Teaching and Learning Inquiry Framework

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Abstract

This article describes the development of the Teaching and Learning Inquiry Framework (TLIF) and applications for its use. For decades teacher preparation and support has been dictated by a narrow mindset in which academic disciplines have been taught in isolation. This landscape, however, is evolving to align with the view that the world is rarely experienced in disciplinary silos. Interdisciplinary approaches to teaching and learning can enable students to make more holistic connections to the world around them and be better prepared for college and career. With the recent publication in the USA of four related standards-based reform documents across each of the core subject areas, teacher preparation and professional development programs are evolving to offer teachers opportunities to examine the implications of the new standards. To address these complexities, a guiding conceptual framework is needed that focuses in on how inquiry can serve as an entry point to frame the integration of content within and across disciplines. The TLIF was developed out of the hypothesis that teachers need to be prepared to teach in a more interdisciplinary way using inquiry methods. There are six recursive stages to the TLIF: 1) stage and engage, 2) ask and pose, 3) plan and monitor, 4) search and gather, 5) analyze and create, and 6) communicate and apply.

Keywords: inquiry, interdisciplinary, teaching, learning, framework, STEM

1. Introduction

1.1 Interdisciplinary Teaching and Learning

Much is expected of today's teachers, as well as the programs and schools that prepare and support these teachers. For decades this preparation and support has been dictated by a narrow mindset in which academic disciplines have been taught in isolation. This landscape, however, is evolving to align with the view that the world is rarely experienced in disciplinary silos. Most real-world problems are interdisciplinary, and interdisciplinary approaches to teaching and learning can enable students to make more holistic connections to the world around them and be better prepared for college and career (Darling-Hammond, Wilhoit, & Pittenger, 2014). As such, in order to be relevant and competitive, educational systems must adopt a more broadly conceived mindset than the siloed construct that has historically framed policy and curriculum.

One response to the historical narrow mindset around academic disciplines has been a recent international emphasis on science, technology, engineering, and math (STEM) education. STEM can serve as a starting point for connecting all disciplinary subjects together, but interdisciplinarity implies more. According to the literature the four STEM disciplines, themselves, should be taught in an interdisciplinary manner, and STEM as a concept often includes other domains such as social studies, English language arts, art, and more (Bybee, 2010; Chiu, Price, & Ovrahim, 2015; Sanders, 2009).

A helpful development is the recent publication in the United States of four related standards-based reform documents across each of the core subject areas—

- *Next Generation Science Standards* (*NGSS*) (NGSS Lead States, 2013)
- *Common Core State Standards in Mathematics (CCSS-Math)* (National Governors Association & Council of Chief State School Officers [NGA & CCSSO], 2010)

- *Common Core Standards for ELA & Literacy in History/Social Studies, Science, and the Technical Subjects* (*CCSS-ELA*) (NGA & CCSSO, 2010)
- *College, Career, and Civics Framework for State Standards in Social Studies* (*C3 Framework*) (National Council for the Social Studies [NCSS], 2013).

A dynamic intersection of disciplinary literacies frames these projects, with all four describing significant shifts in teaching and learning, including: 1) progression of knowledge through the development of increasingly sophisticated skills, 2) core inquiry practices that put into action academic skill, 3) cross-cutting concepts, 4) building content knowledge through reading informational text, and 5) reading, writing, and speaking grounded in evidence. Educators can view these shifts through a lens that recognizes the power of inquiry to unify the disciplines. One effort to do so can be found in, what Bybee (2013) refers to as, *STEM Literacy*, which includes an individual's capacity to: identify scientific questions or problems, explain the natural and designed world citing evidence, understand the features of inquiry and design, awareness of the nature of STEM disciplines, and willingness to engage in STEM-related issues as a concerned and active citizen. Another example can be found in social studies, where the authors of the *C3 Framework* (NCSS, 2013) similarly make the case for integrated literacies through inquiry, including the skills and practices of: questioning, making inferences, using evidence, argumentation, and active civic discourse. Because of these shifts, we see great potential in using inquiry as a framework for conceptualizing the overlapping goals of the standards frameworks, which will, in turn, encourage interdisciplinary teaching and learning.

Advocates argue that integrated approaches to curriculum "make learning more applied, more critical, more inventive, and more meaningful for students" (Hargreaves, Earl, Moore, & Manning, 2001, p. 112). Integration can be put on a continuum moving toward fewer distinctions between subjects (Bybee, 2013; Drake, 1991; 1998; Drake & Burns, 2004). Multidisciplinary forms of integration retain the emphasis on the individual disciplines, while interdisciplinary integration mixes all the subjects in a way that they can't be easily separated and the boundaries among subjects get blurry (Wang, Moore, Roehrig, & Park, 2011). The process of interdisciplinary teaching and learning should begin in elementary school (Carrier, Faulkner, & Bottomley, 2016) and gain complexity as learners get older. This will require teachers to shift their thinking and practice in order to prepare children with the authentic inquiry-oriented experiences needed to make interdisciplinary learning possible (Carrier et al, 2016; Feiman-Nemser, 2001).

1.2 The Role of Inquiry in Interdisciplinary Teaching and Learning

It is important to acknowledge that "inquiry" can mean different things to different people, so before continuing we offer our views on this term. Inquiry can be broadly defined across disciplines as "an approach to learning that involves a process of exploring the natural or material world that leads to asking questions and making discoveries in the search for new understandings" (Exploratorium Institute for Inquiry, 1996). Inquiry provides a way for organizing teaching and learning that gives students opportunities to accept increased responsibilities for developing knowledge. In many ways inquiry reflects approaches we use every day to solve problems and improve our life. While inquiry has applications to everyday life, it also has the capacity to represent the structures of academic disciplines. Furthermore, inquiry has been established as a preferred approach to instruction through decades of research, stretching from John Dewey's work at the University of Chicago Laboratory School to the work of Newmann, King and Carmichael (2007) in positioning disciplinary inquiry as a critical element of authentic intellectual work.

Inquiry, whether presented implicitly as is the case with *CCSS-ELA* and *CCSS-Math*, or explicitly as with the *NGSS* and *C3 Framework*, is important to educators of all disciplines and can serve as an entry point to frame the integration of content within and across disciplines. Science educators have built a substantial research-supported case supporting inquiry as a key to the development of scientific literacy (American Association for the Advancement of Science, 1994; National Research Council, 1996), and other disciplines have similarly conceived of literacy within their fields (Dewey, 1916; Evers, 2011; Grant, Swan, & Lee, 2017). The goal of integrated inquiry-oriented teaching and learning is difficult to achieve, much in part because of the decades-long focus on teaching content knowledge in disciplinary silos. With little attention to cross disciplinary methods and processes of inquiry, the majority of today's teachers and students hold incomplete and inaccurate views of science (Lederman, 2007), mathematics (Lockhart, 2009), and social studies (Adler, 2008), causing them to see each discipline as uninteresting and irrelevant (Lockhart, 2009; McComas, Clough, Almazroa, 1998; Zhao & Hoge, 2005). These views limit teachers' use of inquiry teaching methods (Bencze & Bowen, 2006) and thus limit students' opportunities to practice processes of inquiry. Conversely, teachers with more complete and accurate views of the disciplines have the potential to use more inquiry methods (Shim, Young, & Paolucci, 2010), thereby improving student literacy across the disciplines (Bell, 2009; Bybee, Powell, Ellis, Giese, Parisi, & Singleton, 1991; Driver, Leach, & Millar, 1996; Grant, Lee, & Swan, 2017).

Our hypothesis is that teachers need to be prepared to teach in a more interdisciplinary way using inquiry methods.

With the recent publication of *CCSS-ELA*, *CCSS-Math*, *NGSS*, and the *C3 Framework*, teacher preparation and professional development programs have had to evolve to offer teachers opportunities to examine the implications of the new standards. This is difficult work, for although there are similarities across the four major standards projects they were not developed in full concert with each other. To address these complexities, a guiding conceptual framework is needed that focuses in on how inquiry can serve as an entry point to frame the integration of content within and across disciplines. It is this range of inquiry experiences that we seek to represent in the framework we have developed, aptly named the *Teaching and Learning Inquiry Framework*.

2. Developing the Teaching and Learning Inquiry Framework (TLIF)

In developing an inquiry framework, we started by positioning the four new standards frameworks in support of inquiry teaching and learning (see Figure 1), with *CCSS-ELA* playing a particularly important foundational role because a key design consideration for the *CCSS-ELA* was that “instruction in reading, writing, speaking, listening, and language be a shared responsibility within the school” (NGA & CCSSO, 2010, p. 4). Next, we accounted for the fact that both the *NGSS* and the *C3 Framework* were written to work in tandem with the *CCSS*. For the *NGSS*, connections to the *CCSS-ELA* and *CCSS-Math* standards are included across all disciplines and grade bands; for the *C3 Framework*, the mathematical practices are acknowledged as having applications to social studies inquiry, while the *CCSS-ELA* standards are viewed as “foundational, supportive, and vital” (NCSS, 2013, p. 20) to preparing young people for democratic civic life. The *CCSS-Math and CCSS-ELA* both aim to prepare students for college and career, but explicit connections between the two documents were not made. In the implementation of *Common Core*, states have made efforts to connect the *ELA* and *Math* standards. For example, the state of Wisconsin has published a document entitled *Wisconsin State Standards for Literacy in All Subjects* (Evers, 2011), where they explicitly describe how math is a useful academic context for supporting literacy instruction. Whether explicitly laid out in the standards frameworks themselves or later made more explicit by the states adopting them, a dynamic intersection of disciplinary literacy skills frames these standards projects, with all four describing significant shifts in teaching and learning toward inquiry. These shifts can be accounted for in the “practices” (Note 1) across the frameworks, which consistently stress the importance of asking questions or posing problems, planning investigations, making inference, engaging in argument from evidence, and communicating conclusions. Like the authors of the *C3 Framework* (NCSS, 2013), we view these shifts in literacy skills and practices as “establishing a foundation for inquiry” (p. 20).

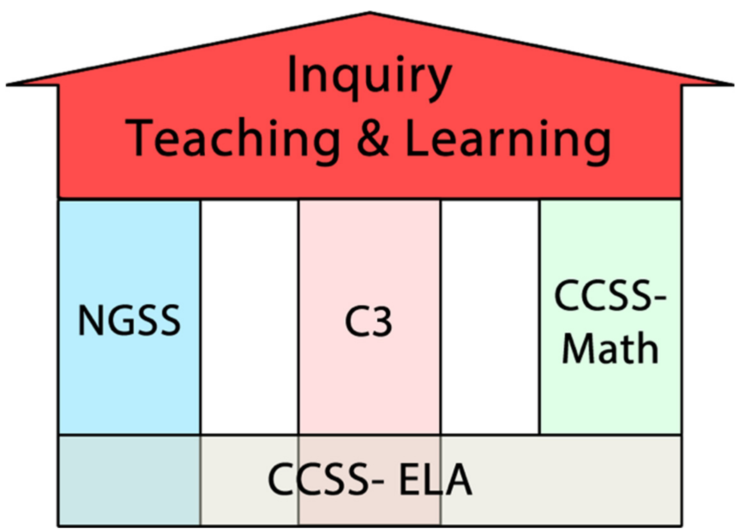

Figure 1. Standards Supporting Inquiry Teaching and Learning

As our next step, we considered how an inquiry framework would have to capture two complex parallel processes: 1) the decisions teachers make in **designing inquiry lessons**, and 2) the instructional moves they make while **facilitating student inquiry**. Capturing these parallel processes led us to investigate a number of established instructional design frameworks and inquiry instructional models. Four of these approaches (Understanding by Design, Universal Design, Gradual Release of Responsibility Framework, and the Inquiry Design Model) are focused on instructional design, while the other four (Project-Based Learning, the 5E Instructional Model, the Conceptual Change Model, and

Authentic Intellectual Work) are focused more directly on inquiry instruction (see Table 1). We acknowledge that other frameworks and models that complement inquiry exist but attempting to account for too many would yield little new information.

Table 1. Instructional Design Frameworks & Inquiry Instructional Models

Instructional Design Frameworks	Inquiry Instructional Models
Understanding by Design (UbD) UbD emphasizes “backward design,” the practice of looking at learning outcomes in order to design curriculum units, performance assessments, and classroom instruction. (See Wiggins & McTighe, 1998; 2005)	**Project-Based Learning (PBL)** Through PBL students actively explore real-world problems and challenges and acquire deeper knowledge, often leading to a designed solution. (See Krajcik & Blumenfeld, 2006; Buck Institute for Education at http://bie.org)
Universal Design for Learning (UDL) UDL provides a blueprint for creating instruct-ional goals, methods, materials, and assess-ments that work for everyone—flexible approaches that can be customized and adjusted for individual needs. (See Rose & Meyer, 2002; Universal Design for Learning Imple-mentation and Research Network [UDL-IRN], 2011; National Center on Universal Design for Learning) at http://www.udlcenter.org	**5E Instructional Model (5E)** The 5E model is a multi-phase instructional sequence that can be used for science programs, specific units, and individual lessons. The phases are: engagement, exploration, explanation, elaboration, and evaluation. (See Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, & Landes, 2006; BSCS at http://bscs.org/bscs-5e-instructional-model)
Gradual Release of Responsibility Framework (GRRF) GRRF has teachers shift responsibility of performing tasks to situations in which students assume all of the responsibility. This is accomplished by delivering lessons planned to incorporate four interrelated instructional phases: 1) Focused Instruction, 2) Guided Instruction, 3) Collaborative Learning, 4) Independent Learning. (See Fisher & Frey, 2013; Pearson & Gallagher, 1983)	**Conceptual Change Model (CCM)** CCM leads learners from explicit discovery of their own existing knowledge and the views of their classmates, through a set of targeted challenges and opportunities, to a new level of understanding that is reinforced through application and extension of ideas and skills. (See Posner, Strike, Hewson, & Gertzog, 1982; Schmidt, Saigo, & Stepans, 2006)
Inquiry Design Model (IDM) IDM is an approach for developing inquiry that features the core elements of the *C3 Framework's* Inquiry Arc. Beginning with a compelling question and standards alignment, the model suggests a series of supporting questions, related formative performance tasks, and sources for completing these tasks. The model culminates with a summative performance task and plan for taking informed action. (See Grant, Swan, & Lee, 2017; Swan, Lee, & Grant, 2018; C3 Teachers at http://www.c3teachers.org).	**Authentic Intellectual Work (AIW)** AIW focuses academic instruction on student construction of knowledge, conceptual understanding, and value beyond school through elaborated communication to answer questions resembling the complex intellectual challenges of work, civic participation, and managing personal affairs in the contemporary world. (See Newmann et al, 2007; Center for Authentic Intellectual Work at http://centerforaiw.com).

Table 1 shows the instructional design frameworks and inquiry instructional models that were consulted in developing the Teaching and Learning Inquiry Framework.

The key, we believe, is that regardless of the instructional design framework(s) and/or inquiry instruction model(s) a teacher must use—and they often vary greatly from school to school—they can all be re-positioned to support inquiry. Much like the similarities that were found in the “practices” of the standards reform documents, our deep dive into instructional design frameworks and inquiry instruction models showed many overlapping characteristics. From all this overlap we identified six overarching phases of inquiry that can be applied when designing inquiry lessons or facilitating student inquiry. These six recursive phases constitute the *Teaching and Learning Inquiry Framework* (TLIF) (see Figure 2):

- Stage & Engage: Stimulating cognitive engagement with relevant topics through experiential activities.
- Ask & Pose: Engagement leads to the asking of questions or posing of problems that spark and sustain inquiry and continued engagement.
- Plan & Monitor: Developing discipline-specific procedures for conducting the inquiry.
- Search & Gather: Seeking out relevant sources and gathering information from within sources.
- Analyze & Create: Applying disciplinary skills and strategies to create findings through the analysis of gathered information; creating products of the inquiry.
- Communicate & Apply: Communicating the products of the inquiry and applying knowledge gained in new settings.

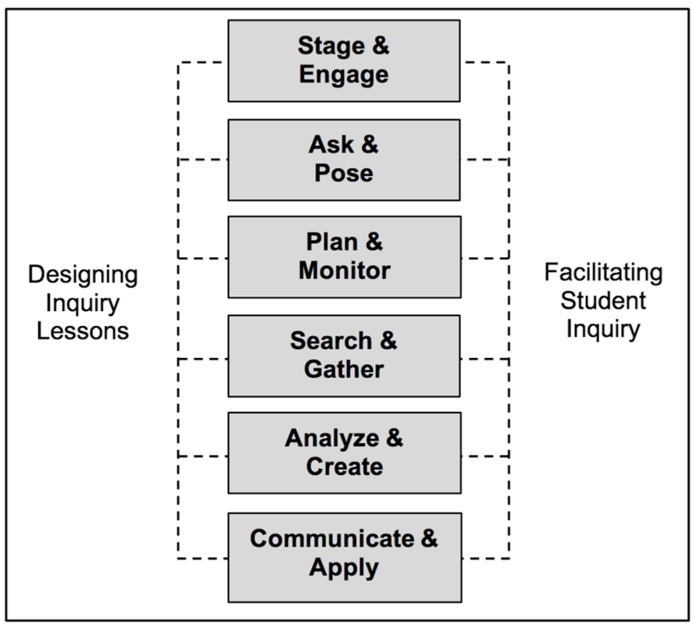

Figure 2. Teaching & Learning Inquiry Framework (TLIF)

We emphasize that TLIF phases can occur in order but sometimes they do not, which is why they can be considered recursive. At any given phase in the process of designing inquiry lessons or facilitating student inquiry, aspects of other phases can be applied. For example, teachers are likely to *Ask and Pose* questions as a way to *Stage and Engage* inquiry or as they scaffold other phases. Similarly, the inquiry process might start with the *Analysis* of existing data/information, which leads to the *Asking* of questions. Or more holistically, the *Plan and Monitor* phase is likely to have overarching applications to all the phases. Because of this potential interactivity, there are implications for a teacher as she engages in the two parallel processes of designing inquiry lesson and facilitating student inquiry. Similarly, because inquiry requires that learners play a more active role, there are also learning implications to be considered. In Figure 3, we describe the unique implications within each phase of TLIF for both teaching and learning.

TLIF Phase	Teaching Implications	Learning Implications
Stage & Engage	Consider the student learning outcomes and anticipated results to develop an engaging introductory activity	Actively participate in an introductory experience that introduces and stages the inquiry
Ask & Pose	Pose questions about how students will engage content and the problems they will encounter during the inquiry	Based on introductory activity, develop compelling questions/problems and supporting questions
Plan & Monitor	Sketch initial ideas for scaffolding student inquiry activities and assessments	With questions in place, determine process for answering questions or solving problems
Search & Gather	Locate sources and information/data needed to implement and scaffold the inquiry	Activate the plan by locating sources and information/data relevant to the questions or problems
Analyze & Create	Determine disciplinary strategies and scaffolds to help novice learners complete expert-like analysis tasks	Apply disciplinary skills and strategies to analyze gathered information/data and to create findings
Communicate & Apply	Establish a range of approaches for students to share and act on what they have learned	Consider implications of the findings and share with relevant audience in ways that resemble real-life work

Figure 3. TLIF Implications for Teaching and Learning

3. Applications of the TLIF

Producing K-12 students that are literate across disciplines will require teachers to improve their disciplinary literacies outside their area of expertise, particularly their understanding of disciplinary and cross-disciplinary methods and processes of inquiry. This is especially true for elementary teachers because they teach all subjects. Unfortunately, because of the siloed thinking around the disciplines, we typically see students' days, even at the elementary level, broken into succinct discipline-specific timeframes. Moreover, it should come as little surprise that we rarely see examples of effective interdisciplinary inquiry-oriented teaching and learning when teacher preparation and professional development programs rarely take such an approach.

Using the TLIF, novice and experienced teachers, alike, can examine the interdisciplinary and inquiry-oriented implications of the new content standards and learn how to position commonly used instructional design frameworks and planning models to support inquiry. Opportunities to accomplish this will ideally occur in contexts in which teachers are trained in approaches to designing and delivering standards-aligned lessons, such as preservice teaching methods courses or inservice professional development offerings. In Tables 2 through 9, we provide an overview of how the aforementioned instructional design frameworks and inquiry learning models can be situated within the TLIF framework, with attention paid to how steps within these frameworks and models can be bridged across phases in the TLIF. Because of its widespread use, we discuss Understanding by Design first and in greater detail now and follow with short discussions of the remaining frameworks and models.

Understanding by Design (UbD) (Wiggins & McTighe, 1998; 2005) is applied by teachers around the world, but this framework for designing lessons is not explicitly aimed at inquiry. With UbD, instructional activities are designed following the step-wise WHERETO process (see Table 2), but this does not mean that instruction should be delivered in the same order. Take for example the countless number of lessons, seminars, and workshops we have all experienced where the first thing the instructor does is cover the day's learning objectives. This approach is taken straight from the UbD playbook where the first WHERETO step, W, has the teacher tell students where they are headed, why they are going there, and what ways they will be evaluated along the way. While it makes some intuitive sense to start this way, it is problematic. As Donald Clark (2015) puts it, "if the first experience many learners have is…a dull list of learning objectives, attention is more likely to fall than rise." It serves inquiry better to start with the second WHERETO step, H, which is to provide a hook to engage students' interest and enthusiasm through thought-provoking experiences. Repositioning UbD steps within the TLIF in this simple way can help to ensure that learning is properly staged and that learners are engaged before they move on to subsequent activities. Table 2 shows one approach to aligning UbD steps to better support inquiry teaching and learning. We acknowledge that there are likely other ways to re-order or re-emphasize the steps UbD for this purpose, as is the case with the other frameworks and models we analyzed.

Table 2. Understanding by Design Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Identify Desired Results: 1) Begin with Standards 2) Determine Big ideas 3) Identify Key Understandings 4) Develop Essential Questions **Plan Instruction:** (WHERETO) ● H = **Hook** and engage students' interest and enthusiasm through thought-provoking experiences at the beginning of each instructional episode.		**Determine Acceptable Evidence:** 1) Explain 2) Interpret 3) Apply 4) Perspective 5) Empathize 6) Self-knowledge	**Plan Instruction:** (WHERETO) ● E = **Experiences** provided to help students make their understandings real and to **equip** all learners for success. ● R = Causing students to **reflect**, **revisit**, **revise**, and **rethink**.		**Plan Instruction:** (WHERETO) ● O = **Organize** learning experiences so that students move to independent applications that emphasize growing conceptual understandings.
Plan Instruction (WHERETO) ● W = Design to tell students **where** they are headed, **why** they are going there, and **what ways** they will be evaluated. ● T = **Tailor** instruction to address unique strengths and needs of every learner.				**Plan Instruction:** (WHERETO) ● E = Students **express** their understandings and engage in self-**evaluation**.	

The TLIF can also be usefully applied to instructional models that were explicitly developed to be inquiry oriented. The 5E inquiry model (Bybee et al, 2006) and the Project-Based Learning (PBL) model (Krajcik & Blumenfeld, 2006) both can lead to structured student inquiry experiences, where questions, procedures, and even expected solutions are given to students in advance. Both models can be positioned within TLIF as a way to ensure that these approaches do not become overly prescriptive and lose sight of larger inquiry instructional goals. Table 3 and 4 explore how the steps of these two models can be repositioned for this purpose.

Table 3. 5Es Model Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Engage: Teacher engages students in a new concept through the use of short activities that promote curiosity and elicit prior knowledge as well as organize students' thinking toward learning outcomes.		**Explain**: Teacher introduces necessary con-cepts, processes, skills, and technical information, while students explain their understand-ings.	**Explore**: Students test predictions and hypotheses, record observations and explanations, form new predictions and hypotheses. **Explain**: Students develop explanations based on data using recorded observations.		**Evaluate:** Students share explanations to others, listen critically to others' explanations, question others' explanations, check for others' understanding.
				Elaborate: Students form new predictions and hypotheses, try alternatives, compare personal explanation with scientifically accepted explanation, and assess own understanding.	

Table 4. Project-Based Learning Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Entry Event: The teacher conducts an entry event that provides students with real-life samples of the projects they will be doing.	**Ask and Pose:** Project work is focused on an open-ended driving question that students explore or that captures the task they are completing.	**Roles and Rules:** Students take on the role of project designers and establish a forum for display. Teacher and students negotiate evaluation criteria.	**Understand:** Students develop knowledge and skills to answer the driving question.		**Present:** Students present projects to public audience.
			Design: Students accumu-late the back-ground information needed and the materials neces-sary for the project.	**Create:** Students create projects.	**Reflect:** Students reflect on the process and evaluate the projects.

Similar to the 5Es and PBL models, the Inquiry Desing Model (IDM) emphasizes structured inquiry learning but also enables student agency through open argumentation and opportunities for taking informed action on what they have learned (Grant, Swan, & Lee, 2017). Table 5 positions IDM within TLIF to show how all stages of inquiry can be presented through IDM.

Table 5. Inquiry Design Model Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Questions/Tasks: Staging the question task(s) introduce students to the ideas behind the compelling question in order to generate curiosity in the topic	**Questions:** Compelling questions address issues found in and across the academic disciplines that make up social studies.	**Questions/Tasks/Sources:** Teachers consider how the Questions, Tasks, and Sources work together to provide an interesting and intellectually useful opportunity for students.	**Sources:** Students work with disciplinary sources to build knowledge needed to respond to compelling question while practicing the skills of social scientists.	**Tasks:** Teacher designs formative performance tasks for students to practice the skills and acquire the content needed to perform well on a summative task.	**Tasks:** Students construct an argument using specific claims and relevant evidence while acknowl-edging competing views. Students take informed action in their communities given what they have learned.

Higher levels of inquiry require students to play active roles in asking questions or posing problems, planning procedures, and discovering solutions (Banchi & Bell, 2008). Using the TLIF, 5E, PBL, and IDM lessons can be planned and delivered with the intent of removing scaffolding over time so that learners are able to become independent inquirers, as is the more explicit goal of the Gradual Release of Responsibility Framework (GRRF) (Fisher & Frey, 2013; Pearson & Gallagher, 1983) and Authentic Intellectual Work (AIW) (Newmann et al, 2007). Tables 6 and 7 provide approaches for positioning GRRF and AIW within TLIF.

Table 6. Gradual Release of Responsibility Framework Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Focused Instruction: Teacher establishes the purpose of the lesson and models his or her thinking.	**Guided Instruction:** Teacher strategically uses questions, prompts, and cues to facilitate student understanding, and focuses on releasing responsibility to students while providing instructional scaffolds to ensure that students are successful.		**Collaborative Learning**: Students work in collaborative groups to produce something related to the topic at hand. Students are provided opportunities to consolidate their understandings before they apply it independently.		**Independent Learning:** Students apply what they have learned in and outside of class.

Table 7. Authentic Intellectual Work Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Connections to Outside World: Students make connections bet-ween substantive knowledge and public problems or personal experiences.	**Connection to Students' Lives:** Students address a concept, problem, or issue in the relevant discipline that is similar to one that they have encountered or are likely to encounter.	**Deep Knowledge:** Students address ideas central to the discipline with enough thorough-ness so that conceptual relationships can be explored and understandings produced.	**Construction of Knowledge:** Students organize and interpret information in addressing a concept, problem, or issue relevant to the discipline.	**Higher-Order Thinking:** Students manipu-late information by synthesizing, generalizing, hypothesizing, and arriving at conclus-ions that produce new meanings and understandings.	**Extended Value:** Students present explanations and conclusions through extended forms of language to resemble real-life work.

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Substantive Conversation: Students engage in extended conversational exchanges with teacher and peers in a way that builds shared understanding of ideas or topics.				**Elaborated Communication:** Students demonstrate an elaborated, coherent account that draws conclusions or makes generalizations or supported arguments. **Disciplinary Concepts/Construction of Knowledge:** Students demonstrate understanding of disciplinary concepts and thinking about disciplinary content.	

The Conceptual Change Model (CCM) is more specifically aimed at students' roles in the inquiry process by addressing students' preconceptions and providing opportunities for students to expand upon and apply new knowledge in novel settings (Schmidt, Saigo, & Stepans, 2006). This model can be particularly useful in helping teachers support students to be actively engaged throughout each stage of an inquiry. Table 8 provides an example of how CCM can be situated within TLIF for this purpose.

Table 8. Conceptual Change Model Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Commit to a Position or Outcome: Students become aware of their own thinking by responding to a question or by attempting to solve a problem or challenge.		**Expose Beliefs**: Students share and discuss their ideas, predictions, and reasoning with their classmates before they begin to test their ideas with activities.	**Confront Beliefs**: Students confront their existing ideas through collabora-tive experiences that challenge their preconceptions, including: working with materials, collecting data, and consulting resources.	**Accommodate the Concept**: Students accommodate a new view, concept, or skill by summarizing, discussing, debating, and incorporating new information.	**Extend Concept**: Students apply and make connections between the new concept or skill and other situations and ideas. **Go Beyond**: Students pose and pursue new questions, ideas, and problems of their own.

Universal Design for Learning (UDL) is a framework used around the world that supports teachers in designing flexible instruction that presents information in multiple formats and media, provides multiple pathways for students' action and expression, and provides multiple ways to engage students in learning (Rose & Meyer, 2002). The application of UDL can occur in traditional classroom contexts, but it can also play a vital role in helping teachers plan for the variety of scaffolds students require to be successful in performing complex inquiry tasks. The Universal Design for Learning Implementation and Research Network (UDL-IRN, 2011) has developed a backwards-design instructional planning process that incorporates five steps, and like UbD these steps can be repositioned to scaffold inquiry. Table 9 explores one such way to do so, accounting for the significant overlap steps can have across inquiry stages.

Table 9. Universal Design for Learning Situated within TLIF

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
Establish Clear Outcomes: Establish a clear understanding of the goals of the lesson, including: ● Desired big ideas learners should come to understand. ● Desired outcomes and essential student understandings and performance for every learner. ● Potential misunderstandings,		**Measurable Outcomes and Assessment Plan:** Establish how learning is going to be measured, including: ● Previously established lesson goals and learner needs. ● Embedding checkpoints to ensure all learners are successfully meeting their desired outcomes. ● Providing learners multiple ways and options to authentically engage in the process, take action, and demonstrate understanding.			**Reflection, New Understandings:** Teacher check-points include: ● Did learners obtain big ideas and desired outcomes? ● What can be improved? ● How did strategies and tools provide for multiple means of representation, action,

Stage & Engage	Ask & Pose	Plan & Monitor	Search & Gather	Analyze & Create	Communicate & Apply
misconceptions, and areas where learners may meet barriers to learning. **Anticipate Learner Needs:** Have a clear understanding of learner needs, including: ● Strengths and weaknesses specific to lesson/unit goals. ● Background knowledge. ● Preferences for language, represent-ation, expression, and engagement. ● Cultural relevance and understanding. ● Curriculum barriers that could limit the accessibility to instruction/materials.		● Supporting higher-order skills and encouraging a deeper connection with the content. **Instructional Experience:** Establish the instructional sequence of events, including: ● Intentional and proactive ways to address the established goals, learner needs, and the assessment plan. ● A plan for how instructional materials and strategies will be used to overcome barriers and support learner understanding. ● A plan that ensures high expectations for all learners and that the needs of the learners in the margins are met. ● Integrate an assessment plan to provide necessary data.			expression, and engagement? ● What additional tools would have been beneficial and why?

4. Conclusion: Interdisciplinarity of the TLIF

We close by returning to our opening comments regarding the complex interdisciplinary needs of the current K-12 educational environment, and specifically why a meta-framework like the TLIF is needed. If our expectation is for all students to be capable of performing expert-like tasks across disciplines, then teaching for inquiry must transfer better across disciplines. It is no longer enough for a teacher to be knowledgeable of the teaching standards only in one's area of expertise. Secondary science teachers, for example, should have deep knowledge of not just the *NGSS*, but also *CCSS-ELA* and *CCSS-Math*. Teaching for interdisciplinary inquiry also requires that teachers not unbendingly subscribe to a single approach to designing and delivering inquiry lesson. This can be difficult, because just as academic disciplines have historically been taught in relative isolation from each other, so too has been the development of many instructional design frameworks and instructional models. The TLIF was conceptualized in an effort to provide much-needed context to the interdisciplinary nature of the four content standards frameworks, and it was subsequently developed through a detailed cross-examination of multiple instructional design frameworks and inquiry instructional models. Two of the frameworks and models we have discussed are discipline specific (Inquiry Design Model, 5Es Model), three focus more on interdisciplinary learning (Project-Based Learning, Conceptual Change Model, Authentic Intellectual Work), and three are content-neutral (Understanding by Design, Universal Design for Learning, Gradual Release of Responsibility Framework). Designing and delivering interdisciplinary inquiry-oriented instruction will likely require the application of a combination of these, and possibly other, frameworks and models. As a meta-framework, the TLIF exists so that regardless of the content standards addressed and design frameworks and/or instructional models applied in the design and delivery of lessons, the goal of interdisciplinary inquiry can be achieved.

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Note

Note 1. The term "practices" is found only in *NGSS* and *CCSS-Math*; the *C3 Framework* refers to similar skills and dispositions in its "inquiry arc," and the *CCSS-ELA* refer to them in their discussion of "student capacities."