The Iterative Design of Professional Development to Impact Teacher Knowledge, Beliefs and Practices

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Project READI operated as a multi-institution collaboration among the Learning Sciences Research Institute, University of Illinois at Chicago; Northern Illinois University; Northwestern University; WestEd's Strategic Literacy Initiative; and Inquirium, LLC. Project READI developed and researched interventions in collaboration with classroom teachers that were designed to improve reading comprehension through argumentation from multiple sources in literature, history, and the sciences appropriate for adolescent learners. Curriculum materials in the READI modules were developed based on enacted instruction and are intended as case examples of the READI approach to deep and meaningful disciplinary literacy and learning.

Introduction

The development of professional learning designs was a significant strand of work in Project READI. Project READI activities built on the understanding that teachers mediate student learning. Therefore, in parallel with the development pedagogies and tools for students' disciplinary reading – reading multiple texts to engage in disciplinary argument – from the outset we knew it was critical to develop professional learning experiences for teachers that would enable them to mediate powerful learning opportunities for their students.

In this report, we detail how READI professional development inquiries evolved from preexisting resources and inquiries developed through design based research processes by the Strategic Literacy Initiative at WestEd, how we incorporated READI learning objectives and curricular resources to leverage and refine these PD inquiry approaches and tools, and how we integrated these inquiries into a professional learning sequence implemented to impact teacher practice and student learning outcomes in the RCT conducted in the final years of the project.[1] Specifically, we detail how the learning environment of the California Teacher Inquiry Network created a design space for the development, enactment, documentation and refinement of new learning engagements to support growth in the teacher knowledge, beliefs, and practices required to support engaged reading and argumentation from multiple sources in disciplinary instruction.

Reading Apprenticeship Overview

Developed by WestEd's Strategic Literacy Initiative (SLI) through multiple R&D cycles spanning more than two decades, Reading Apprenticeship is a model of academic literacy instruction designed to improve literacy skills and academic achievement for all students. While predating current literacy reform efforts, Reading Apprenticeship is aligned with the principles of reform initiatives that specify advanced literacy skills and understandings critical for college and career readiness across the content areas. In particular, teachers across the subject areas learn how to build students' capacities to carry out close, intellectually engaged reading, make meaning, acquire academic and disciplinary language and literacy practices, read independently, and set personal goals for literacy development.

Based on understandings of the close relationship between curricular reform and teacher professional development (Heller & Greenleaf, 2007), Reading Apprenticeship components include both an instructional framework and associated PD model for teachers across the academic subject areas. Guided by the instructional framework (Schoenbach, Greenleaf, & Murphy, 2012), reading instruction is integrated into subject area teaching, rather than being an instructional add-on or additional curriculum. Students are given extended opportunities to read

[1]The authors would like to acknowledge collaborations with Mo-Lin Monica Ko, MariAnne George, Julia Emig, Stacy Marple and Susan Goldman in the development of the professional development sequence and support offered to science teachers during the efficacy study of the READI approach in 9th grade biological sciences.

with instructional support, both in assigned texts and in curriculum-related materials of choice, both during class time and as homework. Through an "apprenticeship" process, subject area teachers learn to explicitly teach students the tacit reasoning processes, strategies, and discourse rules that shape successful readers' and writers' work in their disciplines. Importantly, the framework focuses attention on the learning dispositions necessary for adolescents to engage in focused intellectual work with complex texts; building intellectual and affective engagement, stamina, perseverance, and "code-breaking" stances through new classroom culture and norms. Metacognitive instructional routines help students to clarify content, discuss the processes they use in reading and problem-solving, practice comprehension strategies in the context of meaningful learning, respond to and elaborate on content, engage in word learning strategies, write to learn and to consolidate learning, and make connections to other related texts.

Mirroring the instructional framework, Reading Apprenticeship PD has been designed to transform teachers' understanding of their role in adolescent literacy development and build teachers' generative capacity for literacy instruction in the academic disciplines (Greenleaf & Schoenbach, 2004). The PD is inquiry-based, subject area focused, and designed to address teachers' conceptual understandings as well as practical implementation needs. Teachers participate in carefully designed inquiries to help them unlock their own disciplinary expertise in relation to literacy. They learn to identify the features of disciplinary texts that might present stumbling blocks to learners. In PD sessions, they learn and practice with classroom routines to make thinking processes visible, build student engagement, support student collaboration, and foster authentic discussion and problem solving around course texts. They learn to select texts for instruction and build content-linked text sets to offer a range of genres and challenge levels representative of their disciplines. Importantly, they explore and examine expectations of what their students can accomplish and learn new ways to support students' thinking and learning with academic materials. Teachers learn to attend to students' affective and identity issues, creating relevant and affectively safe learning opportunities that help students become better disposed to engage in academic tasks, discipline-based literacy practices, and inquiry, and to develop identities as resilient learners.

In contrast to a conception of teaching as fidelity to pre-existing instructional strategies, the model is based on an understanding that for practice to become truly responsive to the learner needs and varied contexts of teachers' work, teachers must become adaptive and generative in their use of specific practices (Gillis, 2014). By flexibly adapting Reading Apprenticeship ideas and practices to their specific circumstances, teachers' efforts focus on transforming their classrooms into engaging learning spaces where students participate actively and increasingly take on the intellectual work.

Design Research for Professional Development

The Strategic Literacy Initiative developed the Reading Apprenticeship model through a recursive process of research and development that has spanned over two decades. The Reading Apprenticeship Instructional Framework was piloted in 1995 in an academic literacy course required of all ninth grade students at San Francisco's Thurgood Marshall Academic High School. By the end of the pilot year, reading scores for those students had jumped more than two grade levels on a nationally normed reading test. Since that time, SLI has engaged in iterative design research to develop and disseminate Reading Apprenticeship advancing both the instructional model and the professional development model supporting teacher knowledge growth in the teaching and learning of the complex literacies instantiated in the instructional framework.

The READI PD design work drew on design principles for teacher professional learning developed by the Strategic Literacy Initiative through this iterative process of theory-based design, implementation, study, and refinement (Greenleaf, Litman, et al., 2011; Greenleaf & Schoenbach, 2001, 2004) (Greenleaf, 2001; Greenleaf & Schoenbach, 2004; Greenleaf et al., 2011). Professional learning engagements aim to develop a deep reservoir of knowledge and experience to inform teachers' orchestration and navigation of teaching and learning in the dynamic flow of the classroom (Ball & Cohen, 1999; Hashweh, 2013). Specific goals for teacher learning undergird the design of these learning activities in the professional developing setting, including developing generative, experiential knowledge about reading and texts in their disciplines, developing insight into learners and learning, developing strategic repertoire and conditional knowledge about when particular instructional strategies might be of use, and developing professional judgment (Greenleaf & Schoenbach, 2004). These design principles are rooted in the theory and practices underlying the Reading Apprenticeship Instructional Framework (Greenleaf, Schoenbach, Cziko, & Mueller, 2001; Schoenbach et al., 2012) (Greenleaf, et al., 2001; Schoenbach, Greenleaf, & Murphy, 2012).

At the center of the framework is metacognitive conversation that positions learning as ongoing collaborative inquiry: about learning itself, about texts, about reading and reasoning processes, about literacy and learning tasks, about information, about dispositions and motivations that support and/or undercut learning, and so forth (Greenleaf et al., 2001; Heller & Greenleaf, 2007) (Greenleaf, et al., 2001; 2007). Much of what we understand as skillful reading takes place mentally, hidden from view, and is therefore difficult for students to acquire. However, as experienced adult readers, classroom teachers can provide models and guidance to students once teachers are able to tap into and articulate their own reading practices and engage students in classroom routines that support cognitive apprenticeships in reading (See Lee, 1995). Ongoing metacognitive conversation makes the work of comprehending complex text visible to learners, normalizing the struggle to make meaning and thereby building students' willingness to identify sources of confusion, expend effort toward solving problems, and shift their conceptions of reading, of learning, and of their own capacities (Walsh, 2002). Further, by engaging in metacognitive conversation in a community of other learners, the Reading Apprenticeship instructional framework aims to galvanize students to engage in collaborative sense-making and problem solving, gaining a sense of their own resources and enlarging their strategic repertoires by learning about the problem solving strategies of others.

Metacognitive conversation as a means of making thinking visible and collaborative applies equally to teaching. By engaging teachers in repeated opportunities to reflect on their own teaching, share their teaching successes and dilemmas with others, and capture the insights of their colleagues, we aim to foster ongoing learning from practice(Van Driel & Berry, 2012) as well as to promote an inquiry stance toward teaching. At the same time, we work to normalize the complex, ongoing struggle and problem solving that teaching in response to diverse learners demands. Instruction that lays bare the struggles, complexities, false starts, and partial successes of teachers and learners is risky. It relies on generating a learning environment of mutual respect, where the resources and contributions of all are genuinely valued. This is the professional learning environment we seek to build and support in our work with teachers.

The Role of Inquiry in Teacher Professional Development

The design of Reading Apprenticeship professional development reflects the knowledge base about effective teacher professional development. Leaders in teacher education have long promoted an inquiry stance toward teaching, with teachers learning in and from practice by documenting and reflecting on their work and the responses of their students (Anderson & Herr, 2011; Cochran-Smith & Lytle, 1996; Kennedy, 2016, 2016; Schon, 1984; Stenhouse, 1981). A recent meta-analysis of experimental studies of professional development published in *Review of Educational Research* suggests that inquiry pedagogy may be the most important element of effective professional development (Kennedy, 2016). Specifically, regardless of the aspect of teaching they hoped to improve, professional development programs that facilitated enactment by intellectually engaging teachers with PD content and helping them translate new ideas into their own systems of practice were more likely to increase student achievement than PD models that offered prescriptions or presented bodies of knowledge.[2]

In addition to engaging in these ways with PD content, professional development must engage teachers in inquiry around pedagogical practices: in “reading” students to know more about what they are thinking and learning, in examining perhaps longstanding beliefs and assumptions about learning, and in gaining a repertoire of teaching practice that enables teachers to anticipate many likely responses students will have to particular assignments and classroom situations (Ball &

[2]Reading Apprenticeship was among the effective PD programs included in the meta-analysis.

Cohen, 1999). Thus, to navigate the complexities of teaching, teachers need generative professional knowledge — knowledge that allows them to generate effective responses to students' thinking in the moment of teaching. Building teachers' deep understandings of how students learn particular subject matter through ongoing inquiries into literacy tasks, student work, and the like will be more effective than professional development focused on teaching technique alone.

Inquiry-Based Professional Development for Literacy

At its core then, the Reading Apprenticeship approach to professional development is a series of inquiries that focus teacher learning in areas we have found are key to strengthening literacy instruction in the academic disciplines. First, from long experience we know that many secondary and post-secondary teachers view reading as a basic skill, one that students should have mastered before arriving in their classrooms, rather than a highly complex set of knowledge and reasoning practices within disciplines. Relatedly, because teachers are frequently very familiar with the texts they teach from, they may have "expert blind spots" that prevent them from seeing the complexities and stumbling blocks these texts present to learners. Third when students fail to meet teachers' expectations of their understandings and work with disciplinary texts, teachers may describe students' failings as a lack of critical thinking skills or an absence of interpretive facility when, in fact, these students merely lack experience with disciplinary practices and texts. Fourth, some concerned teachers believe texts present only barriers rather than opportunities for learning and thus actively avoid the text as much as possible, finding other means to deliver content to students. Finally, having rarely seen their students exhibit facility with complex texts or keen insights into text meaning, many teachers from across the academic spectrum harbor perhaps secret beliefs that their students are simply not up to the academic tasks increasingly seen as necessary for college and careers.

To take on this set of understandable but nevertheless unproductive conceptions that many teachers hold, we have designed potent professional development inquiries to build teachers' generative and discipline-specific understanding of the nature of literacy, to build teachers' insights into student learning processes and assets as well as needs, and to build teachers' professional understanding and duration of varied teaching approaches and strategies.[3] A number of key principles undergird the designed inquiries: 1) that they target specific teacher learning outcomes vital to the transformation of classroom learning environments; 2) that they are enacted as models of instructional practice; 3) that they open spaces for teachers to respectfully voice and interactively interrogate multiple perspectives on texts, literacy, student performances, and

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[3] This work is described in brief in Greenleaf & Schoenbach, (2004) and in a forthcoming book on leadership in Reading Apprenticeship Schoenbach, Greenleaf, & Murphy, in press.

instructional strategies; 4) that they recognize and draw on teachers' passions and expertise, while building new knowledge, skill, and motivations for change; and 4) that while goal-driven, they maintain an active, inquiry orientation to support deeply experiential learning.

Though they may serve distinct purposes, Reading Apprenticeship PD inquiries are linked, or bundled, to serve multiple learning goals at once. Looking at student reading performance is never taken on without first having done a metacognitive close reading of the text(s) students read, as well as trying out any specific task with that text. Reading Process Analysis or Text and Task Analysis thus almost always accompany Analysis of Student Work. Reading Process Analysis is often done as a component of the Text and Task Analysis. These inquiries themselves often lead into opportunities to Analyze the Instructional Design of the experience as a model of a close reading/inquiry lesson, and then to Instructional Design and Reflections on Learning. Across a half or full day of learning, teachers thus enact larger inquiry cycles composed of these design elements that lead to their now more informed instructional planning and reflections.

Proven Impact of Inquiry-Based Professional Development

Multiple studies of the impact of Reading Apprenticeship inquiry-based professional development on teacher learning and classroom practice affirms this model of teaching and teacher learning. Teachers participating in Reading Apprenticeship PD make significant gains in classroom practices supporting disciplinary literacy compared to control group teachers (Fancsali et al., 2015; Greenleaf, Hanson, et al., 2011; Greenleaf, Litman, et al., 2011; Somers et al., 2010) (Greenleaf, et al., 2010; Greenleaf et al., 2011; Somers et al., 2012). A strong body of evidence also supports the effectiveness of RA in improving student academic outcomes. Several federally funded randomized control trials of Reading Apprenticeship professional development have found statistically significant gains on standardized test scores in reading comprehension, biology, U.S. history, and English language arts (Greenleaf, Hanson, et al., 2011; Greenleaf, Litman, et al., 2011; Somers et al., 2010). On many measures, students' scores were well over a year ahead of the control students. Results from these studies demonstrate that it is both possible and productive to reconceptualize the aims of teacher professional development not as fidelity to trained teaching approaches, but rather as generative knowledge development.

Collaborative Design Research through Teacher Inquiry Networks

Fundamental to this conception of teacher learning is a focus on teachers collaboratively generating meaning through "deep talk" that takes place over a relatively long period of time (Himley, 1991; Vescio, Ross, & Adams, 2008). We share these values and inclinations but also know that teachers have many demands on their time and attention. Pursuing one's own questions about instruction can lead to great insights, but the path may necessarily meander (Anderson & Herr, 2011). In reality, teachers rarely have the luxury of generating their own research projects, given the press of their many responsibilities. Furthermore, while numerous PD programs based on current theories of high-quality PD have been implemented, few PD programs have been expanded beyond the proof-of-concept phase, involving small numbers of teachers at a single site (Borko, Jacobs, & Koellner, 2010). Yet we believe all teachers, indeed all learners, can benefit from opportunities to reflect and inquire. Reading Apprenticeship addresses the tensions between high quality professional development and efficiency by using inquiries designed to raise key issues related to the kinds of literacy and pedagogical practices that to support students in becoming stronger readers and learners in the disciplines. To accomplish this, iteratively designed inquiries are honed through ongoing teacher-researcher collaboration to have predictable impact on teacher learning and practice, then disseminated more broadly.

The Reading Apprenticeship instructional framework and PD models are products of extended collaborative design research processes, informed by sociocultural learning theory and research in language and literacy development (Greenleaf & Schoenbach, 2004; Schoenbach et al., 2012). Over the 20+ year history of the Strategic Literacy Initiative, we have intentionally focused on new arenas in which to situate and instantiate the engaged, student-driven, metacognitive inquiry at the heart of the framework and thus develop and expand resources, tools, and approaches to an ever-growing set of circumstances. Working in the tradition of collaborative design-based research (Brown, 1992), this work has been carried out in collaboration with teachers through processes of joint inquiry into texts and tasks and instructional supports, collaborative design of routines and lessons, classroom try-outs and reflections, and documentation and examination of student work and learning, leading to renewed efforts and refinements.

In contrast to consumer models of implementation in which an intervention is delivered to teachers with the goal of having teachers execute it exactly as it was designed, collaborative design research positions teachers as co-designers in developing promising approach for building teachers' capacity for teaching complex literacies(Cviko, McKenney, & Voogt, 2014; Odom, 2008). Teachers in these collaborations work together with researchers to co-design, implement, and study the effects of educational innovations and how to make them work within authentic, richly complex contexts (Easton, 2014; Klingner, Boardman, & McMaster, 2013; Penuel, Fishman, Cheng, & Sabelli, 2011; Roderick, Easton, & Sebring, 2009; Voogt et al., 2015). By engaging teachers as knowledge generators alongside researchers in collaborative curriculum design teams, collaborative design research is oriented toward mutual adaptation (Penuel, Gallagher, & Moorthy, 2011) that helps ensure that instructional design is informed by teachers' experiences and expertise, and that the affordances, challenges, and issues teachers and students face when engaging with new instructional practices are not left as problems of scalability, but enter into the very early processes of designing curriculum reform (Voogt et al., 2015). Thus, collaborative design research simultaneously focuses on improving learning environments of classrooms and creating professional learning practices that support teachers in designing and implementing these reforms (Cviko et al., 2014; Ormel, Roblin, McKenney, Voogt, & Pieters, 2012; Penuel, Fishman, et al., 2011; Penuel, Gallagher, et al., 2011).

In our work, we call these SLI researcher-teacher collaborations for the purpose of co-learning *teacher inquiry networks*. Resources developed with teachers in these inquiry networks and iterated in PD contexts to have predictable impacts on teacher learning and practice are then disseminated more broadly. Through multiple R&D cycles, the scope of the work has expanded over time to address a broader set of contexts, grade levels, learner needs, subject areas, and literacy practices. Figure 1, Model System for Knowledge Development, captures this iterative and ongoing process of SLI knowledge development and dissemination, and the central role of engagement with communities of practice in this cycle.

Below we describe how this ongoing collaborative design work has shaped the development of Reading Apprenticeship tools and professional development in science and set the stage for the latest iteration of science R&D utilized in the READI Efficacy Study. The Project READI[4] Efficacy Study was a randomized control trial (RCT) of the effectiveness of an intervention for improving student performance related to Project READI Science Learning Objectives. The semester-long READI intervention targeted students' literacy and science practices through inquiry tasks consistent with the Next Generation Science Standards. Specifically, the intervention combined teacher professional development with text-based investigation modules aimed at supporting students in building knowledge and skills for close reading, cross-text synthesis, explanation and model-building, and argumentation around biological phenomena.[5]

The professional development for the RCT drew on the READI team experience in developing ongoing professional learning communities. In addition, the content of the designed professional development in the READI Efficacy Study was based on the Reading Apprenticeship teacher professional development (PD) inquiry-based model. As part of Project READI, building on prior work developing and testing inquiry-based PD (Greenleaf, Litman, et al., 2011; Greenleaf, Brown, & Litman, 2004), the Strategic Literacy Initiative carried out a program of design research focused on developing and enacting PD inquiries to build teachers' understanding and

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[5] We focused on 9th grade biology because our survey of literature, history, and science curriculum indicated that biology in 9th grade was the most consistently taught course in area schools. Therefore, we determined that we had the highest likelihood of obtaining a sample size with sufficient power to detect effects of the treatment for this grade and subject area. Furthermore, the science text based investigation modules showed considerable promise in the development studies. [See Project READI Technical Reports: #17 Designing Text-Based Investigations in Science, #20 MRSA HS, #21 MRSA MS, #23 Homeostasis, #19 Water]

appreciation of the importance of close reading, cross-text synthesis, explanation and model-building, and argumentation for science learning.

Designing Professional Development for Science Teaching and Learning

As mentioned previously, the Strategic Literacy Initiative began in 1995, evolving from an earlier project for the San Francisco school district to improve high school students' oral and written language. A network of Bay Area middle and high school interdisciplinary teams helped to further develop and test this emerging model of Reading Apprenticeship. Local Bay Area Reading Apprenticeship professional development networks included science teachers from 1997 onward. Inquiries into reading processes, carried out both within and across subject areas, were designed to underscored contrasts in the reading processes employed by skilled readers in the different disciplines, including science readers (See Greenleaf, 2006; Schoenbach, Greenleaf, Cziko, & Hurwitz, 1999, Chapter 9).

In order to build new tools and approaches for broader science dissemination, in 2002 SLI engaged a group of experienced Reading Apprenticeship science teachers and resource personnel in a year-long inquiry network focused on how they implemented Reading Apprenticeship in their classrooms and what they found effective and compelling in Reading Apprenticeship professional development. A collaboration with the K-12 Alliance, a program within WestEd's Mathematics, Science, & Technology Program, afforded further development of Reading Apprenticeship professional development in science. In 2003-2004, SLI and the K-12 Alliance developed and implemented discipline-specific PD for middle and high school science teachers through the Literacy in Science Academy.

Drawing on this abundant experience, in 2005 SLI developed a curriculum module on Reading Science that instantiated a set of science-specific literacy goals as part of the federally funded Enhanced Reading Opportunities (ERO) evaluation study of the 9^{th} grade Reading Apprenticeship Academic Literacy (RAAL) course (Corrin, Somers, Kemple, Nelson, & Sepanik, 2008; Somers et al., 2010). The Reading Science unit included modeling and explanation tasks that drew on multiple sources of information and data, as well as the range of representations used in science communications. Professional development and coaching was a key component of the ERO study of RAAL. The evaluation study found that enrollment in the RAAL course improved students' reading comprehension skills and also had a positive impact on students' academic performance in core subject areas over the course of ninth grade.

The next significant growth in Reading Apprenticeship science PD occurred in the context of two large, multi-year studies funded by the National Science Foundation (NSF) (2005-2008) and the U.S. Department of Education Institute of Education Sciences (IES) (2007-2010). As part of these randomized controlled studies of Reading Apprenticeship in science and history, beginning in 2005, SLI developed and delivered a 10-Day Reading Apprenticeship PD model focused solely on science(Hale, 2009, 2011) The resources developed through these studies provided the foundation for a Bay Area Network PD series (BANS, 2008-2012), in which up to 85% of professional development delivered to teachers was subject specific.

Lessons learned in NSF, IES and BANS PD informed the next iteration of SLI PD design in science, which occurred during a validation study funded by the US Department of Education through its Investing in Innovations program: Reading Apprenticeship in Secondary Education (RAISE, 2010-2015). While RAISE overlapped Project READI substantially, design work and implementation of RAISE PD predated READI RCT PD development, and we were able to draw on the RAISE designs for Project READI.

In developing approaches for the Project READI science work in general, and the READI Efficacy Study in particular, we therefore drew on our long history of design work around Reading Apprenticeship PD in science, including many of the PD designs and teacher resources developed during earlier iterations of the work.[6] Below we trace this legacy from Reading Apprenticeship professional development and collaborative design work to the design of the READI Efficacy Study PD.

Leveraging Reading Apprenticeship Design Principles for Project READI

For Project READI, we applied SLI's design principles for teacher professional learning described above to the problem of engaging students in reading and inquiry across multiple discipline-specific texts for the purpose of making and supporting arguments that were literary, historical, or scientific in nature. This design work occurred substantially through two teacher-researcher collaboration processes: a teacher inquiry network and teacher-researcher partnerships focused on co-designing instructional materials and approaches for supporting text-based argumentation from multiple sources.

First, as is typical of our iterative design research, in Year 1 of the project, SLI convened a teacher inquiry network (TIN) of experienced Reading Apprenticeship middle and high school English language arts, history/social studies, and science teachers. The culture of the TIN was deliberately one of co-learning: "What are we learning about how to support students to engage in evidence-based argumentation (E-BA) from multiple text sources?" was a central question and repeated conversation that marked our work as a shared learning enterprise. In response to conceptual and pedagogical challenges posed by our TIN colleagues, we designed specific

[6] For example, the "How Things Fall" inquiry used in the READI Efficacy Study (see p. 19-23 below) had its origins in a Reading Apprenticeship PD inquiry designed in 2008 to underscore the connection between reading and science inquiries. Similarly, the MRSA module used in the efficacy study had its origins in SLI's prior work on this topic and a preliminary text set developed first for the NSF and IES grants, and then further developed for RAISE.

inquiries to explore quandaries and build teacher capacity to support students in engaging in evidence-based argumentation from multiple text sources.

Second, in developing the intervention that was the focus of the READI Efficacy Study, the READI science design worked with teacher partners in the San Francisco Bay and greater Chicago areas to develop intervention curriculum materials that supported teachers in enacting the most challenging aspects of the READI approach, including two text sets, instructional tools, an investigation of science models, and two text-based investigations of science phenomena linked to the READI instructional progression. Based on previous Reading Apprenticeship science design work, multiple iterations of co-design and implementation work with teachers and students at both sites led to the refinement of these materials.

READI California Teacher Inquiry Network

The READI RCT PD stood squarely on the shoulders of the collaborative design work that took place in Years 1-3 through the READI Teacher Inquiry Networks, particularly the design work with the California TIN science teachers. We convened the READI California Teacher Inquiry Network to draw on the insights and expertise of experienced Reading Apprenticeship subject-area teachers to build new knowledge about teaching disciplinary argumentation, using the same collaborative design processes used to develop and expand Reading Apprenticeship resources and professional development (Brown, 1992). We invited experienced Reading Apprenticeship teachers who were interested in exploring the teaching and learning of evidence-based argumentation across multiple texts. The California Teacher Inquiry Network was thus by invitation only.

Our initial TIN (2010-2011) was comprised of 23 teachers (14 English teachers, 6 history teachers, and 3 science teachers). In the second year of the TIN (2011-2012), there were 31 teachers (16 English teachers, 8 history teachers, and 7 science teachers). The 31 teachers included 21 of the original teachers from the Year 1 TIN and 10 new teachers, recruited specifically to increase teachers in history and science. Again, we invited experienced Reading Apprenticeship teachers who were interested in exploring the teaching and learning of evidence-based argumentation across multiple texts.

The California Teacher Inquiry Network was facilitated by current and former secondary teachers representing the core disciplines to be targeted by the READI project. Two of these – Rita Jensen and Gayle Cribb – were teachers on loan from local school districts, while two –Will Brown and Irisa Charney-Sirott – were current staff members at WestEd. The TIN was designed to engage teachers in intervention development and draw on their expertise across targeted grade levels and subject areas. A high level of camaraderie and familiarity permeated the culture of the Network.

Data collection was designed to capture the ongoing learning of TIN teachers, their iterative try-outs of units and text-dependent investigation modules in their classrooms, and the potential impact of this work for student learning. Over the four years of the California Teacher Inquiry Network, teachers documented their own practices, bringing lesson materials and student work to Network sessions and engaging in reflecting on their implementation of evidence-based argumentation from multiple sources in science. We audio- and videotaped all Network sessions.

The inquiry work of the TIN focused on how to support students to engage in evidence-based argumentation from multiple sources in specific disciplines (literature, history, and science). Teachers were immersed in inquiry routines that typify Reading Apprenticeship professional development, adapted to support inquiry into evidence-based argumentation from multiple sources in the disciplines as specified in the READI research grant proposal and using the initial set of intervention design principles. [see Project READI Annual Report, March 30, 2012 that addresses the design principles.] Table 1 describes core Reading Apprenticeship inquiry routines, with examples of how these were enacted in the TIN in Year 1. We engaged teachers in exploring evidence-based argumentation in their disciplines through professional reading, capturing their own reading and thinking processes during evidence-based argumentation tasks, analyzing students' reading and thinking processes, incorporating disciplinary reading and argumentation into classroom practice, and analyzing student work. We worked to develop common language and discipline-specific language for talking about reading for argumentation and for creating and building arguments.

Year 1 California Teacher Inquiry Network Professional Development Inquiries

Overview of Year 1 (Fall 2010 – Spring 2011)

In the first year of the grant, the California Teacher Inquiry Network met for four full days, spread over the academic year. The TIN was facilitated by current and former secondary teachers representing the core disciplines to be targeted by the READI project. Two of these – Rita Jensen and Gayle Cribb – were teachers on loan from local school districts, while two –Will Brown and Irisa Charney-Sirott – were current staff members at WestEd. The TIN was designed to engage teachers in intervention development and draw on their expertise across targeted grade levels and subject areas.

The inquiry work of the TIN focused on how to support students to engage in evidence-based argumentation (E-BA) from multiple sources in specific disciplines (response to literature, history, and science). We enacted E-BA ourselves with multiple texts and in multiple disciplines in order to articulate what literacy and reasoning practices students would need to be able to engage in, and from there, to design units, lessons, routines, scaffolding tools, and formative assessments that could support such instruction. Over the 4-day network series, we engaged teachers in exploring evidence based argumentation in their disciplines through professional reading, capturing their own reading and thinking processes during evidence-based argumentation tasks, analyzing students' reading and thinking processes, incorporating disciplinary reading and argumentation into classroom practice, and analyzing student work. We worked to develop common language and discipline-specific language for talking about reading for argumentation and for creating and building arguments.

TIN teachers integrated E-BA in their classrooms and brought texts, lesson artifacts, and student work back to Network sessions to ground their reflections and engage in collaborative inquiry into how to teach and support learning of disciplinary argumentation. The culture of the TIN was deliberately one of co-learning: "What are we learning about how to support students to engage in close reading across texts for evidence-based argumentation?" was a central question and repeated conversation that marked our work as a shared learning enterprise.

Following, we describe core Reading Apprenticeship professional development inquiry routines, adapted during Year 1 of the TIN to focus on supporting inquiry into evidence-based argumentation from multiple sources in the disciplines.

Table 1. Inquiry Designs and Engagements with California Teacher Inquiry Network, Year 1

Professional reading and text-based discussion. Professional readings were meant to enlarge everyone's understandings about evidence-based argumentation and disciplinary epistemologies and literacy practices. They were often enacted as text-based discussion routines for the classroom and thus provided a mirror of the Reading Apprenticeship practices promoted for students. In particular, this meant 1) never assigning a reading without making time for text-based discussion; and 2) enacting participation routines that supported each member to meaningfully participate in discussion, such as: giving time in the session to read or to review reading in order to prepare for discussion; giving a common, overarching question or prompt to elicit discussion; enacting protocols for discussion that ensured responsive dialogue and equitable distribution of airtime; and using pedagogies to support concept development. These routines also involved finding golden lines, questions, or issues to share in a small group, then moving to large group sharing to make sense of the texts and findings. In addition to cross-disciplinary readings and discussions, disciplinary groups had multiple opportunities to build their understanding of disciplinary epistemologies, literacy practices, and argumentation. Examples of cross-discipline and discipline-specific reading and text-based discussion from Year 1 included:

- All teachers: Teachers read the *Common Core State Standards for Literacy* (CCSS) in their subject areas, in order to understand the idea of learning progressions, to situate the work of the TIN in this larger context, and to become familiar with the standards. As teachers read, they were asked to highlight the verbs that required a student behavior, interaction, or disposition. They also noted other student behaviors, interactions, and dispositions that may underlie those delineated in the CCSS for their subject areas. Pairs then created a list of the kinds of experiences students would need in order to be able to perform at the levels described in the standards.
- ELA: Hillocks, G., & Ludlow, L. H. (1984). A taxonomy of skills in reading and interpreting fiction. *American Educational Research Journal, 21*(1), 7-24.
- History: Andrews, T., & Burke, F. (2007). What does it mean to think historically? *Perspectives*, *45*(1), 32-35.

- Science: Krajcik, J. S., & Sutherland, L. M. (2010). Supporting students in developing literacy in science. *Science*, *328*(5977), 456-459.

Reading Process Analysis (RPA). Reading process analysis (RPA) is a central routine of Reading Apprenticeship professional development. It aims to make teachers' thinking visible as they engage in reading complex disciplinary texts and carrying out particular tasks. By sharing metacognitively in a community of similarly engaged colleagues, teachers gain an understanding of the processes involved in making sense of texts, the variety of resources and strategies they and others bring to reading tasks, and a language for talking about these mental processes. Metacognitive conversations about reading gives teachers practice in the kinds of "in the moment" conversations that will mentor their students in reading and reasoning about texts. We aim for RPA to become a professional habit. RPAs are documented, frequently through listing the strategies used by participating readers, in a Reading Strategies List, for further analysis and discussion. In the context of Project READI, RPAs engaged teachers in the enactment of evidence-based argumentation with texts, with metacognitive analysis of teachers' reading and reasoning processes. Examples of cross-discipline and discipline-specific RPAs from Year 1 included:

- All teachers: Teachers read a text set that two middle school teachers had put together for use with their 7th grade students for the purpose of inquiry into the process of reading and argumentation. The text set included an excerpt from a 7th grade textbook, "Disease and Medical Treatment," a map from another textbook, "The Spread of the Plague in the Fourteenth Century," captioned illustrations from another textbook, "Medieval Surgery," an excerpt from a juvenile book, *Archers, Alchemists and 98 Other Medieval Jobs you Might have Loved or Loathed, "Caregivers for Lepers,"* and a webpage printout of the poem, "Ring Around the Rosy." Teachers engaged in a Reading Process Analysis with each text, sharing the reading strategies they had used.
- ELA: A "Justice" text set created by the literature design team included the following titles: "We Real Cool," "Scholarship Jacket," "Thank You Ma'am," "There Was an Old Lady," and excerpts from *Lord of the Flies* and *MacBeth*. In pairs, teachers selected two of the four texts to read closely. Teachers selected the high school or middle school texts to read with a partner, and independently read and Talked to the Text (annotate). After reading, pairs shared their reading and thinking processes and clarified any text-based questions they still had. Following this, teachers generated possibilities from the text for disciplinary discussion and argumentation. Pairs formed groups of four and selected one prompt that resonated with the group. In pairs, teachers prepared an argument, citing evidence from the texts to support and defend their claims. Pairs then shared their arguments with the whole group and debriefed the process of literary argumentation from multiple texts.
- History: History teachers engaged in an RPA with a text set developed by READI Chicago colleagues, Goldman et al. The group reported on their reading of the texts, one at a time: What did you find interesting? What connections did you make? What problems in reading the text did you have to solve and how did you do that? What questions do you still have? What issues were raised?
- Science: Science teachers worked with a chemical change text set composed of two texts, "Matter and its properties" (Holt Modern Chemistry Section 1-2, pp 10-14) and a scenario question about chemical change excerpted from Urban Advantage Leadership Institute (Krajcik, BSCS Center for

Professional Development, p. 10).

Text and Task Analysis. The text and task analysis routine engages teachers in identifying not only the reasoning processes they used to make sense of text, but also the text features, language, content and disciplinary perspectives that texts present, and that might pose demands on reader knowledge that students would find a challenge. In Reading Apprenticeship professional development, teachers learn to analyze texts and tasks as a professional habit, in order to anticipate challenges and plan ways to support students through these challenges (rather than protect them from challenge through pre-teaching or reducing text complexity). The analysis of text and task demands follows Reading Process Analysis, during which teachers reflect on their mental processes for making meaning of texts. Shifting their attention to the text(s) and to the task they are asked to complete with the text(s), they then use a graphic organizer to identify aspects of the text(s) that present schema demands in different categories: world knowledge, topic knowledge, language and vocabulary, and disciplinary perspectives/discourse. Examples of cross-discipline and discipline-specific Text and Task Analysis from Year 1 include:

- All teachers: In pairs or trios, teachers analyzed text sets brought by each teacher, using a Reading Apprenticeship Text and Task Analysis notetaker. The presenting teacher then explained how the text might be used in a lesson. Participants then had an abbreviated time to carry out the task and reflect on their own processes: What did you have to know and be able to do to work through the task? What did you notice about the task? What was challenging? What were some of your successes with the task?
- ELA: After reading selections from the Justice text set, teachers were asked to reflect on the following prompt: What are you noticing about similarities and differences in these texts, including ideas as well as text features? Pairs shared what they noticed as well as opportunities they thought these texts offered to surface literary ways of reading.
- History: The history teachers looked back at the Goldman et al. texts to see what claims could be created from these texts. Pairs were charged with developing a claim, based on some, if not all, of the texts. Teachers then shared those claims and then debriefed *how* they developed the claim. What did they *do* to create the claim? The group developed an Argumentation Strategies List.
- Science: Science teachers did similar work with the chemical change text set.

Analyzing student work. Analyzing student work samples is another core routine of Reading Apprenticeship professional development. Its aims are multiple. Most importantly, we aim to build teachers' insight into learning, and the needs and abilities of learners. Dispelling teachers' often held beliefs that their students cannot do complex work and thinking is a specific focus of this work. It is asset oriented – what are students doing well? It leads to instructional decision-making – what do students need to learn to do better? To support these stances, we have developed tools and protocols for grounding conjectures and interpretations of student work in evidence and promoting evidence-based discussion, including an Evidence/Interpretation notetaker and discussion protocol. Similarly, we have developed rubrics and student learning goals to support teachers in identifying strengths and instructional needs. In analyzing student work, teachers sometime work with written work samples and sometimes from videotapes of student performances. Analyzing student work inquiries offered to all TIN teachers during Year 1 included:

- Teachers individually reviewed their reflections on the lesson for which they brought in student work, reviewed their student work, and selected focus students. In pairs or trios, the presenting teacher explained his/her lessons and goals. Teacher pairs/trios then read the texts and the student work and discussed what they saw in the student work. As participants analyzed student work they noted what strategies the students used and what schema the students brought to the text and task. They shared their observations and brainstormed possible supports for students. We documented the whole group's ideas on posters about roadblocks teachers noticed in the student work, where the lesson and the students had been successful, scaffolds that had proved successful and ideas for next scaffolds and possible text pairings.

- The two middle school teachers who had developed and used the Medieval text set wrote a context piece explaining their goals, reasons for selecting the texts, how they had made the selections and the overall design of the lesson and the unit. Teachers read the context piece and responded to it by completing an Evidence/Interpretation Notetaker. Teachers then read 6 samples of students' work selected in advance to represent a range of responses. They first noted how students were making sense of the text and developed a list of the students' reading strategies, working as a whole group. Teachers then were asked to reread the student work, focusing on a few students to identify what they noticed about how the students were making their claims, and what connections they could make between a student's reading and his or her claim. In the whole group, they developed a list of the students' argumentation strategies and discussed instructional implications. How could we support these students in their ability to read multiple texts and use them to make a claim and build an argument? The group identified possible next steps for the students.

Artifact-grounded reflections on practice. Making connections from activities in the professional development setting to practice in the classroom is an ongoing routine in Reading Apprenticeship professional development. A key way of engaging in such connection occurs when teachers are asked to bring in their work, reflect on their teaching and the students' learning, and share their successes and challenges with one another. Artifact-grounded reflections on practice offered to all TIN teachers during Year 1 included:

- Day-long sessions during the school year opened with an opportunity to reflect, in writing, on teaching argumentation. Teachers were asked to bring texts, scaffolds, and student work from units they were teaching to each Network session that focused on evidence-based argumentation. After writing to the prompt, "What have you tried so far towards reading for evidence-based argumentation?" teachers shared their reflections with a partner or in a trio, then shared their conversations more broadly with the whole group.
- As part of a cycle of sharing and analyzing texts, lesson materials, and student work, teachers wrote a reflection about the lesson in which they had used the texts with students, detailing a description of the lesson, their instructional goals and what they observed students doing.
- At year's end, teachers were also asked to gather articles (text, handouts, student work) to bring to the session. They took an hour to write in response to questions about their instruction with these materials. Then, teachers shared their lessons and student work samples in trios, using a protocol for examining and discussing these artifacts.

Analyzing the instructional design of READI materials. Reading Apprenticeship teacher learning experiences are designed to model target pedagogies. Another core professional development routine engages teachers in analyzing the instructional design. Having engaged in reading text sets and enacting the tasks associated with READI-designed modules, TIN teachers analyzed the instructional designs, considering the level and degree of instructional support students would need to be successful. They examined and critiqued scaffolds and tools developed by the project, and offered suggestions to support any gaps or problems they identified. ELA teachers analyzed the instructional design of an E-BA module developed by the literature design team in Year 1 (See Project READI Technical Report #10 Assessments of Evidence-Based Argument in Three Disciplines: History, Science and Literature).

- ELA: Teachers identified similarities such as thematic connections, literary devices, context, and characters and discussed the opportunities across these texts. Following the discussion teachers wrote to the prompts generated by the literature design team. Then there was a whole group discussion about the knowledge demands and opportunities for argumentation. Finally, the teachers worked in small groups to consider what they might expect from their students, together considering how students at different developmental stages would interact with the texts.

Instructional design. As teachers engage in learning in Reading Apprenticeship professional development, they are asked frequently throughout the sessions to make connections to their classrooms and students. These moments of connections can be brief – capturing thoughts for a few moments of writing – or extended instructional planning sessions. Over the course of Year 1, as knowledge among the TIN participants built regarding the grant goals, the concept of evidence-based argumentation from multiple texts, and disciplinary literacy practices, the expectations for instructional design became more specific. Instructional design inquiries offered to all TIN teachers in Year 1 included:

- Teachers were asked to work with a text-based lesson in which students would need to cite evidence before the next session, and to bring in samples of the texts and student work for the next session. In the following session, in pairs or trios, teachers discussed opportunities for evidence-based argumentation using texts they brought in. They generated ideas for other texts that might serve as a compliment for the text. They also generated ideas for implementation.
- Teachers planned new lessons aimed at evidence-based argumentation, considering issues that had come up in group discussions: What about pedagogical supports? Does it help or hinder to give sentence frames? Does it help or hinder to give the task up front? How can you work with your text? What are ways you can plan to use these texts to help students make a claim and support it? What supports students' engagement in creating claims?
- At the final session for the year, teachers worked in disciplinary groups to design an instructional sequence for argumentation using multiple texts. After they had worked together for half an hour, they captured their thinking on a poster to communicate their ideas to other groups. This was followed by a Gallery Walk in which each small group visited each poster, discussed it and responded with inquiry questions, suggested resources, and validated and/or made suggestions about the sequence. The whole group then discussed the different instructional sequences that had emerged.

Reflection on learning. Metacognition is central to the Reading Apprenticeship framework and aims to build learner agency and independence in the classroom. For teachers, routine reflections on what they are learning model the work for the classroom, but also engage them in agentive and purposeful learning for their own knowledge and practice. Simultaneously, reflections on learning, shared with teachers or in our case, professional development facilitators, offers formative assessment. Reflection on learning inquires offered to all TIN teachers in Year 1 included:

- Teachers filled out reflective *Gots and Needs* for each session
- Inquiry cycles with individual teachers' texts, lessons, and student work was followed by whole group sharing focused on reflective prompts: What are we learning? What is challenging? What do we need to do to support students?
- Teachers were asked to bring lesson materials to each session; they were also asked to bring pre and post reflections about the lessons they taught.
- At the end of the year's sessions, teachers were asked to reflect on how participation in the READI Teacher Inquiry Network had impacted their classroom practice, their understanding of their own discipline's argumentation practices, and anything they had noticed about student growth or change connected to this work on argumentation. They were invited to share any other observations or insights as well.

As Core Constructs of Knowledge and design principles were developed by the larger READI project team to support the construction of modules for evidence-based argumentation in disciplinary instruction and learning progressions for students from grade 6 to 12, these constructs and principles were integrated into ongoing TIN inquiry activities. (See Goldman et al., 2016)

The TIN inquiry activities provided essential grounding for the design of the READI RCT PD learning experiences focused on modeling and evidence-based argumentation in science. Below we elaborate on the activities of the science TIN.

Science Teacher Inquiry Network

A total of seven science teachers participated in the READI California Teacher Inquiry Network. Six of the seven had been trained in Reading Apprenticeship. These teachers taught various science content domains and grade levels.

Over four years (2010 – 2014), the science teachers in the California Teacher Inquiry Network met four full days per year, with an additional two days of focused work each summer. During the course of the four years, the science teachers engaged in professional reading about science argumentation; analyzed their reading processes with science texts; engaged in science argumentation and science model construction and critique to understand how to offer supported opportunities to their students to engage in the same; collaboratively and independently designed science reading and argumentation units for their own curricula; and implemented instructional units that embodied READI science learning goals. These intentionally designed inquiry learning opportunities for science teachers had two goals: a) to build the teachers' understanding of the project goals so that they were increasingly able to integrate scientific argumentation into their science teaching; and b) to draw from teachers' experience teaching science and supporting close reading of science texts through Reading Apprenticeship instructional approaches to design tools and scaffolds for the use of teacher and student learning beyond the California Teacher Inquiry Network. As teachers in the Network integrated these approaches into their teaching, the Project would learn how these tools and practices impacted student learning, and the implementation would provide pathways and tools for the use of other science teachers.

Tables 1, 2 and 3 describe science TIN activities and inquires that supported science teachers in exploring the epistemologies and practices informing evidence-based argumentation in the science and subsequently served as the foundation for doing the same in the READI Efficacy Study.

Year 2 California Science Teacher Inquiry Network Professional Development Inquiries, Year 2

In this second year of the TIN, there were 16 English teachers, 8 history teachers and 7 science teachers. Twenty-one of the teacher participants had participated in the network during the 2010-2011 school year and 10 teachers were new to the Network, recruited specifically in history and science.

To integrate new teachers into the TIN community and its project of collaborative inquiry, we developed a two-day summer session to introduce Project READI and its aims and to engage teachers in the learning opportunities from the first year that seemed to have had a noticeable impact on teacher learning. Continuing in Year 2, the TIN conducted similar inquiries into reading multiple disciplinary texts to make claims and arguments, reading research about E-BA in specific disciplines, and examining and critiquing Project READI-developed units of instruction, or modules.

TIN inquiries were increasingly discipline-specific. The work of science teachers focused on the MRSA module materials.[7] Teachers continued to integrate evidence-based argumentation in their classrooms and brought texts, lesson artifacts, and student work back to TIN sessions to ground their reflections and engage in collaborative inquiry into how to teach and support learning of science argumentation. Year 2 Science TIN inquiries are described below.

Table 2. Inquiry Designs and Enactments with Science Teachers in California Teacher Inquiry Network, Year 2

Professional reading and text-based discussion.
• Kuhn, D. (2010). Teaching and learning science as argument. *Science Education*, *94*(5), 810-824.
Reading Process Analysis (RPA). The science teachers read the proposed MRSA texts closely over multiple sessions, sharing their reading and sense-making processes as they worked to design the module.

[7] The MRSA unit used in the READI Efficacy Study had its origins in SLI's prior work on this topic and a preliminary text set developed first for the NSF and IES grants, and then further developed for RAISE. TIN science teachers worked with the READI science design team to develop the MRSA and models modules, through multiple iterations of trying out and refining and making those available to other teachers.

- Science teachers enacted the first modeling task in the MRSA module to discover the range of processes participants enact. Individuals responded to the prompt: "Create a visual representation of a model for depicting how MRSA transmission and infection occur based on the evidence in the article, 'Superbug MRSA Worries Doctors, Athletes.'" After attempting the task, they then individually reflected on their processes. Afterwards participants shared the processes they enacted and the models they designed.

Text and task analysis.

- Science teachers completed a text and task analysis to gain insight into how students might respond to the MRSA module texts. They identified the literacy learning challenges and opportunities afforded by the proposed MRSA texts and proposed scaffolds for supporting students in working with the texts.

Analyzing student work.

- Using Evidence/Interpretation Notetakers, teachers across the disciplines read and analyzed 6 samples of students' work with the Medieval Text-Set in the first Network session, working in pairs or trios.
- Thereafter, teachers were asked to bring their own student work samples from lessons or units focused on evidence-based argumentation in their discipline. During each of the TIN sessions during the school year, teachers met in pairs to discuss the work samples, then joined table groups to share insights they had gleaned about the challenges students faced, and instructional supports that might increase their success with this work. These small-group sharing times were always followed by whole group discussion.

Artifact-grounded reflections on practice.

- Day-long TIN sessions during the school year opened with an opportunity to reflect, in writing, on teaching argumentation. Teachers were asked to bring texts, scaffolds, and student work from units they were teaching to each session that focused on evidence-based argumentation. After writing to the prompt, "What have you tried so far towards reading for evidence-based argumentation?" teachers shared their reflections with a partner or in a trio, then shared their conversations more broadly with the whole group.
- In advance of the final Year 2 session, teachers received an Evidence-Based Argumentation Assignment collection packet. They were asked to gather artifacts from a lesson (text, handouts, student work, etc.) and bring these to the session. They took an hour to write in response to questions about their instruction with these materials, based on the CRESST-developed Teacher Assignment instrument.

Analyzing instructional design of READI modules and approaches. Having engaged in reading text sets and enacting the tasks associated with READI-designed modules, TIN teachers analyzed the instructional designs, considering the level and degree of instructional support students would need to be successful. They examined and critiqued scaffolds and tools developed by the project, and offered suggestions to support any gaps or problems they identified. For example:

The science teachers engaged as an intervention design team, examining and working with the MRSA module materials over the course of the year:

- Teachers looked at an overview of the entire intervention with a focus on the beginning days. Teachers considered the pedagogical supports for prompting prior knowledge and tracking conceptual change throughout the intervention. They discussed scaffolds such as meaningful chunking of the text and noticing language.

- Teachers examined 20 texts under consideration for inclusion in the science intervention unit on MRSA. Working small groups, the science teachers identified instructional sequences for the texts that supported topical cohesion and logical progressions. The teachers identified multiple cohesive modules within the text set and unit. This supported the intervention team to sub-divide the intervention into five modules.

Instructional design.

- Teachers worked collaboratively or independently on their lesson plans for the start of the school year. Teachers planned their introduction of argumentation.
- At the last session of the first year of the READI network, disciplinary groups created a poster representation of a possible progression for teaching evidence-based argumentation with multiple texts. One year later, we again had teachers form disciplinary groups and gave them the same prompt, to create a progression for teaching students to engage in evidence-based argumentation with multiple texts. Disciplinary groups worked together, sharing their experiences over the year and charting out a developmental trajectory for students. From this discussion, they created a poster representation of a possible progression for teaching evidence-based argumentation from multiple texts. They then participated in a gallery walk during which they gave feedback and asked critical questions of their colleagues' work, revised their own progressions based on feedback from colleagues, and then discussed their ideas with the whole group. Groups returned to their progressions and made revisions. We then passed out the progressions from the year before as a point of comparison. Teachers discussed the changes they noticed in a whole group discussion.

Reflection on learning. Metacognition is central to the Reading Apprenticeship framework and aims to build learner agency and independence in the classroom. For teachers, routine reflections on what they are learning model the work for the classroom, but also engage them in agentive and purposeful learning for their own knowledge and practice. Simultaneously, reflections on learning, shared with teachers or in our case, professional development facilitators, offers formative assessment. For example:

- Teachers filled out reflective *Gots and Needs* for each session.
- Based on the discussions, notes, and teacher reflections from prior sessions, the facilitators created a list of inquiry questions about evidence-based argumentation. This list was distributed to the teachers. Teachers read the questions then worked in small groups to answer some of the questions, drawing on the material resources such as professional readings and modules as well as their experiences working with texts and tasks. We then had a whole group share out of ideas in response to the inquiry questions.
- At the end of Year 2, teachers were asked to reflect on how participation in the READI Teacher Inquiry Network had impacted their classroom practice, their understanding of their own discipline's argumentation practices, and anything they had noticed about student growth or change connected to this work on argumentation. They were invited to share any other observations or insights as well. Teachers spent about 30 minutes responding to prompts and reflecting on their learning and growth over the past 2 years. We asked them to tell their version of the story of their own growth and learning to contribute to the findings from the grant to date.

The initial work of the California science TIN focused on surfacing the types of knowledge implicit in teachers' disciplinary discourse and science literacy practices, on exploring science practices of argumentation, and on developing instructional supports based on these understandings that could support students to engage in evidence-based argumentation with multiple science texts.

Additionally, beginning in Year 2, teachers were invited to both implement text-dependent investigation modules created collaboratively with the Project READI design teams as well as to design their own units, consonant with instructional design principles and learning goals developed by Project READI. Emergent from our reviews of the literature was a defining focus for our work: reading for understanding in science, particularly reading to carry out argumentation in science, centered on developing explanations and models of science phenomena and arguing from evidence to support them. By trying out these practices and approaches in their own classrooms and bringing their experiences and classroom artifacts back to the TIN sessions and discussions, the TIN teachers assisted in the ongoing design research by developing tools and scaffolds, refining classroom and curricular approaches, and informing the project more generally as to what was possible and practicable in their contexts and for their students. In this way, with participating science teachers' input, several science argumentation modules and pre/post assessments were designed to embody project design principles and science learning goals, with pedagogical approaches and instructional scaffolds and tools built into teacher guides and accompanying interactive notebooks and text sets for students.

The professional development inquiry designs were also informed by what we observed in TIN classrooms. In the spring of Year 2 and fall of Year 3, we conducted observations in several TIN science teachers' classrooms with a particular focus on how teachers supported students to construct and critique explanatory models of science phenomena. We witnessed models serving various roles: as physical tools to support concept attainment (stick models, marble models of atoms), as aesthetic displays of information, as manipulatives to use in hands-on inquiries to identify variables affecting results (boat models in buoyancy labs, car models in speed ramp labs), and, rarely, as representations of students' current understandings of a science phenomenon. Similarly, in the enactment of project-designed, text-dependent investigation modules during Year 2 of the project, we noticed that when students were asked to construct models, they made pictures, sometimes storyboards narrating an event, and focused on the neatness and aesthetic qualities of their work, rather than science explanation based on evidence. When it came time to look at one another's models and give feedback, students failed to focus on key factors such as the extent to which models explained all of the information and evidence.

We thus saw a need to refocus teachers' conceptions of argumentation on scientific explanation, and to better support and scaffold class discussions to help students make sense of what they were reading, to revise their ideas based on new evidence as it emerged, and to decide how to represent their ideas in explanatory models. In response, we designed TIN sessions for science teachers in Year 3 to bring clarity to the practices of constructing, justifying, and critiquing models and explanations, as called for in the Next Generation Science Standards, and in Project READI science learning goals.[8] [See Appendix 1] Year 3 PD inquiries are shown in Table 3. The modules and PD designs were subsequently incorporated into the READI Efficacy Study.

Thus, in addition to informing teacher professional learning experiences for the RCT PD, teacher-researcher collaboration during the TIN also assumed the form of design work focused on developing intervention curriculum materials to support RCT teachers in enacting the most challenging aspects of the READI approach. These two SLI teacher-researcher collaboration processes—the design of specific PD inquiries to explore quandaries and build teacher capacity, and multiple iterations of co-design and implementation with teachers and students—went hand in hand in the TIN to inform the problem of engaging students in reading and inquiry across multiple discipline-specific texts.

Year 3 California Science Teacher Inquiry Network Professional Development Inquiries

> During the 2012-2013 project year (Year 3), we again started the Teacher Inquiry Network with two days in the summer, followed by four day-long sessions during the school year. In this third year of the TIN, we focused more directly on teachers as design and data collection partners. We continued our reading and reasoning process inquiries through enactment of E-BA in the disciplines, ongoing experiential critique of project-developed modules, and examination of classroom artifacts and student work. However, we invited teachers directly into the module design process through examination of the student learning goals and design principles developed by Project READI design teams in the three disciplines.
>
> The work of the Network shifted to focus more on documenting teachers' uptake of evidence-based argumentation practices. As teachers engaged in reflections on their lessons and artifacts, we asked them to reflect on how their teaching instantiated these principles and addressed these learning goals. We developed processes and tools to closely document their lessons and units linked to Project goals and design principles, and we invited them to co-design modules (with other TIN teachers and with us) for the Project. In addition to engaging in ongoing reflection and sharing from their classroom implementation of E-BA, teachers planned lessons and units based on Project design principles and learning goals during the Network sessions, often in collaboration with other teachers of their subject areas and Strategic Literacy Initiative staff.

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[8]In parallel, observations in design partner science classrooms in Chicago gave impetus to design modules to build students' knowledge of Science Models. The Project developed a Reading Science Models module for instructional use, to focus students on developing criteria for good models in science, based on an assessment task designed by (Pluta, Chinn, & Duncan, 2011). [See Project READI Technical Report #22 Developing and Implementing a Reading Models Mini-Unit to Support Evidence-Based Argumentation in Science.)

PD inquiries for the Year 3 Science TIN are described below.

Table 3. Inquiry Designs and Enactments with Science Teachers in California Inquiry Network, Year 3

Professional reading and text-based discussion. Teachers engaged in professional reading and discussion focused on how the READI Core Constructs in their disciplines mapped onto Reading Apprenticeship.

All teachers:

- Project READI: 14 Design Principles for Evidence-Based Argumentation.
- Project READI: Core Constructs of Knowledge for Literature, History, and Science.
- Cavagnetto, A. R. (2010). Argument to foster scientific literacy: A review of argument interventions in K–12 science contexts. *Review of Educational Research*, *80*(3), 336-371.
- Schoenbach, R., Greenleaf, C., & Murphy, L. (2012). Chapter 4, "Metacognitive Conversation," *Reading for understanding: How reading apprenticeship improves disciplinary learning in secondary and college classrooms*. John Wiley & Sons.
- Schoenbach, R., Greenleaf, C., & Murphy, L. (2012). Chapter 8, "The Knowledge Building Dimension," and "Student Learning Goals," *Reading for understanding: How reading apprenticeship improves disciplinary learning in secondary and college classrooms*. John Wiley & Sons.

Science teachers:

- Models in Science, from MUSE website. Teachers began with their existing understandings of "modeling" in science, then read the MUSE definition and discussed its implications for science education.

Reading Process Analysis (RPA). During Year 3, science teachers engaged in the following RPAs.

All teachers:

- Water Module: Teachers engaged in RPAs on "What's in Third Creek?" and "What's in the Chicago River?"

  Science teachers:
- How things fall inquiry. Teachers engaged in an investigation into the phenomenon of playing cards falling through air, working in pairs. They used Think Aloud and notetaking to document their reasoning processes, then worked in small groups to develop a model that explained their observations. Their shared their models with other small groups, asking clarifying questions, making critiques, and documenting their processes.
- Force and motion text set. After engaging in the card dropping investigation, science teachers read several documents about the forces involved in fluid dynamics. They then returned to their models of the card dropping phenomenon and revised them, based on new information and evidence from the texts. They reflected on the processes of generating and revising explanatory models in science, and how to support students in such work.

Text and task analysis. During Year 3, science teachers engaged in the following text and task analysis.

All teachers:

- Water Module: Teachers analyzed think/write tasks, think aloud on "What's in Third Creek?" and "What's in the Chicago River?"

  Science teachers:

- Force and motion text set. After engaging in the card dropping investigation (see RPA, above), science teachers read several documents about the forces involved in fluid dynamics. They then returned to their models of the card dropping phenomenon and revised them, based on new information and evidence from the texts. They reflected on the processes of generating and revising explanatory models in science, and how to support students in such work.

Analyzing student work.

Artifact-grounded reflections on practice. During Year 3, all TIN teachers engaged in the following artifact-grounded reflections on practice inquiries.

- During the summer two-day session, teachers were asked to reflect on aspects of their teaching focused on the texts they were using (complexity, range, volume, number, relationships between texts), the tasks they were assigning with these texts (close reading, argumentation, disciplinary reasoning, knowledge-building, integration of information across texts), and classroom culture (epistemological framing, routines, collaboration, metacognitive routines, close reading routines, differentiation, social interactions) and scaffolding of learning dispositions.
- Teachers used online tools to document their practice, sharing what they had done so far to create a classroom environment that supports students in close reading practices. They documented beginning lessons and routines, describing the first piece of academic work that they used to support evidence-based argumentation. They brought the texts and student work to the session, shared their work in pairs or trios, and discussed what they had tried so far. Colleagues asked clarifying questions and exchanged resources.
- Continuing through the year, teachers used a modified documentation tool to describe evidence-based argumentation lessons they implemented and map it onto the revised Project design principles. Frequent rereading of the Core Constructs and design principles preceded reflection and sharing of their documented lessons in pairs or trios and with the larger group.

Analyzing instructional design of READI modules and approaches. During Year 3, science teachers engaged in the following inquiries focused on analyzing instructional design of READI modules and approaches.

All teachers:

- Water Module: Having conducted RPAs with several texts and tasks contained in the Water Module, teachers mapped the READI 14 Design Principles onto the module.

Science teachers:

- Teachers explored the middle school module on Reading Models and discussed its utility for science instruction on text-based argumentation.

Instructional design. During Year 3, the TIN science teachers continued to work as design team partners in the development of intervention materials and approaches. They engaged in the following instructional design inquiries.

All teachers:

- Teachers were given extended planning time and access to each other and SLI staff during the two-day summer session. Teachers were given two templates to scaffold their planning. One used categories of text, task, and classroom culture to reflect on their practices. The second used the Reading Apprenticeship instructional framework, prompting for content goals, texts, and knowledge building foci as well as classroom pedagogy to support the Social, Personal, Cognitive, and Knowledge-Building dimensions, as well as Metacognitive Conversation and formative assessment tools and processes. Teachers were prompted at intervals to look back at the READI design principles and talk to a partner about how they were planning to instantiate these principles.
- After drafting plans for their classroom, teachers moved into cross-disciplinary groups to present their plans and give each other feedback and support for improvement. Conferring teachers were asked to give each presenting teacher kudos as well as ask an inquiry question that might strengthen the presenting teacher's thinking and planning.
- Reflecting on the Design Principles and Core Constructs for their disciplines, teachers were asked to make connections to their own work in the classroom: What connections are you making to your classroom? What are the implications of these for your interventions? What questions do you have about the design principles for your class?
- During the year, teachers began the day with documentation, reflection, and sharing with others about their implementation of evidence-based argumentation, and ended the day with extended planning time during which they planned a new evidence-based argumentation lesson. As they planned, they had access to SLI staff and colleagues as well as tools and processes to support their planning. An Evidence-Based Argumentation Notetaker scaffolded their planning. The notetaker asked teachers to record their ideas, potential texts and materials, potential learning objectives/goals, potential tasks, and potential instructional supports. Teachers were asked to choose three design principles they could commit to integrating into their lessons.

Science teachers:

- Science teachers continued to work as design team partners. The high school teachers developed a version of the Reading Models module for use in high school classes.

Reflection on learning. During Year 3, all TIN teachers engaged in the following reflection on learning inquiries.

- Teachers filled out reflective *Gots and Needs* for each session. In addition, teachers were asked, Will you be able to implement elements of your planning session in your classroom? If yes, how? If no, why not?
- As in the prior year, at the end of the 2012-2013 year's sessions, teachers were asked to reflect on how participation in the READI Teacher Inquiry Network had impacted their classroom practice, their understanding of their own discipline's argumentation practices, and anything they had noticed about student growth or change connected to this work on argumentation. They were invited to share any other observations or insights as well.

"How Things Fall": A Case of Iterative Design of a READI RCT Professional Development Inquiry

As indicated throughout this report, the design of the READI PD drew heavily on design principles and inquires for teacher professional learning for disciplinary literacy instruction developed by the Strategic Literacy Initiative (Greenleaf, Litman, et al., 2011; Greenleaf & Schoenbach, 2001, 2004), informed by the collaborative design work that took place in the READI Teacher Inquiry Networks. To illustrate how the PD in the READI Efficacy Study evolved from preexisting SLI resources and inquiries, incorporated READI learning objectives and curricular resources, and ultimately impacted teacher practice and student learning outcomes in the RCT conducted in the final years of the project, below we trace the iterative design of "How Things Fall," an inquiry ultimately used on Day 6 of the READI RCT PD, from its initial inception as a Reading Apprenticeship PD inquiry. We selected the "How Things Fall" inquiry because its evolution illustrates the mutual adaptation that is a goal of researcher-teacher collaborative design research (Penuel, Gallagher, et al., 2011). To paraphrase our earlier description of our teacher-researcher collaborative design work, the trajectory of this iteratively designed inquiry reveals how READI RCT PD inquiries, building on SLI's design principles for teacher professional learning, were honed through ongoing teacher-researcher collaboration to have a predictable impact on teacher learning and practice. Informed by our partner teachers' experiences and expertise, READI researchers repurposed this inquiry to explicitly target the affordances, challenges, and issues teachers and students face when constructing scientific explanatory models from multiple text sources.

The Reading Apprenticeship "How Things Fall" PD inquiry was adapted from "The Self-Directing Cards," an activity in the book *Invitations to Science Inquiry* (2nd Edition) by the well-known science educator Tik Liem. The book offers a set of activities designed to teach the inquiry processes of science through active engagement in investigation.

The original "How Things Fall" PD inquiry (2008) was designed for the SLI LIRA Science Breakout to help teachers to explore the connection between literacy and science inquiry (see Appendix 2 for the original Reading Apprenticeship "How Things Fall" investigation facilitator agenda). This inquiry was structured in a Five-E cycle (engage, explore, explain, extend, evaluate) for science inquiry (Bybee, 1995) to foreground the role of reading in science investigation. Specifically, the inquiry was designed to underscore the common role of metacognitive routines and conversation to support science and literacy learning:

- The inquiry dispositions and processes of science are important parts of teaching science literacy;
- Metacognitive routines and metacognitive conversation can support making science thinking processes visible;

- Science thinking begins with careful description and curiosity about the natural world. From the patterns they observe, scientists generate hypotheses and alternative explanations for these patterns that can be tested to develop theories, and so on; and
- This inquiry habit of mind can be made visible while carrying out science investigations as well as engaging in science reading

The original inquiry began with a hands-on science investigation. Pairs of teachers took turns dropping playing cards one at a time and thinking aloud about their exploration. Then groups of four worked together to explain what they were learning from the falling cards, capturing their learning and discussion on an evidence/interpretation notetaker. Teachers then used two established Reading Apprenticeship reading and discourse routines, Think Aloud and Talking to the Text, to read and discuss multiple texts on force and motion, and used information from the articles to extend their exploration and explanation of the card dropping activity. Finally, participants evaluated their learning about the importance of metacognitive conversation in the classroom and how to scaffold it.

During Year 3 of the science TIN (Day 3, 020513), the "How Things Fall" inquiry was modified significantly to explicitly foreground processes for reading multiple texts for the construction of scientific explanatory models. In particular, based on our finding that models in these science teachers' classrooms only rarely served as representations of students' current understandings of a science phenomenon, the inquiry was refocused to probe teachers' understandings of modeling as a scientific practice as well as why and how they might promote that work in the classroom for their students. Thus, the original "How Things Fall" inquiry was revised to serve additional learning goals.

We originally structured the "How Things Fall" inquiry through a hands-on investigation structured around a Five-E learning cycle. The revised "How Things Fall" activity was redesigned to engage teachers in developing and justifying a scientific model. In anticipation of constructing a scientific model accounting for the observed phenomenon named 'the self-directing cards,' the "How Things Fall" inquiry was bundled with a preceding inquiry designed to engage teachers in careful clarification of the diverse and possibly competing conceptions of science models that science teachers may hold.

To begin the inquiry, science TIN facilitator Will Brown asked the TIN science teachers to think, write, and talk about their current understanding of science models. The teachers wrote about their existing understandings of science models, responding in writing to the prompt: "Make a list of ideas you know, remember or wonder about science models. List your questions too." The teachers then had an opportunity to share their musings with a partner. As anticipated based on our prior design work, during the ensuing whole group discussion facilitated by Will, the teachers revealed a concept of models as physical surrogates for reality, analogies for the target concept they want to teach students. At the same time, teachers expressed concern that these physical representations were not really satisfactory because they inevitably misrepresent things. In fact, some teachers questioned whether it might be better to just teach students the right answers, the accepted and agreed upon understandings that teachers want them to end up with, rather than inviting them to generate their own inaccurate understandings, their own explanatory models.

Anticipating that the discussion would surface these conceptions and misgivings, as the next step of the redesigned inquiry, the revised inquiry engaged teachers in a professional reading and text-based discussion about the role of models in science. The text, “Explanatory Models in Science,” drawn from the Modeling for Understanding in Science Education (MUSE) project website (2002), contains descriptions of scientific models and their purposes: “*A scientific model is an idea or set of ideas that explains what causes a particular phenomenon in nature.”* The webpage describes the work of practicing scientists as *“the development of an understanding of how various parts of the natural world work.”* To do so, *“scientists make observations, identify patterns in data, then develop and test explanations for those patterns.”* These explanations, the webpage asserts, are called *scientific models.* (See Appendix 3 for a copy of the MUSE Modeling for Understanding in Science Education text.)

As they discussed what they had read, reflecting and linking it to their prior discussion, with Will’s facilitation the teachers gradually began to differentiate the physical model that stands in for a phenomenon from the mental model or conceptual understanding students may have of how phenomena work, bringing into play the label “mental model” to describe this idea. Thus, through reading and discussing the role of building models in science, the redesigned inquiry helped these teachers recast the goal of engaging students in developing models as a process of learning and conceptual change.

Designed to build on this emergent learning about the value of developing models as a process or learning and conceptual change, the science teachers now engaged in the “How Things Fall” hands-on investigation, with the goal of constructing an explanatory model for the way playing cards fall through the air. Pairs took turns dropping playing cards one at a time—varying the ways they held the cards before dropping them—thinking aloud and notetaking to document their reasoning processes about how the changes affect the way the card behaves. Teachers then took turns thinking aloud and notetaking about a new challenge: *How could you separate the cards into three equal piles by dropping them?* Using an evidence/interpretation notetaker, partners reviewed and sorted out the notes they made into experimental evidence and observations from interpretations and science reasoning. Partners then created a “first draft metacognitive scientific model” for the cards falling phenomena. Groups shared their models with the group, asking clarifying questions, making critiques, making recommendations, and documenting their processes.

After creating a "first draft metacognitive scientific model" based on the hands-on investigation, individuals read two articles from a Force-Motion-Aerodynamics text set to help then create a scientific model accounting for the 'self-directing cards' phenomenon using an I Saw/I Thought notetaker to capture and share their reading processes, and created a second draft of their metacognitive science model for self-directing cards.

The teachers continued the inquiry at the next TIN meeting, Day 4 (031213). Over the course of the inquiry, teachers moved from paired and small group active investigation, to close reading, to explanation and model building, then to sharing and critiquing one another's models. As the teachers worked, we captured their thinking about additional lesson structures, instructional prompts and sentence stems that might support students in doing similar work. In particular, we focused on how to support students in the thoughtful work of model building and explanation, rather than artwork, and how to engineer the challenging peer critique processes that could assist students in reconsidering and revising, or updating, their explanatory models.

Finally, having completed the inquiry into their modeling of the card dropping phenomena, the science teachers met in a table group conversation focused on instructional planning. In this conversation, the science teachers began to revise an existing lesson to reflect scientific argumentation. Will participated in this discussion among four of the science teachers about modifying the lesson to involve more close reading and argumentation. The existing lesson was introduced by one teacher as a "dry lab" in which students receive data about a hypothetical rat that has been autopsied and must determine what hormone is responsible for anatomical changes based on these data (Odenweller et al., 1997). The lesson included several types of science texts: models of negative feedback systems for regulating several hormones in the endocrine system, informational text about hormone production and impact on the body, and six different rat scenarios providing anatomical data pre and post hormonal treatment and autopsy.

Not satisfied that the lesson as constructed met the goals of the READI project for science, the presenting teacher invited her science colleagues to help her "tweak" this lesson to "do more argumentation." As they redesigned the lesson together, argumentation centered around a model that would explain what had occurred in the rats' endocrine systems based on evidence from the text, which students must use to "back up" what they put forward as an explanation. In this exchange, a full explanation of what happened to the rat required a cause-effect model showing how various parts of the endocrine system have interacted to produce an imbalance. In the ensuing exchange, the teachers described what such a task would require: an explanation for what's going wrong with the rats, based on the data in the scenario, and arguing for why the model best accounts for the data. The teachers were clearly operating here with an understanding of model quite different from the idea of model as surrogate they held in the previous Inquiry Network session.

The significantly revised inquiry, informed by the teacher-researcher collaboration and renamed Multiple Text Argumentation Model to reflect its goals for teacher learning, was subsequently used on Day 6 of the RCT PD, building on the protocols, materials, and learnings of the SLI PD staff following use with the TIN science teachers (see Appendix 4 for the RCT PD "Multiple Text Argumentation Model" inquiry and investigation facilitator agenda).

Designing Professional Development for the READI Efficacy Study [9]

The intervention tested in the READI Efficacy Study combined teacher professional development with text-based investigation modules and materials aimed at supporting students to engage in evidence-based argumentation in science, centered on developing explanations and models of science phenomena and arguing from evidence to support them. With this focus, we had worked across sites and with teacher design partners over the first four years of the project to develop and field test intervention modules, which in science were instantiated as READI text-based investigations. The design team teachers, working with READI staff,[10] designed and implemented modules aligned with READI learning objectives and progressions with the intention of sharing with other teachers as objects of study [see READI Tech Reports #17-23 and READI Curriculum Module Technical Reports CM #23-30]. As described above and in Tables 2 and 3, the development of the MRSA and Models intervention modules was a significant focus of the California TIN science group.

In developing the science intervention, the READI science design team endeavored to be deliberate in progressive sequencing to build a set of skills and dispositions for student science learners. The Text Based Investigations thus are intended to deliberately provide "spotlights" on instructional routines to build needed skills and dispositions and progress them over time in the classroom. Based on observations from the iterative design and implementation process as well as on available research literature regarding development of the various kinds of knowledge and skills identified in the core constructs, the science team drafted and refined an instructional progression to guide intervention development and instructional sequencing. One finding from these observations was that students needed to learn discourse norms and routines for text based, metacognitive conversations that support sense-making, building knowledge of science, and building meta-knowledge for science reading and modeling. Another finding from classroom

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[9] Will Brown, Cynthia Greenleaf, Mo-Lin Monica Ko, Gayle Cribb, MariAnne George, Julia Emig, Stacy Marple and Susan Goldman participated in in the development of the professional development sequence and support offered to science teachers during the efficacy study of the READI approach in 9th grade biological sciences.

[10] The READI science team included Will Brown, Cynthia Greenleaf, Gina Hale, Ursula Sexton, Mo-Lin Monica Ko, Katie James, MariAnne George, and Susan Goldman.

observations was that students needed to learn about the warrants for argument in science. The instructional progression built in these threads as aspects of science literacy practice that would build over time. The instructional progression was thus an attempt to reflect an iterative instructional cycle that mirrors a gradual learning process, beginning with initial exposure, often through modeling and explicit instruction, followed by scaffolded practice with opportunities for feedback, and ultimately to fluent grasp of the concepts and practices that reflect core constructs in the discipline. While the sequencing was developed from research literature and observation, the timeline was bounded by the single semester duration of the efficacy study.

The READI science progression instantiated in the READI RCT PD, then, is a framework for 'on-boarding' novice science readers into science reading practices, culminating in reading multiple science texts for evidenced based argumentation. The progression supports teachers who having completed READI teacher professional development and are implementing instructional approaches that develop student science reading, specifically the READI science modules. The READI science progression is organized into six strands of learning, one for each READI science learning goal:

- Close Reading
- Multi-text Synthesis
- Construct explanations of science phenomena
- Justify explanations of science phenomena
- Critique explanations of science phenomena
- Science Epistemology and Inquiry

In the 2013-14 school year multiple middle school and high school teachers in the READI science TIN instantiated the READI science progressions in their specific science curricula to generate grade level specific instructional examples to instantiate the progressions as well as to provide feedback on the progression itself. Classroom observation and teacher feedback reported that the discrete learning goals with the instructional progression aligned with student learning, while the timing and duration for 'onboarding' novice science readers into science reading practices varied by grade level and context, corroborating the Project READI theory of change foregrounding teachers' role in mediating the opportunities that students have to learn.

READI RCT PD Overview

Thus the READI RCT PD design was the outcome of multiple interrelated strands of Project READI design research. The design challenge for the READI science intervention PD was also multifaceted. In the broadest sense, the goal was to 'on-board' science teachers to teaching with text as a resource for science investigation and to facilitate student learning of READI science learning goals using the intervention curriculum. The absence of close reading in the baseline observations in science classrooms suggested that science teachers in the READI RCT study would be unpracticed in teaching science with texts as a resource for investigation (Litman et al., 2016). It was necessary, then, to assist teachers in constructing richer and more complex theories of reading, in seeing their students' capacities to read and learn in new and more generous ways. Furthermore, design partner teacher feedback and the high visibility of hands-on investigation and relative obscurity of reading in science standards suggested that many of the science teachers would be skeptical or resistant to reading as a significant science practice. It was, therefore, critical to assist the RCT science teachers in drawing on and developing their own resources and knowledge as teachers for reading in science, repositioning text as a resource for science investigation.

Given the depth and scope of learning required, the READI PD consisted of 11 day-long meetings. These began six months prior to the RCT study semester, to provide teachers opportunity to practice the pedagogy for the READI text based investigations. Because Project READI was unable to negotiate with districts and schools to release their teachers for consecutive days of PD during the school year, we adapted SLIs professional development design in significant ways. A design of 4 separate days in the spring and 5 consecutive days in the summer was adopted.

Overall, READI RCT PD consisted of four one-day meetings, a five-day summer session, and two one day meetings during the RCT semester. After the RCT study semester, a final meeting was convened for reflection and closure. A seven-day professional learning series was provided for the control teachers after the completion of the RCT study. The READI PD was facilitated by three project READI staff: Willard Brown and Mon Lin Ko, designers of the READI science curriculum, and Gayle Cribb, designer of READI history evidence-based argumentation modules.

Table 4. READI PD Overview

Timing	**Learning Focus**
Days 1-4 • 4 single days • Spring Semester 2014	• READI and the Reading Apprenticeship Framework • Inquiry into Science Reading • Metacognitive Conversation and Text Complexity • Formative Assessment and Reciprocal Modeling • Using READI pedagogies in classroom practice
Days 5-9 • 5 consecutive days • Summer 2014	• READI Science Learning Goals • READ Science Text Based Investigations • READI science goals and Instructional Progression

	• Planning use of READI intervention pedagogy and materials in RCT study semester
Days 10-11 • 2 single days • During study Semester	• Reflection on classroom experience with READI intervention pedagogy and materials • Formative assessment of student learning • Planning ongoing use of READI intervention pedagogy and materials
Day 12 • post study	• Reflection on READI Intervention pedagogy and materials

Table 4 provides an overview of the READI RCT PD. The design of the READI PD drew on three bodies of professional development research. The design principles and inquires for teacher professional learning for disciplinary literacy instruction developed by the Strategic Literacy Initiative through iterative processes of theory-based design, implementation, study, and refinement (Greenleaf, Litman, et al., 2011; Greenleaf & Schoenbach, 2001, 2004) comprised the core of the READI PD and informed all aspects of the design. The READI PD was also built on the collaborative design work described above that took place in the READI Teacher Inquiry Networks which provided grounding for all learning experiences focused on modeling and evidence-based argumentation in science. Finally, the READI PD was also informed by lessons learned through various professional development projects of READI (e.g. Wiley et al., 2009; Wolfe & Goldman, 2005; Zech, Gause-Vega, Bray, Secules, & Goldman, 2000).

Designed to lay a foundation for teaching with texts as a resource for science investigation, the first four days of the READI RCT PD largely drew on Reading Apprenticeship professional development inquiries. Our collaborative design work with the California TIN teachers taught us that successful student engagement in argumentation was built on a foundation of Reading Apprenticeship practices that do not necessarily look like argumentation *per se*. However, while these practices were second nature to the experienced Reading Apprenticeship teachers who participated in the TIN, they were new to teachers in the RCT PD. Therefore, to build a foundation for supporting students to engage in evidence-based argumentation in science in particular, as a first step, RCT PD introduced teachers to the Reading Apprenticeship Instructional Framework and approaches. To this end, we included inquiries that could focus science teacher learning in areas we previously found were key to strengthening literacy instruction in science (Greenleaf, Litman, et al., 2011) and that were revealed in our READI teacher-researcher collaborations and classroom observation research to be foundations for engagement in evidence-based argumentation in science (Charney-Sirott, Cribb, Jensen, & Brown, 2012; Litman et al., 2015).

These inquiries personally engage the learner (the science teachers) in comprehending complex science texts and make apparent their knowledge of the features of text that may present challenges to the inexperienced reader, their recognition and appreciation of the specific literacy practices of their disciplines, their ability to articulate the formerly tacit mental moves they rely upon when faced with comprehension problems, and their confidence in their capacity to support students in becoming stronger readers and learners in the disciplines. The inquiries also support teachers in understanding the ways social environments have shaped their own literacy capacities and identities over time, and by extension, play weighty roles in their students' relationships to reading, writing, and learning in school. In addition, by understanding and using Reading Apprenticeship tools and approaches, teachers are able to learn from their students in the very process of teaching — through ongoing formative assessment, inquiry, and reflection. Days one through four thus provided the foundational knowledge and practices for using the READI science intervention pedagogy and curricular materials.

Days five through eleven, focusing on the READI intervention materials, were comprised of a combination of Reading Apprenticeship professional development inquiries and inquiries focused on evidence-based argumentation from multiple text sources developed through the California TIN. Prominent among these were cycles of teachers taking on the role of learner, working through the READI intervention materials, especially the text dependent investigations. Teachers explored and analyzed their own personal processes for reading multiple texts, constructing models and explanations, and argumentation in the modeling and explanation tasks. Teachers analyzed the pedagogy and design of the READI intervention text dependent investigations, and drawing on lessons learned from these, planned how that might use the READI pedagogies and materials with their students. Days ten and eleven, supporting teachers in ongoing use of READI intervention pedagogies and materials, also drew on a combination of Reading Apprenticeship professional development inquiries and inquiries developed in through the READI California TIN. Each of these days was comprised of cycles of reflection on practice, formative assessment of student work, and planning how to continue to use READI pedagogies and materials with their students.

Concluding Remarks

The iterative design of professional development developed, enacted, documented, and refined through the Teacher Inquiry network produced PD designs addressing a range of aspects of disciplinary reading as defined in Project READI – reading multiple texts to engage in disciplinary argument – in three disciplines: literature, history and science. This work is significant in that it explored the professional learning critical for implementing new initiatives such as the *Common Core State Standards for Literacy,* and *the Next Generation Science Standards* building on a highly effective model for professional learning. These designs were then leveraged for the READI Efficacy Study.

The READI Efficacy study PD design was remarkable in the ambitious scope of professional learning goals – encompassing goals for establishing a science literacy classroom culture, extending to goals for supporting students in reading multiple science texts to construct, justify and critique explanatory science models. To address these goals, the PD incorporated designs from the pre-existing highly effective PD with the newly developed READI PD designs to address the whole range of professional learning goals for the PD. Significantly, the READI PD was an integrated learning experience supporting teachers to consider how the different aspects of science reading related.

The READI Efficacy study PD design was also remarkable in the pace for the PD. The PD began only six months in advance of the intervention study semester. It continued for eleven learning days in ten months. Notwithstanding the substantial basis of the READI RCT PD design in proven Reading Apprenticeship PD designs, the design team members had questions about the timeline of the RCT study. Given the complexity of learning goals and brief timeline for PD, it was a fair question how much would teachers come to understand and take up the READI approaches and enabling pedagogies to support engaged, metacognitive inquiry with texts.

The READI Efficacy study treatment included both professional development and the provision of the READI materials including the instructional progressions, text sets, and text based investigation modules. The study provides, then, an opportunity to explore and gather evidence for how the READI materials impact teacher learning. On one hand the materials are a support, providing texts and text based investigations tasks that teachers otherwise would not have. On the other hand, the READI materials set a high bar for teacher implementation and student learning, potentially an intimidatingly high bar. How would teachers respond to the READI materials? How might the READI materials impact teachers taking up READI pedagogies?
The results of the READI study of teacher practice and student outcomes may shed light on these questions. [See READI Technical Report #26.]

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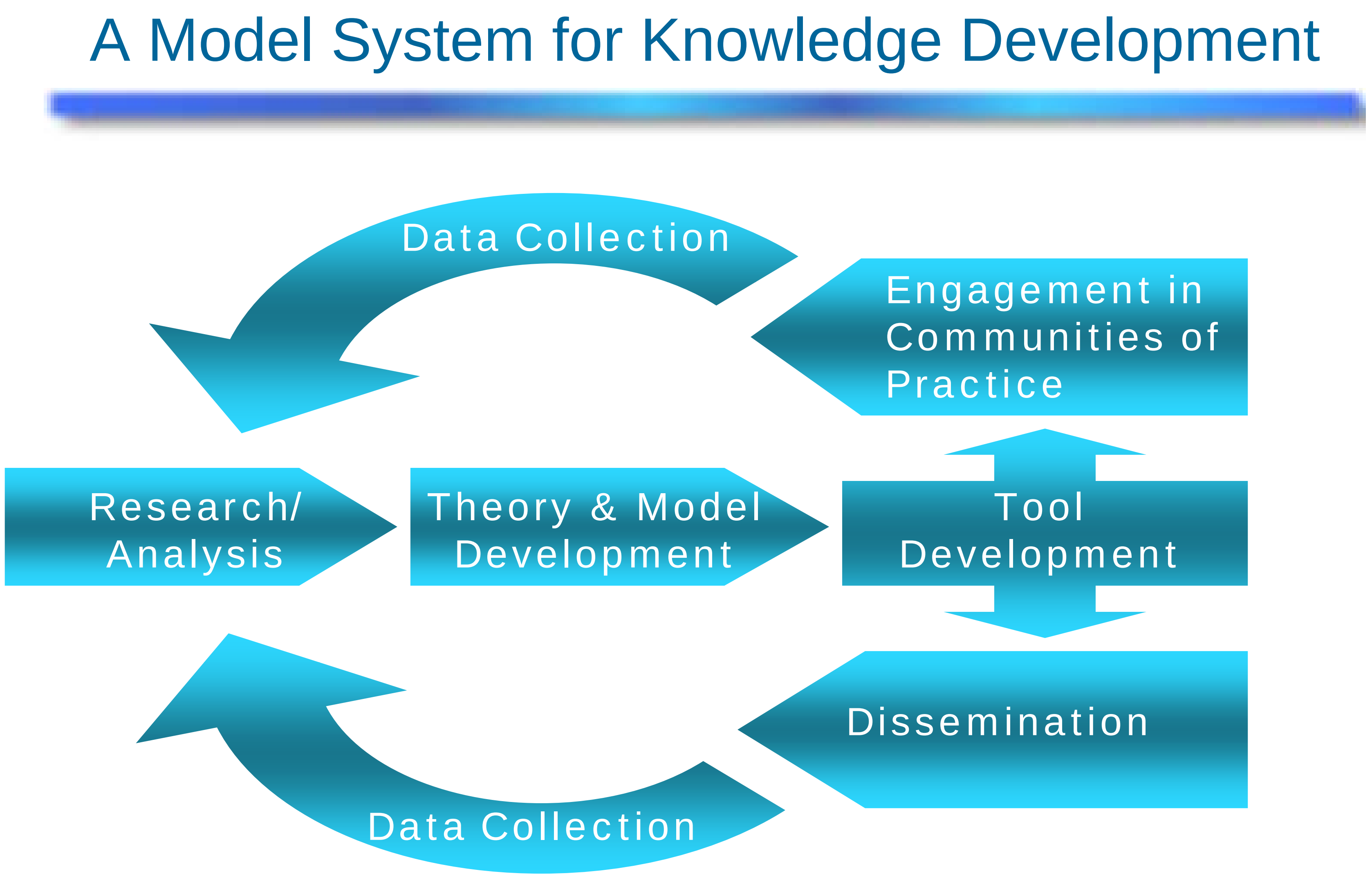
Figure 1.


A Model System for Knowledge Development
Data Collection
Engagement in Communities of Practice
Research/ Analysis
Theory & Model Development
Tool Development
Dissemination
Data Collection

PROJECT READi
Reading, Evidence, and Argumentation in Disciplinary Instruction

Science Learning Goals

1. Engage in close reading of science information to construct domain knowledge, including multiple representations characteristic of the discipline and language learning strategies. Close reading encompasses metacomprehension and self-regulation of the process.

2. Synthesize science information from multiple text sources

3. Construct explanations of science phenomena (explanatory models) using science principles, frameworks and enduring understandings, cross-cutting concepts and scientific evidence.

4. Justify explanations using science principles, frameworks and enduring understandings, cross-cutting concepts and scientific evidence.

5. Critique explanations using science principles, frameworks and enduring understandings, cross-cutting concepts and scientific evidence.

6. Demonstrate understanding of epistemology of science through inquiry dispositions and conceptual change awareness/orientation (intentionally building and refining key concepts through multiple encounters with text); seeing science as a means to solve problems and address authentic questions about scientific problems, tolerating ambiguity and seeking "best understandings given the evidence", considering significance, relevance, magnitude and feasibility of inquiry.

Metacognitive Conversation—

Thinking Aloud with Science Inquiry

Overview

What does it mean to have a classroom conversation in which the teacher is not at the center? What does a Reading Apprenticeship classroom sound like? We want to explore how to structure the kinds of metacognitive conversations that are at the heart of a Reading Apprenticeship classroom.

Goals for Participants

- To extend the conversation about Metacognitive Conversations in the science classroom
- To further practice Metacognitive Conversation routines
- To focus on how to structure rich metacognitive Conversations
- To recognize that an inquiry habit of mind can be made visible while carrying out science investigations as well as engaging in science reading

Sequence and Timing 85m

11:00 – 11:50	1	Engage: How Things Fall Investigation (5m)
11:50 – 12:10	2	Explore: Paired Think Aloud Investigation (20m)
11:50 – 12:10	3	Explain: Evidence and Interpretation (10m)
11:50 – 12:10	4	Extend: Think Aloud while Reading and Talking to the Text (15m)
11:50 – 12:10	5	Extend: Reading and Talking to the Text (15m)
12:10 – 12:25	6	Evaluate (20m)

Materials

- 2 decks of playing cards [or use 3X5 cards for all]
- Set of 3X5 cards for inquiry extensions
- Evidence/Interpretation Chart
- Overhead of Page 1 of Combined Forces in *Science Explorer*, DK Publishing, Inc., p. 348-349, 2004

- Science text: Forces and Motion text set (esp. Changes in Motion from *Holt Physics*, *Airfoils and Lift*)
- Metacognitive Conversation Packet

85m Metacognitive Conversation- Thinking Aloud with Science Inquiry

05m 1. Engage: How Things Fall Investigation

02m

Facilitator Introduction

Direct participants to take out '*Thinking Aloud with Science Inquiry*', Evidence/Interpretation notetaker, the science text set (in the Supplemental Texts binder), and the Metacognitive conversation packet.

Explain that we'll explore the connection between literacy and science inquiry with the '*How Things Fall'* investigation.

- The inquiry dispositions and processes of science are important parts of teaching science literacy
- Metacognitive routines and metacognitive conversation can support making science thinking processes visible.
- Science thinking begins with careful description and curiosity about the natural world. From the patterns they observe, scientists generate hypotheses and alternative explanations for these patterns that can be tested to develop theories, and so on.
- This inquiry habit of mind can be made visible while carrying out science investigations as well as engaging in science reading.

Explain that 'your' role will be timekeeper and facilitator. All the parts of the investigation are described in the "Thinking Aloud with Science Inquiry'. After the investigation we'll discuss our learning process and the literacy-inquiry connection.

The '*How Things Fall*' investigation is adapted from an activity – "*The Self-Directing Cards*" (p. 68) – in the book Invitations to Science Inquiry, Second Edition by the well-known science educator Tik Liem. The book offers a set of activities designed to teach the inquiry processes of science through active engagement in investigation. This lesson is structured in a Five-E cycle (Engage, explore, explain, extend, evaluate) for science inquiry (Rodger Bybee, 1995).

Metacognitive Conversation is at the heart of a Reading Apprenticeship classroom. The better we understand its power through experience in this PD, the better we can help colleagues, and students engage in it productively.

What does it mean to have a classroom conversation in which the teacher is not at the center? What does a Reading Apprenticeship classroom sound like? We want to explore how to structure the kinds of metacognitive conversations that are at the heart of an Reading Apprenticeship classroom.

03 m ▫ TA Bookmarks ▫ Playing cards HO	**Engage: Model Scientific Thinking Using Think-Aloud** Invite participants to use the Think Aloud bookmarks as a guide for listening to the TA Facilitator drops cards one at a time and thinks aloud about his/her exploration. Elicit observations from participants. *“What do you notice about the facilitator’s thinking?”* *“What kind of thinking is the facilitator doing?”*	See the ‘Thinking Aloud with Science Inquiry’ directions for details of the participant activities. Model science Inquiry disposition and process in the think aloud: For example: • Pose purpose-setting questions: “What might I learn from dropping cards? Maybe I could learn about motion in air, forces and interactions between air and the cards. What else?” • Pose experimentally testable questions: What if I drop the card the same way each time, will it fall the same way? Does it matter how I let go of the card? • Recall science schema: Earth’s gravity pulls downwardly. But air current can blow things around especially if they are lightweight. • Make hypothesis and predictions: I If I hold it level and drop the card, it will drop straight down. • Test the predictions experimentally a few times (Is the result reproducible?) • Compare predictions and observations … • Revisit hypothesis and predictions and form new questions …

20m	2. Explore: Paired Investigation while Thinking Aloud	
10m ▫ Playing cards HO	**Explore: Paired Investigation while Thinking Aloud:** Invite participants to form pairs for the investigation. Distribute 9 cards to each pair. Ask participants to use their journals to record their partner's Think Aloud. Go over the Think Aloud and Listen and Record roles before turning them loose. Invite participants to take turns exploring with the playing cards and thinking aloud as they do so. Remind participants to use the prompts on the Think Aloud bookmarks (in the Metacognitive Conversation Packet) as a guide, if needed. As participants carry out their paired investigations of the cards, listen for scientific ways of thinking that you can weave into debriefs later. Ask Participants to Switch roles after 5 minutes.	Be aware that participants may want to change some of the forces to explore their ideas further. For example, they may want to change the shape of the cards by bending, tearing, or balling them up. Provide 3X5 cards for that purpose. Partner One will Think Aloud, Partner Two will listen and record.
10m	**Explore: Challenge** Prompt pairs to try the 'challenge' on the second page of the investigation. Remind pairs to continue thinking aloud and taking notes.	See the ''Thinking Aloud with Science Inquiry' directions for details of the participant activities.
10m	3. Explain: Evidence and Interpretations	
10m	**Explain: Evidence and Interpretation Notetakers** Ask participant pairs to join up with another pair to form a foursome. Direct participants to the 'Explain' part of the 'How Things Fall' investigation. Ask participants to work with their small groups to explain what they are learning from the falling cards. Explain that previously we used T-charts as	Encourage participants in the small group discussion to continue the explanation of the movement of the cards that they have already begun in their Think Aloud.

	an inquiry tool in our case studies but now we are trying out a classroom use for the Evidence/Interpretation T-Chart. Ask participants to use the Evidence/Interpretation T-Chart to capture their learning and discussion.	
15m	**4. Extend: Reading and Thinking Aloud**	
15m Forces HO Changes in Motion HO	**Extend: Reading and Think Aloud** **Think Aloud Model** Briefly model think aloud with a text on force and motion, “Combined Forces” in *Science Explorer* Ask original investigation partners to briefly Think Aloud on a segment of the “Combined Forces” text to make explicit connections to the investigation, following your model. **Read and Think Aloud** Ask participants to take turns (in pairs again) thinking aloud as they read a section of “Changes in Motion” from Holt Physics **Discuss** *“How does the information in the article help with your exploration and explanation of the card dropping activity?”* *“What new questions arise?”* Have participants add their thoughts to their Evidence/Interpretation T-Chart.	As you think aloud, make explicit connections to the card dropping inquiry, modeling the integration of literacy and science investigation. Depending on timing and the familiarity of the group with using Think Aloud to tackle a science reading (since working with it the previous day), you may want to skip the step of modeling Think Aloud with “Combined Forces”.
15m	**4. Extend: Reading and Talking to the Text**	
10m Science Text HO	**Read and Talk to the Text** Direct Participants to ‘Extending Reading And Understanding’ Invite participants to choose an article to continue reading from the set of materials you have received, and to Talk to the Text as they read noting questions, connections, ideas, “roadblocks” in the form of difficult words, sentences, ideas, or “missing” background knowledge.	See the ‘‘Thinking Aloud with Science Inquiry’ directions for details of the participant activities.

5m	**Pair and Share** Prompt participants to take turns sharing their reading process with a partner who has read the same text and discussing how the reading informs the inquiry or sparks new questions.
20m	**5. Evaluate**
05m 15m	**Evaluate** Ask participants to reflect on their learning and prepare responses to the discussion questions. Elicit participant response to the following questions: • *"How does the reading shed light on the inquiry you did earlier? How did the inquiry prepare you for the reading?"* • *"How confident are you in your understanding of what is happening with the playing cards? What would you do next to strengthen your understanding?"* • *"How did the Think Aloud process – your own and your partners' – affect your thinking and learning today?"* • *"How did the Talking to the Text process and sharing of your own and your partners' reading affect your thinking and learning today?"* • *"How are Think Aloud and Talking to the Text different? When might you use which of these in the classroom?"* • *"How might this collaborative, metacognitive thinking support your students' science literacy? What would you need to do to scaffold their use of these metacognitive routines?"* • "What are we learning about the importance of metacognitive conversation in the classroom and how to scaffold it?"

***Transition*: Next we'll talk about team planning.**

Explanatory Models in Science

A scientific model is an idea or set of ideas that explains what causes a particular phenomenon in nature.

We are interested in models from the perspective of what practicing scientists actually do. The most important overall goal of scientists is the development of an understanding of how various parts of the natural world work. To do this, scientists make observations, identify patterns in data, then develop and test explanations for those patterns. Such ***explanations*** are called ***scientific models***.

It is important to note that scientists use drawings, graphs, equations, three dimensional structures, or words to communicate their **models** (which are ***ideas*** and ***not*** physical objects) to others. However, the drawings, replicas or other tools are distinct from the underlying models they purport to explain.

Explanatory models in science are continuously judged by a community of scientists. To evaluate a particular model, scientists ask:

1. Can the model ***explain all the observations***?
2. Can the model be used to ***predict*** the behavior of the system if it is manipulated in a specific way?
3. Is the model ***consistent with other ideas*** we have about how the world ***works and with other models*** in science?

In judging models, scientists don't ask whether a particular model is "right". ***They ask whether a model is "acceptable"***. And acceptability is based on a model's ability to do the three things outlined above: ***explain, predict, and be consistent with other knowledge***. Moreover, more than one model may be an acceptable explanation for the same phenomenon. ***It is not always possible to exclude all but one model*** – and also not always desirable. For example, physicists think about light as being wavelike or particle-like and each model of light's behavior is used to think about and account for phenomena differently.

Finally, we note that in practice, models are continuously revised as they are used to probe new phenomena and collect additional data.

This site was developed by the National Center for Mathematics and Science in the Wisconsin Center for Education Research at the University of Wisconsin-Madison.

READI Science Professional Development
Day Six • Agenda

8:00 AM	Coffee and Conversation
8:30	Opening Routine
	Classroom Case: One Teacher's Academic Literacy Class: "Superman and Me"
	Planning for the First 7 Weeks
12:00 PM	WORKING LUNCH
12:30	Mid-Day Learning Reflection
	Inquiry: Reading Multiple Texts, Building Models and Argument • What Are Scientific Models? • 'Self-Directing Cards' Investigation
	Closing Routine
4:15	Adjourn

Preparation for Day Seven

With the perspective of model-building and argumentation, read the Models Module.

- Make connections to today's experience, the READI Science Learning Goals.
- Note questions and ideas for implementation.
- What can students learn about models and argumentation through this module?
- What would have to already be in place in your classroom for your students to tackle this module?

Opening Routine Notes

Opening Routine Notes

Classroom Case Inquiry Prompts and Notetaker

While you watch the video, make Evidence and Interpretation notes.

Ones: What do you notice about **students' reading, thinking, and talking**? What do you notice about students' reading, thinking and talking about reading that is **scientific**?

Twos: What do you notice about the **supports for reading, thinking, and talking**? What do you notice about the **teacher's talk** that support students reading, thinking and talk?

Evidence	Interpretation

Classroom Case Inquiry Prompts and Notetaker

Evidence	Interpretation

One Teacher's Academic Literacy Class

Profile

School: Dreher High School, Columbia, South Carolina
Teacher: Cindy Ryan
Class: Reading Apprenticeship Academic Literacy
Lessons: Reading the First Amendment; Reading *Jailed for Freedom*

About Dreher High School

Located in the state capitol of Columbia, South Carolina, Dreher High School serves 1,179 students from inner-city and suburban residential areas. Dreher families range from low- to high-income and from varied occupations: service, manufacturing, business, professional, and government careers. Thirty-two percent of Dreher students receive free or reduced-priced lunch.

The school population includes 52 percent African American students, 46 percent white students, and 2 percent Hispanic/English learner students; 15 percent of Dreher students are designated for Special Education.

Dreher High School has been honored with a "Palmetto Gold Award" and recognized as a "Red Carpet School" and "Flagship School of Promise." On the South Carolina Report Card, Dreher is rated "Excellent." Eighty-five percent of Dreher graduates attend college; nearly two-thirds attend a four-year college.

Dreher offers a multi-level instructional plan. Students who seek higher education may pursue either the H (Honors) or the CP (College Preparatory Program). Advanced courses (H, AP) are limited to students who qualify based on test scores, grades, faculty recommendations, and desire for rigorous study.

Dreher High School is on a block schedule; classes meet for 90 minutes every other day.

About Cindy Ryan

Cindy Ryan is a veteran teacher with 17 years of teaching experience. Since 2005 she has been Dreher High School's reading specialist. She holds a B.A. in English from Francis Marion University and has done graduate work at the University of South Carolina. Her certifications include English, SC Gifted and Talented, AP Endorsements from the College Board in Literature and Composition and in Language and Composition.

One Teacher's Academic Literacy Class

Cindy was introduced to Reading Apprenticeship in fall 2003, when she attended a five-day Leadership Institute in Reading Apprenticeship (LIRA) with colleagues from the Richland One School District. She immediately began implementing Reading Apprenticeship in her English classes. In 2006, she first taught the Reading Apprenticeship Academic Literacy course as part of a federally funded study of promising adolescent literacy programs. Her students averaged the highest gains of any in the study. One year later, during the year of the filming, Cindy was teaching five sections of Academic Literacy.

About Reading Apprenticeship Academic Literacy at Dreher High School

Academic Literacy is a ninth grade course at Dreher High School. Students are identified for the course through eighth grade scores on South Carolina's Palmetto Achievement Challenge Test (PACT), scoring at the Basic or Below Basic levels. Interestingly, they include a mix of honors, college prep, and special education students. Cindy explains that some of the honors students develop coping skills that mask their difficulties with reading. Enrollment in Academic Literacy does not reflect Dreher High School demographics: Academic Literacy students are overwhelmingly African American.

Principal Jeanne Stiglbauer is a staunch supporter of Academic Literacy and limits each class section to 15 students.

The purpose of the Academic Literacy course is not only to foster young people's development of reading comprehension strategies, but also to build their confidence in using these strategies—even when texts may be very difficult to read. Students are encouraged to tolerate ambiguity and adopt a code-breaker stance in response to these complex and unfamiliar texts, thereby broadening their repertoire of textual problem-solving strategies.

Cindy orchestrates students' reading and discussion to foster their engagement with complex texts and ideas, their growing disposition to persevere in the face of complexity, and their flexible application of a variety of problem -solving strategies. She models ways of approaching and interpreting these texts, and her students practice and acquire discipline-specific reading approaches and strategies. Students learn to annotate texts with their thoughts, connections, and questions as they read.

Collaboration and group work give students the support, challenge, and choice to engage in increasingly difficult discipline-specific reading. As students work, Cindy moves from group to group, monitoring students' progress, stopping to give support as needed, and listening to the insights or difficulties individual students demonstrate as they engage in the task.

Classroom conversational routines focus on metacognition and build students' ability to monitor and control their reading. Because she has listened to group discussions, Cindy is prepared to draw groups and individuals into the whole class discussion, to make the knowledge and strategic resources they have offered in small group work available to the entire class, to solve problems that have emerged in common, and to make connections between texts and their own lives.

In this class, the knowledge students have gained outside of class is invited into the class to bring life to texts that may seem impenetrable. Rather than shielding students from the hard work of academic literacy until they demonstrate the capability to comprehend such texts on their own, Cindy engages them in academic reading and provides expert teacher support and a collaborative learning environment. She sees this as the most important way to build young people's academic capabilities.

Yearlong Routines

The Reading Apprenticeship Academic Literacy curriculum covers three units:

- Unit 1: Reading Self and Society
- Unit 2: Reading History
- Unit 3: Reading Science

Students use a handful of metacognitive reading routines to support them in making sense of the varied texts they read in the class:

- Talking to the Text, Think Aloud, summarizing, and a variety of notetakers
- Journal/Unit Learning Log/interactive notebook assignments
- Quick-writes, notes, and reflections
- Ongoing metacognitive conversations

In addition, students engage in significant in-class Silent Sustained Reading (SSR) of at least 15 minutes a day to increase fluency and help them learn how to find and read books they enjoy. Beginning with Unit 2, students are also required to read for an hour a week at home. Students keep an SSR Metacognitive Log that helps them become more aware of their reading preferences, strengths, and challenges. Students set SSR goals every six weeks.

Lesson at a Glance: Reading "Superman and Me"

Cindy's students are just learning about metacognition and how to have a metacognitive conversation with a text. In this lesson, Cindy briefly models a Think Aloud and writes notes about what she is thinking on a projected copy of the beginning of Sherman Alexie's essay "Superman and Me." Cindy then sits down and we see a succession of two student volunteers who take up the Think Aloud modeling role from the front of the room. Classmates offer additional metacognitive comments, which the volunteer of the moment writes on the projected text.

Lesson at a Glance: Reading the First Amendment

This lesson was filmed in January, at the start of Unit 2, History. Students began the unit by creating Personal History-Reading Histories around the following questions:

1. What history-reading experiences stand out for you?
2. What books or other history materials do you remember positively or negatively? Why?
3. What topics in history interest you the most?
4. When have you experienced connections to yourself, your family, or your culture in history? How did that make you feel?

The filmed lesson occurred during an inquiry into the First Amendment. On the day of the filming, students did a close reading of the First Amendment. The following day they would use their knowledge of the First Amendment to determine whether or not a set of court cases related to the First Amendment involved violations of First Amendment rights.

During their First Amendment inquiry, students used metacognitive reading and discourse routines to unpack these unfamiliar and challenging documents and genres. They engaged in ongoing partner, small group, and whole class metacognitive conversation about their reading and thinking processes. Through this recursive cycle of reading and talk, students surfaced confusions, shared problem-solving strategies, engaged in collaborative meaning making, practiced reading and thinking skills, and gained a deep understanding of the First Amendment.

One Teacher's Academic Literacy Class

Lesson at a Glance: Reading *Jailed for Freedom*

This lesson, which shows students reading and discussing an excerpt from a first-person account of the U.S. women's suffrage movement, was filmed in April. It is a continuation of students' exploration of history texts about human and constitutional rights, including, at this point in the unit, suffrage rights.

On the day before the filming, students read and Talked to the Text on an excerpt from the preface to *Jailed for Freedom*, starting with just the title. In a teacher-facilitated inquiry of the title, students spontaneously made connections to other cases where people were jailed for "fighting for freedom" (Martin Luther King, Jr., etc.). One student made a connection to First Amendment rights.

Cindy then projected a transparency saved from January, and written in the handwriting of various students who had helped facilitate the class discussion, of the five freedoms the class had identified during their study of the First Amendment. (Cindy had the transparency at hand these many weeks later because her text and task analysis of *Jailed for Freedom* anticipated that students would make a connection between this new text and the First Amendment.)

From the transparency list of the five freedoms, students identified the specific rights the suffragettes were exercising and for which they had been jailed. Students spoke with understanding about the right to petition the government for a redress of grievances.

The following day, students individually reread the *Jailed for Freedom* excerpt and their Talking to the Text notes, and then, in the portion of the lesson captured on video, sat in a circle and engaged in a student-run debriefing of their notations, understandings, questions, and confusions.

A few days later, the class repeated this seminar-style process with a second excerpt from *Jailed for Freedom*, an account of the author's experiences being incarcerated in the Occoquan Workhouse. Individual students took turns leading the debriefing of the reading and their annotations. In addition to sharing their own Talking to the Text notes, students invited classmates to share their questions and thinking.

In this second seminar, Cindy further reduced her support. According to Cindy, these seminars were the best, most exciting work the class had done all year.

Getting Started

Starting Out Routines

- Think Pair Share
- Think Aloud
- Talking to the Text
- Reading Strategies List
- 1-2 Minute Teacher Model/Guided Practice/Metacognitive Conversation/Formative Assessment
- SOLAR
- Personal Reading History
- Capturing the Reading Process

Reading Strategies to Model Early

- Connecting to prior knowledge
- Predicting
- Questioning
- Using text features
- Identifying and sharing confusions
- Reading visuals
- Clarifying

What Are Scientific Models?

Our ideas about science models

Individual

Make a list of ideas you know, remember, or wonder about science models. List your questions too.

Pairs

- Take turns sharing your ideas with each other.
- Listeners make notes about your partner's ideas. Mark at least one idea you want your partner to explain with a star, and also mark at least one idea that you find really interesting/important with an exclamation point.
- When you have both shared all your ideas, ask your partner to further explain the ideas marked with a star and tell your partner why you found the interesting/important ideas interesting or important.
- As a pair, pick two ideas to share with the whole group.

What Are Scientific Models? (Continued)

Individually

Read "Explanatory Models in Science" and Talk to the Text.

Pairs

- Take turns sharing your Talk to the Text comments.
- Discuss how the information in the article helps you understanding what scientific models are. What new questions arise?
- Pick a few key ideas about models to share with the class.

'Self-Directing Cards' Investigation

Purpose

- Develop and justify a scientific model accounting for the observed phenomena known as 'self-directing cards.'
- Refine our Scientific Models Criteria List.
- Begin a Constructing Scientific Models Strategy List.
- Refine our science Reading Strategy List.

Materials

- 2 decks of playing cards
- Set of 3X5 cards for inquiry extensions
- Force-Motion-Aerodynamics text set

Experiment: How do the cards fall?

1. Hold one playing card at a time between your thumb and index finger by the short sides above a table. Drop the card onto to the table and take note of its motion and landing position.

2. Drop more cards one at a time varying the way you are holding the cards before dropping them to the tabletop.

    Hold the card horizontally.

    Hold the card vertically.

    Slant the card.

    Vary the degree of slant.

    Drop the card from a lower and higher elevation from the tabletop.

   How do these changes affect the way the card behaves?

Think Aloud Model

Make notes about your partner's thinking. What kind of thinking is he/she doing?

Think Aloud notes

Paired investigation while Thinking Aloud:

Take turns experimenting with the playing cards and Thinking Aloud as you do so. After 5 minutes, switch roles.

Partner one: Think Aloud as you drop a playing card. Remember to hold one playing card at a time between your thumb and index finger by the short sides. Be sure to say out loud what you are planning to do, what you wonder or predict will happen, what you notice, etc. Think Aloud as you try to account for the way the playing card drops, trying to give an authentic view of your thinking. Try variations in how you hold the card as described in step 2 above.

Partner two: Silently listen to the kinds of thinking your partner is doing. Write down as many of your partner's thoughts as you can. This record will be useful to you later when you record observations and work to make explanations.

Think Aloud notes

Think Aloud notes (continued – note all the ideas your partner Thinks Aloud)

Experiment: Three piles of cards

How could you separate the cards into three equal piles by dropping them? Continue your exploration while you try to meet this new challenge. Take turns Thinking Aloud and recording one another's thinking.

Think Aloud notes

Explain

Review/share the notes you made. Sort out experimental evidence and observations from interpretations and science reasoning.

Record your observations on the left side of the T chart.

Discuss your observations, trying to explain each of the observations you made. Record these explanations on the right side of the T chart. Feel free to be tentative:

We think what is happening is…

We wonder if…

Also chart any questions that you have in this column. These questions can provide good starting places to take into reading a text to find answers.

Some guiding questions:

What made the cards fall so differently?

Did any of the cards stay steady while falling? How do you explain that?

Did any of the cards turn while falling? How do you explain that?

Evidence	**Interpretation** (questions, confusions, connections, hypotheses, predictions, applied principles)

Evidence	**Interpretation** (questions, confusions, connections, hypotheses, predictions, applied principles)

Reading research

Pairs

Choose two articles to read from the Force-Motion-Aerodynamics text set that will help you create a scientific model accounting for the observed phenomena known as, "self-directing cards."

Individual

As you read, make Evidence and Interpretation Notes, writing down any questions you have, connections you make, ideas you think about as you read, as well as any "roadblocks" you encounter in the form of difficult words, sentences, ideas, or "missing" background knowledge.

Pairs

With a partner who has read the same texts, take turns sharing your reading process – how you went about the reading, what roadblocks you encountered, what questions or connections or ideas occurred to you as you read, etc. (10 min.) Discuss how the information in the article helps with understanding the self-directing cards phenomena. What new questions arise?

Evidence	**Interpretation** (questions, confusions, connections, hypotheses, predictions, applied principles)

Evidence	**Interpretation** (questions, confusions, connections, hypotheses, predictions, applied principles)

Science modeling: The first draft

Scientific models are explanations of phenomena and as such are tentative. Scientists working on/with science models know the evidence base for the model, its limits, its assumptions, what it explains well, what it does not account for, what questions remain. Diagrams illustrating science models in textbooks foreground the explanatory strength of a science model but not the "science" behind the explanation. But without the science there would be no model. We are going to focus on the science – the evidence, the messy work of making sense of the evidence. We are creating a scientific model for the phenomena known as, "self-directing cards" – i.e. the observations you just made – but we can't get there in just one step on our own.

To support our thinking and collaboration, we are going to create metacognitive models for the phenomena. Our diagrams will show our observations, our questions, our confusions, our predictions (both those that worked and those that didn't), the science principles we think apply, and our hypotheses, our predictions and justifications for the explanations we are advancing. We are making these visible because they are the moving parts for figuring out phenomena.

The audience for this model is yourself and all the people in the room who are your "partners" in trying to understand how the card fell. It is about making our thinking visible so we can collaborate in creating a scientific model.

Use the space below and on the next page to create your first draft metacognitive scientific model for how the cards fall.

Some guiding questions:

What made the cards fall so differently?
Did any of the cards stay steady while falling? How do you explain that?
Did any of the cards turn while falling? How do you explain that?
What science principles can help you interpret the observations?
What hypothesis, predictions, questions, confusions, and tentative explanations can you build on or do you need to keep track of?

Peer Review Protocol for Models and Explanations

Purpose

Peer review is essential to science knowledge-building. Peer review provides assurance that someone who is familiar with the topic has double-checked new claims and findings. In peer review of models, we ask:

- Does the model help us explain the phenomenon?
- Does our model help us address our investigation/inquiry questions?
- Does the model (explanation) account for all of the evidence?
- Can we use the model to predict what will happen if we manipulate the phenomena?
- Does the model agree with our understandings about how the world works and other science models?

By cooperating (having each other's back) in peer review we'll develop more reliable and clearer explanations.

Small group analysis or own model

Prepare for peer review by analyzing your process and progress with your own model. Write your notes in **Box 1** on the Peer Review Organizer.

- **Significance:** What ideas did you think about and what questions did you grapple with as you constructed your model? What was the puzzlement?
- **Purpose:** Why did you include what you did in your model? What does your model help explain, predict, or describe?
- **Reliability and justification:**
  - o What aspects of the phenomena or evidence does your model account for? What is your evidence and reasoning for your explanation?
  - o What have you not accounted for yet or what are you unsure about in your model?
- **Future research:** What questions do you have about the phenomena or explanatory model at this point in the investigation?

Presenting and listening

Provide your model to your peers – give them some time to read it over before you present. Some points to address in your presentations are:

- **Significance**: The big question for us was ______ . What was hard to explain was ______.

- **Purpose**: We built our model to try to explain ______. We think it helps explain, predict or describe ______ because ______.
- **Reliability and justification**: We are very confident about ______ parts of our model because ______. We are still unsure about ______ parts of our model because ______.
- **Future research:** We still have questions about ______.

Remaining group(s) listens, reads and makes notes in **Box 2** on the Peer Review Organizer about:

- Anything that is clear in the model.
- Anything that is unclear or potentially misrepresented in the model.
- Anything that is missing from the model (such as evidence that is unaccounted for).
- Anything that does not belong in the model (such as something that appears to lack evidence).
- Questions you wonder about.
- Ideas for refinement to the model.

Developing a response

Listeners take a few minutes to discuss their peers' model and develop a response.

- What is well explained and accounted for in the model? Why?
- What is clear in the model? Why?
- What is unclear or misrepresented in the model? Why?
- What is missing from the model? Why?
- What does not belong in the model? Why?

Prepare two to four substantive responses to your peers' model. Write these in **Box 3** on the Peer Review Organizer.

Sharing feedback

Groups take turn sharing and discussing their response to their peers' model.
Each group makes notes of the feedback they receive from the peers in **Box 4** of the Peer Review Organizer.

Peer Review Notetaker

Our Model

1. My notes for the presentation	4. My notes from peers' feedback

Peers' Model

2. My notes about peers' model	3. My response to peers' presentation

Appendix 4

Reflection and Revision

Small Group Discussion

Discuss how you will respond to the feedback you received.

- What did you see or hear from other groups' models that you liked?
- How will you modify your model, based on the classroom discussion?

Note: Use different colored sticky notes provided by your teacher to label parts of your models that you:

- Are very confident about and want to keep.
- Would like to add to your model.
- Still have questions about.

Revise: Make the revisions (upgrades!) to your model.

Source and Notes:
Adapted from "The Self-Directing Cards," p. 68, in the book *Invitations to Science Inquiry, Second Edition* by Tik Liem. The book offers a set of activities designed to teach the inquiry processes of science through active engagement in investigation.

Classroom connection

This activity provides a model of literacy instruction. What connections are you making to your practice as a teacher in your discipline? What questions and insights do you have at this point?

End-of-Day Reflective Review

This daily routine provides time for you to use flexibly to assess and consolidate your learning and resources, reflect on your own questions and connections to your practice, and write feedback to us

1. Review and Reflect

   Talk to the Text about questions, insights, and connections to practice:
   - Daily agenda
   - Binder section for the day
   - Professional Learning Goals

2. Organize and Consolidate

   Use the blank pages, as desired, to note locations of resources you want to find easily, based on your own interests and questions.

3. End-of-Day Feedback

   Write reflective feedback to the team, based on your review of your insights, ideas, and questions. Please identify yourself on the feedback to allow us to respond to individuals. Logistical feedback (coffee, thermostat, etc.) is welcome, but we really need to know about your learning Gots and Needs:

   Got (for example)
   - I *so* got…
   - I am really starting to get…
   - I got some strategies and am ready to try…

   Need (for example)
   - I have questions about…
   - I'm not clear about…
   - I need more time to…
   - How could I…?

End-of-Day Feedback

Name ______________________________

Date ______________ Email ______________________________

Note: We ask you to identify yourself so that we can get back to you with responses, questions, individual resources…or just a conversation.

Today, I really "got"… (new insights, understandings, confidence about…)	**Today, I need…** (help with questions about, more time on…, to just…)