# Chapter 6: Looking under the hood: Productive messiness in design for argumentation in science, literature and history

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In this chapter we look under the hood, and share the processes of developing designs to support adolescents' learning how to engage in text-based argumentation in science, literature, or history. The work took place in a large, multi-discipline, multi-stakeholder development and research project. The participatory design process surfaced multiple perspectives and debates about central concepts and how to provide instructional support. We make visible some of the often-invisible "productive messiness" of design-based research, exploring the processes of making design decisions, implementations, and iterative revisions as a window into the nuances and adaptations that are integral to teaching and learning processes.

**Introduction**

Design-based research (DBR) as theorized within the Learning Sciences (Brown, 1992; Design-based Research Collective, 2003) aims to enhance our theoretical understanding of mechanisms and processes of learning, while grounding inquiry in improving learning *in situ* in real-world learning environments. Early DBR efforts reflected tension between the application of systematic, rational, "scientific" methods and an "argumentative participatory process in which designers are partners with the problem owners" (Cross, 2007, p. 2). More recently, DBR has embraced more "designerly ways of thinking and communicating" (Archer, 1979, p. 17) in recognizing that designed environments embody conjectures about the interactions and experiences that are theorized to mediate learning (Sandoval, 2014). But the origins and evolutions of these conjectures in the process of design decisions and implementation–revision cycles are often hidden in publications that conform to "scientific" explication of design rationales, learning outcomes and theoretical insights (e.g., Barab et al., 2007). The conceptual and practical dilemmas wrestled with in a participatory design process are left "under the hood" and not discussed.

In this chapter we look under the hood to provide a glimpse into the productive messiness that occurred in the context of a large, multidiscipline, multi-stakeholder development and research project: READI (Reading, Evidence, and Argumentation in Disciplinary Instruction), a five-year project funded in 2010 as one of six projects comprising the U. S. Department of Education Institute for Education Sciences' (IES) Reading for Understanding initiative. READI defined reading for understanding as evidence-based argumentation with multiple sources of information, situated within three disciplines—science, literary reading and history.

Although we began with consensus at a general level regarding design conjectures (e.g., instructional principles, materials, tools, task structures, discursive practices) and theoretical conjectures about how the designs would lead to the desired outcomes, our participatory design process brought to light multiple, often fuzzy and conflicting conjectures about how specific tools, materials, etc. were going to mediate particular learning outcomes (cf. Figure 1, Sandoval, 2014). When it came to actual design decisions, we engaged in "messy" discussions that led to productive clarification and refinement of our thinking about not only how to support student learning but the very nature of what students needed to know and be able to do to engage in argumentation in the three disciplines. In this chapter, we illustrate the productive messiness of design decisions around tools to support students' grasp of the fundamental elements of argumentation—claims, evidence and the reasoning connecting them. We elaborate first on the overall context of Project READI because it introduced several constraints on the design process.

**Design context: Project READI**

Requirements of the IES call for proposals shaped the research and design space for READI. Citing a lack of educational research that effectively addressed reading comprehension beyond the basics of learning to decode, IES called for 5-year proposals to conduct: (1) basic research to contribute to theories of complex comprehension and inform the development of instructional interventions; (2) iterative cycles of design and revision to inform basic research; and (3) randomized controlled trials with the interventions. To maximize the likelihood of interventions impacting classroom practice, practitioners were to be among the project personnel from the inception of the project. READI targeted adolescents from 12 (6th grade in the USA) to 18 (12th grade).

Project teams were free to define reading for understanding as they wished. The READI definition highlighted two considerations often overlooked: the literacy demands of integrating across sources and the specific disciplinary norms and practices governing knowledge production and communication (e.g., Gee, 1992; Goldman & Bisanz, 2002; Lee & Spratley, 2010), such as criteria for sound arguments (e.g., Toulmin, Rieke, & Janik, 1984) and expected forms of information representations (e.g., texts and visuals).

We proposed to design Evidence-Based Argumentation (EBA) modules that would provide students with inquiry tasks that scaffolded opportunities to develop the knowledge, skills and practices needed to engage with sources of information typical of each discipline. These included traditional verbal texts but also diverse "text" forms such as photographs, diagrams, maps and simulations (cf., Goldman, 2012; Lee & Spratley, 2010; New London Group, 1996).

READI personnel were organized into design teams for each discipline plus a basic studies group. Design team members represented multiple scholarly and professional perspectives: university-based researchers in the learning sciences, education and/or psychology; curriculum and professional development designers; disciplinary experts; and classroom teachers (Voogt et al., 2015).

In this chapter, we illustrate the productive messiness of our participatory design process for one component of the larger effort: Evidence and Interpretation (E/I) charts, a tool we conjectured would support students in differentiating claims from evidence. The design of these charts in each discipline evolved through the productive messiness of our participatory design process and efforts to iteratively refine and clarify our conjectures about how the designs were expected to lead to intended outcomes. Our struggles over the "best" way to design these charts and activities around them led to insights into the dynamic nature of disciplinary inquiry and instruction that supports it.

**Design story**

*Initial EBA design efforts*

The incompleteness of our general-level design and theoretical conjectures emerged soon after the grant was awarded and disciplinary teams attempted to develop concrete work plans and timelines for basic studies and designed modules. Across the teams, suggestions for tasks, texts, and support tools made by one team member were met with questions and counterproposals from other team members. For example, in the history team, some wanted to pose questions that asked students to make judgments about particular historical events (e.g., "Was the United States justified in intervening in Vietnam?). Others proposed questions aimed at causal explanations for historical events (e.g., "What events and circumstances led the United States to send troops to Vietnam?"). These debates reflected differences in experience (e.g., classroom versus laboratory), disciplinary orientation (e.g., English language arts versus science education versus psychology) and methodological commitments (e.g., experimental versus ethnographic paradigms). At the first meeting of the whole team three months after the grant began, each disciplinary team attempted to provide the others with a sense of argumentation in that discipline. From this attempt to establish common ground emerged the need to be explicit about the competencies—the knowledge, skills and practices—involved in evidence-based argumentation in each discipline. The hope was that this would allow a clearer articulation of the similarities and differences in disciplinary argumentation and set the stage for specification of the intended outcomes of the interventions.

Each disciplinary team worked on these separately, mining research literature and existing designs. We identified an overarching similarity: five categories of *core constructs* appropriate for capturing the competencies for each discipline: (1) epistemology (what counts as knowledge/how do we know what we know); (2) inquiry practices/strategies of reasoning; (3) overarching concepts, themes and frameworks; (4) forms of information representation/types of texts; and (5) discourse and language structures that are invoked in comprehending and constructing arguments from evidence found in texts. The specifics within each category were particular to the discipline (Goldman, et al., submitted). However, we found that there was little research about developmental similarities and differences in these competencies across the adolescent grade band.

The whole READI team also generated an initial list of “design principles” (more accurately design features) that we agreed to incorporate into EBA designs in all three disciplines. These were derived from work of our own and others (e.g., Bransford, Brown, & Cocking 2000; Britt & Aglinskas, 2002; Donovan & Bransford, 2005; Goldman, Braasch, Wiley, Graesser & Brodowinska, 2012; Lee, 2007; Radinsky, Loh, & Lukasik, 2008; Schoenbach, Greenleaf, & Murphy, 2012; Shanahan & Shanahan, 2008; Wiley & Voss, 1999). In the list below, the first eight refer to features of topics, texts and tasks; and the remaining six to tools or scaffolds that guide the design and realization of classroom instruction.

1. Draw on Core Constructs, addressing at least one aspect of each of the five types of elements.
2. Text set informs the causal model for the phenomena or event in science and history but poses interpretive problems in literature.
3. Integrating across multiple sources is necessary to complete the task.
4. Dynamic model of differentiation (reading proficiency is a reader x text x situation interaction, not a reader trait)
5. Guiding questions, essential questions, key questions, core/big understandings, touchstone concepts are kept in the forefront of the class’ discussion
6. Draw attention to puzzlements and conundrums, to things that puzzle us.
7. Gateway activities, hook or entry points for students to make meaningful connections
8. Consequential tasks are meaningful to students and in the discipline.
9. Routines for metacognitive conversations.
10. Close reading of text to support engagement and reading carefully.
11. Support for text-based discussion citing evidence.
12. Argumentation Templates to provide models for oral and for written argument.
13. Participation Structures that provide opportunities for student talk.
14. Ongoing assessment and formative feedback.

We knew these were ill-defined—a good reflection of the messiness of our design conjectures at this point in the intervention development. Likewise, we had only vague and largely unstated assumptions about how these would mediate processes of learning and result in students developing core competencies. However, we expected to engage in reflections on how the implementations fared—what seemed to "work" for whom, what problems arose, what modifications teachers made while enacting the initial modules—and that these insights would be critical to revising our design and theoretical conjectures. As one PI reminded the group, "We know we aren't going to get it right the first time."

*Initial Evidence/Interpretation charts in science*

The design and use of the E/I charts by the science team and in classrooms revealed the complexity of supporting EBA. Prior to introducing E/I charts in classrooms, science team members read and annotated two texts planned for the Water module and completed an E/I chart (Figure 6.1) to address the inquiry question: "How and where do we get fresh water?" The column headers in Figure 6.1 were intended to promote three processes: identification of text-based evidence; generation of claims, hypotheses or questions; reasoning between claims and evidence. Each team member was to complete the tasks individually and then share their ideas about how these potential texts and tasks fit with our existing core constructs and design features.

<Figure 6.1>

Figure 6.1. Preliminary E/I chart for Water module, prior to classroom trials.

As members of the team shared their experiences and reactions, the complexity of what we were expecting of students became clear. A PI noted her struggle with the 3rd column labeled *Implications: Claims, Hypotheses, Questions* (see Figure 6.1). She remarked that most of what she had written in that column appeared to be summary statements. "Are these really claims?" she wondered. Similarly, a research associate noted that filling out the E/I chart helped him discern important information from the text, but it did not seem to support him in constructing arguments, “It’s a tool that should be a stimulus for students to need to make some sort of argument.” Another PI countered by noting that making sense of the texts was a key step to engaging in text-based argument, and that “you don’t start by putting down evidence that’s ‘relevant’…it presupposes that [the students] know where they’re going, because they don’t know. Some of the things might be evidence, but not for the inquiry question we have.” A former classroom teacher emphasized that the E/I chart should be “one step away from initial contact with the text,” and treated as a more careful selection of aspects of the text that fit with the inquiry questions. Working through the texts and tasks as a team surfaced different perspectives on the purpose and function of the E/I chart, and pointed to differences in team members’ conceptions of what counted as legitimate claims and evidence in the context of text-based inquiry.

This activity also made salient the inextricable relationship between the information selected for inclusion in the E/I charts, the texts, and the task. One research associate attributed the absence of claims to the inquiry question itself: “My hunch is that it has to do with the question itself. It’s hard to get very interpretive about that [a how and where question]. Claims are about interpreting things.” We could not resolve any of the tensions at this point, and a PI summarized this tension: “The note taker(s) [E/I chart] and their role is a really interesting one. We need, but have not yet developed, a way to support students in making claims with the evidence and making explicit connections between them. It raises the question: how do we support claim making and the argument we want kids to get to?”

Although these texts and tasks fit the criteria outlined in the core constructs and aligned with our design features, testing them revealed different perspectives about the purpose and function of each major component of the design (Inquiry task/question, texts, and support charts) and interactions among them. This pushed our team to deeper consideration of how to begin supporting students’ engagement with complex texts and the series of instructional scaffolds that would build their capacities to engage in EBA. We continued to wrestle with these questions as we began to conduct formative observations and collect artifacts as evidence of how teachers and students were engaging with inquiry questions, texts and E/I charts. Our designs continued to evolve as we gained better understanding of how various aspects supported students' engagement in text-based inquiry.

The experience of the science team was not unique. The history team had similar discussions about what made a piece of information evidence for a particular claim and whether sources produced at the time of a historical event were narratives that described what happened or should be regarded as claims that the event occurred. In the literature team, the discussions considered disciplinary disputes about the very nature of interpretive claims about a literary work.

*Learning from initial EBA modules: The inherent messiness of claims and evidence*

Over the course of a two-day project-wide meeting at the end of the second year, there was lengthy discussion about the nature of claims and evidence in different text genres and the challenges this presented for creating tools to support students in differentiating them.

The science team reported on their experiences trying to use E/I charts to support the differentiation of claims and evidence. They shared that although students were learning to identify and interpret statements in the texts that would address the inquiry question, they were not yet distinguishing between claims and evidence in the text (Figure 6.2). For instance, students simultaneously listed statements that might be considered *claims* ("Bacteria can cause a disease") alongside statements that might be considered *evidence* ("The creek is contaminated"). Thus, despite the use of *Evidence* as the column header in the E/I chart, students were not specifically distinguishing *claims* from *evidence*. Instead they "treated both claims and evidence equally" (PI, meeting. transcript).

<Figure 6.2>

Figure 6.2. Evidence/Interpretation chart for sixth grade Water module

One of the PIs on the science team noted that this lack of differentiation of claims and evidence should not be surprising given that most of the texts available in classrooms were textbooks: “This is what a science textbook does. It gives claim after claim after claim with no evidence for the claim.” As a result, “it is sensible that students would see claims as evidence, when really they are to be treated quite differently, and it’s clear that they don't know how to do that.”

Although most members of the team agreed with this characterization of science textbooks, several PIs pointed out possible conceptual problems with teaching students to differentiate *claims* from *evidence,* writ large. One of the cognitive psychologists on the project pointed to the potential danger of conveying a false sense that the status of *claim* or *evidence* somehow inheres in any particular piece of information. She framed it this way:

> I'm just wondering if everything that is a claim can be evidence, and can also be a claim. […] So you can use the same statement eventually to support another statement, and it could need to be supported. So in a way it almost doesn't help I think [to focus on differentiating claims from evidence in a text]. I'm a reductionist, totally, and a component skills person, but this is the one piece I wouldn't reduce and teach people to distinguish these two things, because in the end, functionally, it's all the same. They have to use one piece of evidence to support another piece of evidence, which also has to be supported.

Another PI agreed: “Information in the abstract is not either claims or evidence. You can't generically distinguish. There's nothing inherent in the information that makes it a claim or evidence. It’s its function in some context.”

The impact of these exchanges on design decisions around E/I charts was messy; the goal for students to differentiate a claim from the evidence that supported it remained, but the design of the E/I charts shifted in the direction of distinguishing between information relevant and irrelevant to the inquiry question and being able to explain why it was relevant. For example, in the second iteration of the Water module, the E/I chart contained three column headers: (1) Evidence: What we saw in the text; (2) Interpretation: What we thought about it; and (3) Next

Steps: What we think we know or need to know next (to address the inquiry question). This shift towards contextualizing the task in the inquiry question was similarly reflected in E/I chart design for the second iteration of the history modules. However, observations of student thinking led to additional adaptations to the support tools.

*Expanding supports around E/I charts: The case of history*

For the second iterations of the history modules, both the high school and middle school teachers started their classes by re-orienting students to history as inquiry into the past, thereby motivating the interrogation of texts and other artifacts, re-positioning them as potential sources of evidence about the past. A sixth grade teacher introduced the study of history by posing two questions—"What is history? How can we know about the past?"—and having students generate the kinds of questions historians might ask about artifacts from the past (Field notes, October 2, 2012). Students offered questions such as "What time period is this from?" and "What is the purpose of this object?" She then introduced an adapted version of the E/I chart with two columns labeled *Observations* and *Inferences*. Students used this to make observations and inferences about artifacts from the past (e.g., an antique rug beater, a catalogue of advertisements for a variety of rug beaters). During whole-class share outs, the teacher used follow - up questions to elicit the reasoning for their inferences and also modeled the targeted forms of reasoning.

During a meeting to debrief this lesson (October 2, 2012), the teacher and two history team researchers who had been participant observers during the lessons noted that sometimes students were differentiating observations from inferences but often they were not. For example, one student wrote about the catalogue: "On each picture it tells a couple of sentences of how its good to buy." The inference written next to this observation stated: "They are trying to persuade people to buy them." However, this same student also wrote in the observation column "A flyer that has pictures of carpet beaters" and in the corresponding inference column "It shows how 4 different designs of carpet beaters look like." The struggle to distinguish observations and inferences was pervasive among the students. As the teacher put it, "[students] get confused in the process" and tend to put their observations and inferences in "the wrong categories." She said she noticed that students tended to skip to making inferences without understanding how specific textual observations *led* to a given inference. One researcher observed “[students] don’t slow their thinking enough to catch that that’s now an inference.” The other researcher reported, “that table [of students] was having trouble. Their observation was ‘it's cheap.’ Their inference was ‘it's cheap and useful.’ I was trying to get them to see you can't have it the same and how does cheap relate to useful. But they still seemed confused about that connection. They still thought cheap and, they couldn't explain the connection.”

The teacher and the researchers engaged in productively messy brainstorming about additional ways of leading students to make their reasoning more explicit and thus better differentiate between observations and inferences. The teacher noted that she had previously used a three-column chart—observation, what I know, and inference—“but I think that's even more confusing. You're breaking it down into the parts but you're being too obvious. Asking them to think about what they know so explicitly—it kind of confuses them. I like this [2 column chart] better but it leaves out a piece because you jump from observation to inference” leaving out the reasoning because there is no need to “write down what you know” that leads you to the inference. She also did not think more modeling on her part was the answer: “They were dying, they wanted to say everything.” As a result, the teacher reported that she did not think her efforts to model observations, inferences and the reasoning from observation to inference were being heard. Ultimately, the tool introduced was sentence stems for observation statements and other stems for inference statements. Class discussions focused on the reasoning.

During the next history lesson (October 3, 2012), students brought in personal artifacts from their homes. They took turns making observations about each other’s artifacts using sentence stems such as “I notice,” or “I see” or “I observe …” They then made inferences about each other’s artifacts using sentence stems such as “I can infer …” or “I can guess …” or “I can figure out …” In debriefing this lesson, the teacher and researchers agreed that students were more successful at differentiating between observations and inferences and attributed this success to the sentence stems. As one researcher noted, “It’s hard to say ‘I notice this is special to your family’ right? … You’re not going to say, ‘I can infer this is red.’ So I thought that really scaffolded it.” The differentiation was also evident in the statements written in the observation and inference columns of the charts. Thus, the teacher's design decision to make observations and inferences step-by-step with the support of sentence stems seemed to help students differentiate between the two processes.

The history teacher's design implementation illustrates the need for adaptations to be made in response to feedback that the support tools are not working for students. The "messiness" in the design-based research process is precisely the phenomena that Brown (1992) cited as motivating the need to engage in DBR in the first place. That is, the best laid designs may turn out not to suit the particular context in which they are implemented for a variety of reasons, including the knowledge students bring to the task as well as the affordances of the materials, tasks and tools. This is a common phenomenon in instruction and one of the reasons teachers need to be adaptive experts (cf. Darling-Hammond et al., 2007).

*What claims are the E/I charts supposed to support? The case of literature*

Teachers on the literature team implemented modules that focused on the rhetorical device of symbolism in stories with a coming of age theme. However, they used different literary works, reflecting differences in grade levels (8th, 9th, or 11th) and student demographics. The literature E/I charts were intended to guide students in identifying and interpreting symbols in literary works (See Figure 6.3). The column headers directed students to reason from "What the text says" to "Associations I can make," and from these to "What the symbol means." This progression builds on textual evidence and both real-world and textual associations to determine the meaning of a symbol in a text, as understood by the student. However, this focus on simply what a symbol represents inside a text leads to what one PI, a former English teacher with a Ph.D. in English education and the head of the literature design team, termed "symbol hunting." As she put it, without support to take it further, the message to students becomes "There (are these things) out there, symbols, they exist and you should know them, so go find them." Indeed, several teachers focused on "symbol hunting" in their initial attempts to enact symbolism modules, and once students identified and interpreted the symbols in a text, they left it at that. For instance, one of the teachers showed a video clip of two middle school students discussing the meaning of the black cat in one of Edgar Allen Poe's stories. Literature team members noticed that although the students were discussing the meaning of the symbol, they never went beyond that to discuss the story. It appeared that from the students' perspectives, finding and interpreting the symbol was the end goal of the activity. The implementing teacher agreed and expressed the frustration of his students around the interpretation of the symbol on the E/I support sheet: "I don't get what [that] column is, I told you what it said in the text, I told you the associations I can make, and now I am just going to synthesize the second column and the third column (to put something in [it])." This reflected the problem with "symbol hunting": the students thought their task ended with the interpretation of the symbol.

<Figure 6.3>

Figure 6.3. Literature E/I worksheet used to scaffold symbol identification and interpretation

This discussion of symbolic interpretation led to new insights about this process. As one member put it, once a reader has made an interpretation, they need to think about how that interpretation relates to the text as a whole:

> The reasoning comes back to how much does that explain about what happened in the story and if you can create an argument about how much it explains then you have a reasonable argument and someone else can say it represents something else.

We began to understand that the ultimate argument was not about the meaning of the symbol, but rather how that meaning contributed to an overall understanding and interpretation of the text. This way of thinking about the E/I chart and the support that students needed led the teacher to new understanding of the utility of the symbol column: "how much explanatory power does it give you, the so what, why do we care that you can make the associations about a black cat that they represent bad luck. Why does it matter in this text?" It became clear that the importance in doing activities with the symbolism E/I chart was in pushing students beyond the everyday understanding of the black cat symbolizing bad luck and getting them to think about why the author used a black cat and what it meant for the story.

In this meeting, the discussion stimulated by the video clips and the examination of the E/I chart exposed the raggedy nature of team members' grasp of intended outcomes for symbolic interpretation. This was the case even though we had previously discussed how to support these interpretive processes. In our experiences, especially with multidisciplinary groups, key concepts frequently reflect this type of "messily" shared understanding. As in the present case, it often takes a joint activity engaged in by the group to reveal key differences that stimulate productive exploration of concepts fundamental to the group's work.

**Discussion and conclusions**

The design story for each of the disciplinary teams did not begin with clear, coherent learning objectives for evidence-based argumentation. Instead, our design processes involved rounds of iteration and reflection by all members of the design teams based on observations of what happened during implementations and analyses of student work on the E/I charts. The iterative implementation and reflection moved our thinking toward clearer understandings about how specific design elements supported students in moving towards constructing explanatory and interpretive claims. This process is aptly described as 'productively messy' in that we identified issues about which there was far from universal agreement or understanding among team members. These could not be easily or quickly resolved; design decisions were made in the midst of both uncertainty and urgency to test our imperfect designs in classrooms. Furthermore, we could not easily identify a single design or aspect of a designed artifact as the focal point of revision. Rather, we came to acknowledge the importance of aligning all components of our modules—the inquiry question, the E/I charts and text sets—in order to move towards our objectives. While messy, this process also resulted in productive advances, both to the designed artifacts, as well as our own conceptions of how to support EBA in different disciplines.

Our description of this "productive messiness" differs from a typical depiction of the DBR process. Although we could have described how our design processes contribute to *ontological* *innovations* (diSessa & Cobb, 2004), we focused our efforts here on exposing the messy participatory design process that is often hidden in publications. It might be tempting to attribute the messiness to working in a large, interdisciplinary team. We argue, however, that part of the messiness reported here is a result of *not* iterating on existing tools (e.g., McNeill & Krajcik, 2009; Monte-Sano, De La Paz, & Felton, 2014) or attempting to use one argumentation design template across the disciplines. Instead, and consistent with design recommendations made by Smith, Smith, and Shen (2012), we started with analyses of disciplinary differences in conceptualizations of argument and students' existing competencies, and dove into how teachers and students took up embodiments of our design conjectures. Our work suggests that DBR does not move in a linear, unidirectional fashion (cf. Figure 1, Sandoval, 2014), from conjectures to designed tools, and then to observed outcomes. Instead, studying the designed tools in action can surface messiness that leads to greater clarity in theoretical conjectures about how these designs mediate desired outcomes.

Finally, our work suggests that the process of turning textual information into *evidence* for a *claim* is not straightforward. Supporting students in constructing arguments requires a critical examination of discipline-specific notions of argument that often go unexamined. Our work would have been severely limited if we had focused our efforts on making argument the *object* of teachers' and students' activity (Manz, 2014). Instead, we took up messy discussions and debates that clarified how argument serves as a *tool* for producing knowledge in each discipline. The three questions to which we have returned repeatedly throughout READI—"What is argument?" "What are similarities and differences based on discipline?" and "What instructional affordances support it and how?"—reflect our ongoing commitment to productive messiness. We speculate that these questions, and the subsequent disagreements, frustrations and designs that resulted, would not have been so evident had our work been situated within a single discipline. In closing, we hope that this brief discussion of the participatory design process in READI provokes further conversations about the more designerly, messy, yet productive aspects of DBR.

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