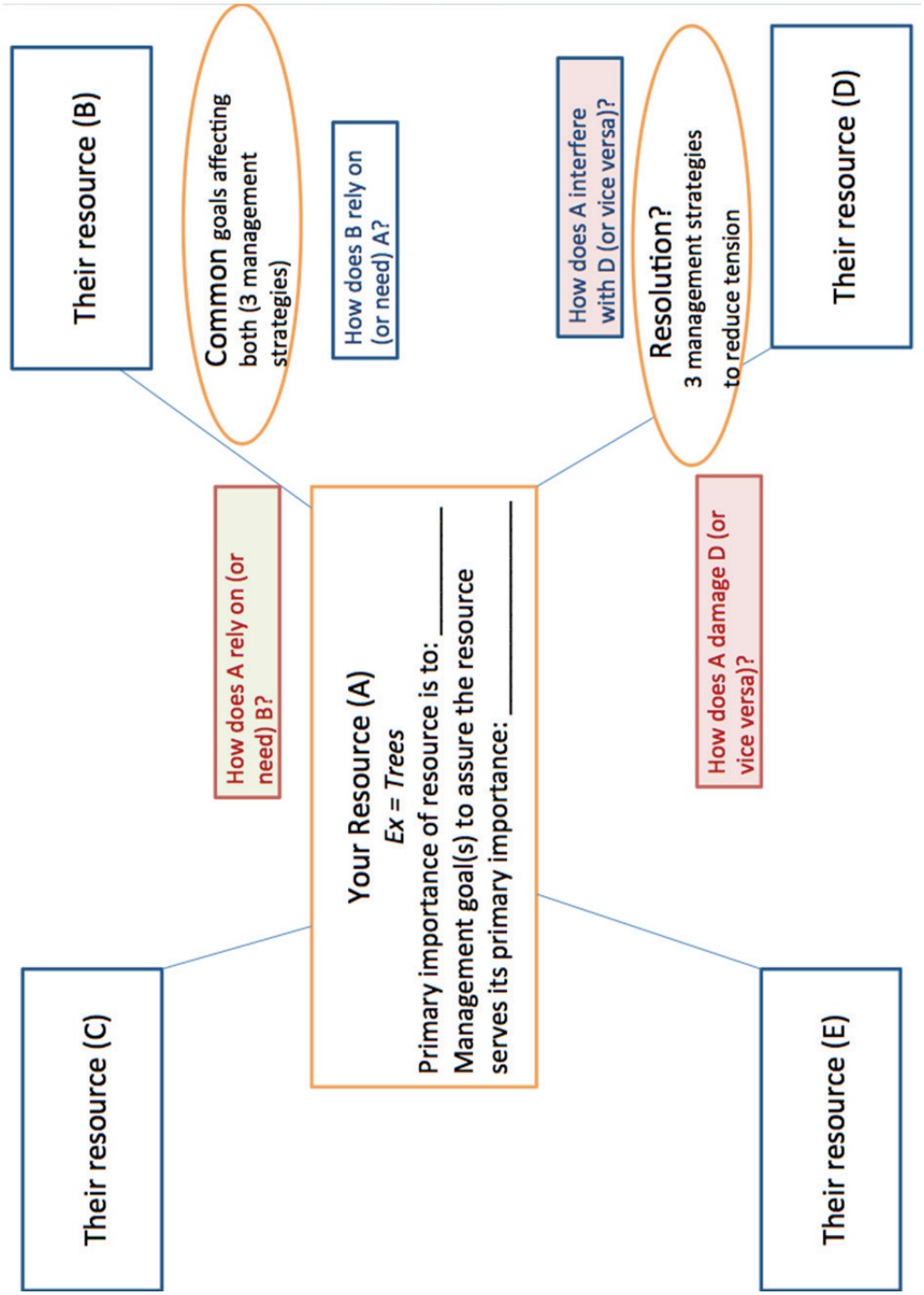
- ○Both in US
- ○One in US, one in another country
- ○Both in another country
- ○Don't know

17. How often do people in your home speak to each other in a language other than English?

- ○Never
- ○Once in a while
- ○About half the time
- ○All or most of the time

Appendix G.

Day 2 Map PowerPoint Slide[16]



[16] This PowerPoint slide was co-created by the two focal teachers, Shila and Terry.

Appendix H.

Codes Table

Theory (definition)	Codes	Connection to the Dataset
Productive Disciplinary Engagement		Engle & Conant (2002) Engle (2012)
• Engagement (6 criteria)		Students in both classes were engaged (meet all 6 engagement criteria). See engagement table for details.
• Productive Engagement (makes progress)		Students in both classes were engaged productively, but not necessarily in the discipline. See PDE description below for more details.
• Disciplinary Engagement (engages in disciplinary practices)	Role of CONTRIBUTOR Role of CRITIQUER Connection with NATURE/evidence Addressivity to Scientific COMMUNITY	All students discussed science content (related to their state resource), but only Shila's students used both the Contributor and Critiquer Roles in addition to prompting each other for evidence from nature to support questionable knowledge claims (associated with science practices).
• PDE (makes progress using disciplinary practices)	Overlap of **productive engagement** and **disciplinary engagement** codes	Shila's students were PDE while Terry's students were PE. Students in both classes were engaged productively, but not necessarily in the discipline. One class of students (Terry's) was primarily productive in relation to completing school tasks, while the other class of students (Shila's) was productive both in terms of completing tasks and making progress with their descriptions of disciplinary content (using disciplinary roles).

Theory (definition)	Codes	Connection to the Dataset
4 supports for PDE		The more supportive the T and classroom environment are of these 4 things, the more likely students will exhibit characteristics of PDE.
• 1. Authority (T or S or aspects of the discipline: nature/evidence or scientific community)	Authoritative discourse (T authority) OR Dialogic discourse (S authority)	*Connection to "promoting student authority" in Framing for Transfer theory.* When the teacher used dialogic discourse to promote student authority rather than teacher authority, the students transferred more adaptively than when the teacher used authoritative discourse to promote hers own authority.
• 2. Accountability (to T or other S or the discipline of science)	Authoritative discourse (acct'y to T) OR Dialogic discourse (acct'y to other S or the discipline)	*Connection to "promoting student authority" in Framing for Transfer theory.* When the teacher used dialogic discourse to promote student accountability to other students or the discipline, the students transferred more adaptively than when the teacher used authoritative discourse to promote accountability to herself.
• 3. Problematizing ("problematizing is any individual or collective action that encourages disciplinary uncertainties" (Engle, 2012, p. 168).	Role of CRITIQUER (S) Role of CRITIQUER (T)	**Part of the curriculum**: The Map activity on Day 2 included an aspect of conflict resolution, where students (as resource managers) were asked to resolve potential conflicts between their management goals. However, Shila emphasized making connections and resolving conflicts between groups on Day 2, while Terry de-emphasized connections and resolutions, calling them the most difficult part of the assignment. In **Shila's class**, students problematized each other's descriptions of scientific content (using the scientific Role of Critiquer) on both days. In **Terry's class**, students rarely problematized each other's descriptions of science content, relying on the teacher to take-up this Role.
• 4. Resources (time on task & material resources)		Time = highly similar Material Resources = highly similar (but not framed the same way – see inclusion of material resources in Framing for Transfer theory)

Theory (definition)	Codes	Connection to the Dataset
Framing for Transfer		Engle et al. (2012)
Aspects of Social Contexts		
• 1. Time	T references past/present or future times	= expansive framing of time
• 2. Place	T references past/present or future places	= expansive framing of place
• 3. Participants	T references past/present or future people	= expansive framing of participants
• 4. Roles	Student Role = bounded Resource Manager Role = expansive Disciplinary Role = expansive Role of CONTRIBUTOR Role of CRITIQUER	**Expansive** (associated with disciplinary practices) or **Bounded** (associated with classroom practices) Shila's students engaged in the practices of the discipline of science: contributing, critiquing, and supporting arguments with evidence from their own experiences (and references to nature).

Theory (definition)	Codes	Connection to the Dataset
• 5. Material Resources	Document (Day 1) • "Handout" • "Sheet" • "Worksheet" • "Tool" • Side 2 • T talks about Document • S asks question about Document (unrelated to content) Map (Day 2) • "Concept Map" • "Paper" • "Poster" • T talks about Map • S asks question about Map (unrelated to content) Fact Sheet PowerPoint Scratch paper (Day 1 warm-up) T talks about collecting/not collecting T talks about S making up/not making up	**Expansive** (associated with disciplinary practices) or **Bounded** (associated with classroom practices) Both teachers reference past/present or future resources, talking about how the Document is useful for supporting their Day 2 conversation with other resource groups (expansive). The terms in quotes were the ways the teachers **named** the two primary material resources (the Document and the Map): terms related to schooling were more bounded. The teachers talked about either **collecting** (bounded) or not collecting (expansive) the Document from Day 1. The teachers asked students on Day 2 to either **make up** (bounded) or not make up (expansive) the Document from Day 1. Shila **reviewed** side 2 the Document at the end of Day 1, making students accountable to each other for finishing side 2 by the end of class on Day 1 (expansive). Terry reviewed side 2 of the Document in class on Day 2, making the students accountable to her for completing the document to turn into her by the end of class on Day 2 (even though it would no longer help them prepare for the Day 2 activities – the purpose of the Document) (bounded). Shila did not *prolong work on* the Document, stopping students from editing it in class on Day 2 (expansive). Terry either did not notice or purposefully did not stop students from working on the Document during class on Day 2 (bounded)
Methods of Framing		
• Connecting Settings	T references past/present or future times, places, people, and/or material resources	Teacher framed one or more of the aspects of the context in an expansive way (time, place, participants, and/or materials).
• Promoting Student Authorship	Dialogic discourse (S authority and accountability)	*Connection to "authority" and "accountability" in PDE theory.* Indicated by teacher using dialogic discourse.

Theory (definition)	Codes	Connection to the Dataset
Types of Transfer		Bransford et al. (2000) Engle et al. (2012)
Transfer		Transfer of disciplinary content
Adaptive transfer	Overlap of **Transfer** and **Critiquer Role** codes, followed by a strengthening or change of the Contributor's knowledge claim.	
Negative transfer		Tracked in case students were consistently transferring negatively (as a potential difference between the classes). This was not the case.
Discourse Theory		Scott et al. (2006)
Authoritative Discourse	• authority of T is clear • T prescribes direction of discourse • T acts as gatekeeper to points of view • T ignores or rejects S ideas • T reshapes S ideas • T asks instructional questions • T checks and corrects • T constrains direction of discourse to avoid dispersion	Terry primarily used this type of discourse with her students.
Dialogic Discourse	• T assumes a neutral position • T avoids evaluative comments • T incites greater S-T symmetry • T prompts S contributions • T seeks clarification and further elaboration • T asks genuine questions • T probes S understandings • T compares and contrasts different perspectives • T encourages initiation of ideas by students	Shila primarily used this type of discourse with her students.

Theory (definition)	Codes	Connection to the Dataset
Episodes	Teacher Episodes (when teacher interacted with a resource group, the focal group, an individual student, a researcher, the whole class, or the student teacher)	
	Student Episodes (when the students talk to their resource partners, to other resource groups, to the teacher and to the whole class)	
	Terry Focal Group (for teacher videos)	
	Shila Focal Group (for teacher videos)	

Appendix I.

Transcription Conventions

MS = Male Student

FS = Female Student

a word with- (dash at the end) = speaker stopped talking abruptly at the location of the dash

(comment) = comments in parentheses describe actions visible in the video during transcription of the spoken language

(?) indicates unclear speech

Appendix J.

Comparative Case Tables

Table J1 and Table J2 provide a brief comparison of the two classrooms across the two days of data collection. These tables serve to organize and point out similarities and differences across the two classrooms that are expanded upon in Chapter 6.

Table J1. Comparative Data Analysis Table: Day 1

Day 1	Teacher 1: Shila	Teacher 2: Terry
1. Warm-up	Shila checked that the resource groups completed and remembered their fact sheet via a warm-up.	Terry checked that the resource groups completed and remembered their fact sheet via a warm-up.
2. Warm-up Share Out	Shila had all fourteen of the available resource groups share their summaries in the whole class setting, structuring their reports, but not critiquing them.	Terry checked-in with five of the fourteen student groups in the whole class setting, re-stating their findings and evaluating them for correctness.
3. Day 1 Document Intro	Shila segued into the Day 1 Document activity by making connections with the fact sheet and with the Day 2 activity (3 minutes). She had the students read over the Document in their groups (2.5 minutes), then came back together as a whole class to field questions before starting work on the Document (4 minutes).	Terry segued into the Day 1 Document activity by giving examples about the content of the Document. She spent about nine minutes going through the Document with the students (P2, 24:22-33:11), taking questions along the way.
4. Day 1 Document Group Work Time	Shila noticed while circulating that not all students were completing side 2 of the Document, so she arranged for an end-of-class report-out when six groups shared content from side 2 with the whole class.	Terry circulated and interacted with individual students and resource groups for the rest of class time. She noticed that students were not completing side 2 of the Document, but did not alter the day's plan.

Note. This table shows a comparison between activities in the two classrooms on the first day of data collection.

Table J2. Comparative Data Analysis Table: Day 2

Day 2	Teacher 1: Shila	Teacher 2: Terry
1. Review Day 1 Document	Shila used review time to begin work on the Day 2 Map, having students write their resource name and management goals on post-its to put on the center of their Map.	Terry spent a few minutes (2.5) reviewing the Day 1 Document and going over how to answer the questions on side 2.
2. Teacher restated whether or not she planned to collect the Document	Right after giving the directions for completing the Map, Shila told a resource group not to edit the Day 1 Document because it was just to prepare them for Day 2.	After reviewing side 2, Terry told students they would turn the Document in for both her and the researcher to look at.
3. Students prepared to talk with other resource groups	Greg & Nate quickly referred to their Day 1 Documents and agreed that they wanted to talk to the tree group first. They got up and located the tree group right away.	Bree & Rae spent 10 minutes deciding who to talk to, talking to Terry, and then adding logging to their management goals before a group approached them to talk about the Day 2 Map.
4. Students met with other resource groups	Greg & Nate talked with five groups and wrote about three of them on their concept map.	Bree & Rae talked with 4 groups and wrote about all of them on their concept map. Rae worked primarily on the Day 1 Document side 2 while Bree completed the Day 2 Map.

Note. This table shows a comparison between activities in the two classrooms on the second day of data collection.

Appendix K.

Student Engagement Table

"Evidence for student engagement can best be seen by analyzing students' discourse" (Engle & Conant, 2002, p. 402).

Student Engagement	Teacher 1: Shila	Teacher 2: Terry
A. "More students in the group sought to make, and made, substantive contributions to the topic under discussion" (Engle, 2012, p. 164)	Greg: salmon as adversaries (Day 1 warm up): "Nate: What's something about salmon? Greg: Oh um, so fires like when they burn plants, they like kill the plants and it causes erosion (Nate: oh right) because the plants are right? and then it erodes into like rivers. Nate: Alright, true. Greg: It decreases the quality of the water, which is detrimental to salmon" (P3, 10:45). Nate: fires as beneficial for trees (primary argument, Days 1 and 2): "N: So, (looks at paper) Oh. Oh yeah. Except, we did- say [adversaries are] native plants, because they don't really burn down trees very much. G: yeah they do. N: No, they don't" (P3, 38:00)	Rae- relationship between trees and small mammals: "Rae: I said (reads from paper) small mammals use trees for shelter slash, I meant to say like homes but I said live (laughs) uh and (Bree: oh yeah) bring salmon for nutrients" (P1: 36:00) Bree - why trees are important: "Bree: Ahh, habitat, um, habitats for other animals (Rae is writing), and biodiversity in forests, and for salmon, they shade river beds so it's cool enough and um, they prevent erosion and filter out, like, so sediments don't go in the river and like pollute it" (P1, 13:00)
B. "Students' contributions were more often made in coordination with each other, rather than independently of each other (Barron, 2000; Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001)" (Engle, 2012, p. 164)	Greg and Nate: FSO: fires just like ruin everything Greg: ehhh Nate: no, they don't (arms crossed while FSsitting is copying their post-its?) Greg: they're good for ecosystems Nate: they're like good for trees FSH: they're good for like new trees to grow Nate: they're good for old trees- Greg: yeah, they're good for standing trees- Nate: and we don't really destroy your habitat, we just burn the understory (P7, 43:51)	Bree and Rae: Rae: So then, watershed (looks over at Bree while she's writing). Clean water for trees. Bree: (?) and trees like help watersheds (makes a face) Rae: Is it a river or is it like a shed where they have captured the water (both laugh). Bree: Definitely not (Rae laughs). No, I think it's like the surrounding area of like a body of water. (P1, 37:00)

Student Engagement	Teacher 1: Shila	Teacher 2: Terry
C. “Few students were involved in unrelated ‘off-task’ activities” (Engle, 2012, p. 164). Examples of students quickly re-focusing on the task when faced with a distraction from another student.	Male Student A visits and gives Nate & Greg stars: You’re a star Greg. You're a star, too, Nate. Greg: Do you want to say something to the mic? I'm on a mic (?). Nate: What are you [MSA]? MSA: Aquatic organisms or animals or organisms. (Nate: Oh.) Greg (looking at Nate): Wait, we don’t have any relationship with them because fires can’t go under water (Nate laughs) Boy, diiiaaaang. Ok, um (both look at paper). (P1, 36:24-36:49)	Rae (to Bree): Yeah write that down. No mining by rivers, that means we have an agreement with mining. Rae and Female Student R talk about the name of another student. FSR: Uh, so another solution to prevent erosion would be selective harvesting which you’re planning on doing, right? (P5, 45:53-46:15)
D. “Students were attending to each other as assessed by alignment of eye gaze and body positioning (McDermott, Gospodinoff, & Aron, 1978; Schultz, Florio, & Erickson, 1982)” (Engle, 2012, p. 164).	Nate: (looks up from writing, at Greg) What's something about salmon? Greg: (stops looking at papers) Oh um, so fires like when they burn plants (looks at Greg), they like kill the plants and it causes erosion (Nate: oh right) because the plants are- right? And then it erodes into like rivers. Nate (nods): True. Alright, cool (writes). Greg: It decreases the quality of the water, which is detrimental to salmon. (P3, 11:15)	Bree: So (both write on handout) Rae: And what, like biodiversity? (looks at Bree, doesn’t write until she responds) Bree: Um Rae: Like, not just all the same kind of tree? Bree: Yeah (both write) (P1, 30:43)

Student Engagement	Teacher 1: Shila	Teacher 2: Terry
E. "Students often expressed passionate involvement by making emotional displays (Tannen, 1989)" (Engle, 2012, p. 164).	Nate: What're you guys? Female Student LM: We're large mammals. Nate: Oh. Are we bad? We're not bad to you. FSLM: No, you're definitely bad. Nate: No we're not, trust me. Female Student SI: You like kill our homes. Nate: I know (Greg: sort of). We also rejuvenate your house. Female Student HT: And some of our like food source, too, because some of the mammals that require (?) (Greg: Yeah) like deers, so, you kill off our food source. Greg: Yeah, sometimes- if forests are not controlled, they're just- FSLM: Fires just like ruin everything Greg: Ehhh Nate: No, they don't (arms crossed). Greg: They're good for ecosystems. Nate: They're like good for trees. (P7, 43:20)	Bree: Where mostly is your mining? Like, is it- Female Student R: We're streams and open pit Bree: Streams? FSR: Streams (laughs) Bree (shakes head): That's just not going to happen FSR: Open pit. We've got to lot of shit going on. (Female Student L: Surface mining) Surface mining. FSL: Underground mining. Rae: Yeah, we just don't want you guys anywhere near our forests. (P5, 44:02)
F. "Students spontaneously got reengaged in the topic and continued being engaged in it over a long period of time. (Engle & Conant, 2002, p. 402)" (Engle, 2012, p. 164).	See the example from C for spontaneous reengagement. "Long period of time" is not applicable in this dataset, as it only covers a period of 2 days.	See the example from C for spontaneous reengagement. "Long period of time" is not applicable in this dataset, as it only covers a period of 2 days.