MIDDLE SCHOOL NATURAL DISASTER INQUIRY UNIT WITH SCAFFOLDING

By

Megan Ireson-Janke

A Project Presented to

The Faculty of Humboldt State University

In Partial Fulfillment of the Requirements for the Degree

Master of Arts in Education

Committee Membership:

Dr. John Y. Lee, Committee Chair

Dr. Shannon Morago, Committee Member

Dr. Eric VanDuzer, Program Graduate Coordinator

May 2018

ABSTRACT

MIDDLE SCHOOL NATURAL DISASTER INQUIRY UNIT WITH SCAFFOLDING

Megan Ireson-Janke

Inquiry based learning is complex and challenging. In order to maximize its benefits, it is vital to understand what teaching methods and scaffolds best support different student populations as they are introduced to inquiry-based learning in different contexts. One major challenge of inquiry is organizational: planning the process and organizing the information. This project studied the effectiveness of using a particular scaffolding tool, an advanced organizer template, to support seventh grade science students in an introductory inquiry-based unit. One group of seventh grade students used the advanced organizer template and one group did not. Students chose the type of project to create and their partner. Previous performance in their science class, the type of project they chose, and whether or not they used the Advanced Organizer Template were all statistically significant predictors of their success in the project. The data collected and observations made helped to develop the final Natural Disaster Unit.

ACKNOWLEDGEMENTS

I would like to thank Dr. John Y. Lee and Dr. Eric VanDuzer for their support and feedback in this project as well as throughout my journey through this program. Thanks as well to Dr. Shannon Morago for her time and suggestions. Brian Fink was my informal statistics teacher, comic relief-provider, and fellow traveler.

My husband Eric picked up the slack for our family—without him I wouldn't have been able to do this—and our kids were understanding and tolerant of my other life. My mother was another source of incredibly valuable support. Thank you all!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

While science education in the US over the last several decades has historically contained an element of inquiry, embedded through teaching the scientific method, teacher-centered content delivery has been the norm. With Common Core State Standards and Next Generation Science Standards, there is an increased emphasis on learning content through student-directed and inquiry-based learning (IBL). While a positive development, this change is challenging not only for teachers, but also for students. Many students spent the early years of their education becoming accustomed to teacher directed, standards-based content instruction.

In the “traditional” school model, teachers and textbooks identify the problem, tell students what kind of answer they need to produce, and give them the directions for doing so. Out in the “real world” people identify and define the problem for themselves, then figure out what kind of solution they need, and determine how to reach the solution. In the classroom, the transition from traditional to inquiry-based learning is complex and challenging; when studying the effectiveness and outcomes of different inquiry methods, the number of possible variables is astronomical. Learning what approaches work for different populations and in different circumstances are essential to making the transition to IBL.

As a science teacher interested in using more inquiry-based and less teacher-directed learning, the purpose of my project is to develop an inquiry unit specifically for my students, to support them during the beginning of their transition to inquiry-based learning, and to provide the appropriate balance of freedom and support (scaffolding) for them to start developing their independent learning skills. In my experience, students new to IBL struggle to define the question, plan an approach, find and identify reliable information, and organize their information. I found inspiration in Zhang and Quintana's (2012) study of middle school students engaging in online inquiry; I saw a model that I thought would work for my students. Not only was the type of project similar, but the scaffolding tool (a software called the Digital IdeaKeeper) used in the study appeared to address the areas in which my students had struggled. In developing this unit, I included various scaffolding methods aimed at those areas in which my students have been challenged in the past. I also conducted a study to see whether a particular scaffolding tool would improve student outcomes on an inquiry-based project, taking into consideration their existing general science knowledge and skills. While this unit has specific science content, the basic framework and rubrics can easily be adapted to any topic, including in other academic subject areas.

The scaffolding in the unit in this study, the Natural Disaster Unit, includes modeling for identifying and defining the problem, an introduction to skills involved in evaluating information and a tool for organizing research and information. The organizational tool was designed to assist students in organizing the process and the information and was the scaffolding tool tested in this study.

Rather than start with science inquiry in the form of scientific experimentation, the Natural Disaster Unit is a non-experimental research project. There are two reasons for this choice: 1) many science teachers, myself included, are already comfortable teaching experimental science and 2) it is adaptable to different subject areas.

Chapter Two presents literature relevant to understanding inquiry-based learning and scaffolding and how scaffolding strategies can be useful in transitioning students to inquiry-based learning. Chapter Three describes the methodology, specifically the overall format of the unit, with scaffolding, the action research to test a particular scaffolding tool, and the results and observations from the unit implementation and study. Chapter Four contains the unit, in a format suitable for teacher use, and Chapter Five summarizes the findings of the action research and unit implementation, and suggests how the unit fits into the process of transitioning students from “traditional” teacher-directed learning to open-ended inquiry-based learning.

LITERATURE REVIEW

Introduction

During the last several decades, science teachers have frequently taught using at least some aspects inquiry, in the sense that they explicitly taught the scientific method as a process and utilized it in experiments (Blanchard, Southerland & Granger, 2009; Eick, Meadows & Balkcom, 2005; Peters, 2010). Many, however, approached much of the science content information through more traditional teacher-directed methods, such as textbooks, notes, and videos (Blanchard et al., 2009; Eick et al., 2005; National Research Council, 2000; Peters, 2010). Labs, as well, were often fairly scripted, including procedures and data tables generated by the teacher rather than the student (Blanchard et al., 2009; Eick et al., 2005; Peters, 2010). The shift in standards to Common Core State Standards and Next Generation Science Standards corresponds with a recognition among educators and policy-makers that the skills needed in life, work and citizenship have evolved, with the ability to analyze information, solve problems, think critically, communicate, collaborate, make strong arguments, and continue to learn becoming more important (Common Core State Standards, 2010; Larmer, Mergendoller & Boss, 2015; Next Generation Science Standards, 2012; Next Generation Science Standards, 2016; Next Generation Science Standards, n.d.a; Next Generation Science Standards, n.d.b.). In order to prepare students for skills that will be necessary in work, personal, and public life, the new standards emphasize these process skills (Kotb, 2013; Common Core State Standards, 2010; Next Generation Science Standards, 2012).

As a result of the new standards and accompanying proficiencies, teachers need to adjust their teaching methods to promote the development of student skills in analyzing information, solving problems, thinking critically, communicating, collaborating, making strong arguments, and continuing to learn (Kotb, 2013). While science teachers often have experience teaching the specific skills relevant to the scientific method, such as asking questions and developing hypotheses, designing experiments, organizing and analyzing data, and presenting conclusions, inquiry-based learning in other segments of science curriculum can promote the development of analyzing, problem solving, thinking, communicating, collaborating, and learning skills in a broader context (National Research Council, 2000). Inquiry-based learning (IBL) encompasses a multitude of approaches that intend to build those skills (Barron & Darling-Hammond, 2008; Boaler, 2002; Duch, Groh & Allen, 2001; English & Kitsantas, 2013; Larmer et al., 2015). While science teachers are generally familiar with the scientific method, that doesn't translate directly to running an inquiry-based classroom (Blanchard et al., 2009; Eick et al., 2005). In fact, experienced science teachers may teach and model the scientific method without giving students an opportunity to ask and answer their own scientific questions (Blanchard et al., 2009; Eick et al., 2005; Peters, 2010). While that practice includes an inquiry component, the scientific method, many would not consider it to be inquiry in its highest and best form (Barron & Darling-Hammond, 2008; Eick et al., 2005; Larmer et al., 2015; MacKenzie, 2016). Even experienced science teachers may need support in transitioning to a more truly student-centered inquiry-based style of teaching (Anderson, 2002; Blanchard et al., 2009; Peters, 2010).

Through approaching real-world issues and problems in open-ended contexts, IBL inspires students to develop skills such as analysis, critical thinking, problem-solving, and communication, as well as collaborating with others (Barron & Darling-Hammond, 2008; Boaler, 2002; Duch et al., 2001; English & Kitsantas, 2013). For students who began their education with a teacher-directed experience, the transition to a more open-ended learning environment is challenging (Eick et al., 2005; Peters, 2010). Therefore, a question facing many science teachers is how to best support and scaffold students in the transition from more traditional teacher-directed learning environments to an IBL environment. While there are numerous approaches to scaffolding inquiry, there are substantial overlaps between them, and many of the studies discussed in the literature review include multiple scaffolding methods (English & Kitsantas, 2013; Hannafin et al., 1999; Hitt & Smith, 2017; Holbrook & Kolodner, 2000; Hsu et al., 2015; Larmer et al., 2015; MacKenzie, 2016; Pea, 2004; Peters, 2010; Simons & Klein, 2006; Zhang & Quintana, 2012).

The overall purpose of this literature review is to identify and understand scaffolding methods that may be useful for supporting my seventh grade science students, whose previous inquiry-based learning experience is very limited, in developing the skills necessary for successful IBL.

This review of the literature begins with an overall review of IBL, its history in the United States, benefits and challenges, and the plethora of ways in which it can be practiced. Next, the theoretical basis of scaffolding and its role in IBL is addressed. Finally, this review explores specific methods of scaffolding that have been used in IBL in middle and high school.

Inquiry-Based Learning

Definition of inquiry-based learning

In inquiry-based learning (sometimes called inquiry learning), students carry out a collaborative investigation to solve an authentic question or problem, and, in the process, learn content and reasoning, communication, and analysis skills and practices (Anderson, 2002; Hmelo-Silver, Duncan & Chinn, 2007; Mikroyannidis et al., 2013).

Origin of inquiry-based learning in the United States

Inquiry-based learning is frequently traced back to John Dewey, a progressive era educator and thinker (Larmer et al., 2015; Maida, 2011; Spires, Hervey, Morris & Stelpflug, 2012). Dewey founded an experimental school in Chicago, the University Elementary School, with the vision that children would engage in inquiry (Dewey, 1900; Spires et al., 2012). Dewey claimed that people learn best by experiences in life, by being active and engaged, rather than passively absorbing knowledge; he also asserted the importance of self-direction and interdisciplinary study (Dewey, 1900). Dewey remarked on changes in education that he attributed to the changes in the American social system of the time (Dewey, 1900):

> ...to make each one of our schools and embryonic community life, active with types of occupations that reflect the life of the larger society, and permeated throughout with the spirit of art, history, and science. When the school introduces and trains each child of society into membership within such a little community,

> saturating him with the spirit of service, and providing him with the instruments of effective self-direction, we shall have the deepest and best guarantee of a larger society which is worthy, lovely, and harmonious. (p. 44)

Dewey's idea of schools reflecting the occupations of the larger society and providing students with self-direction and skills of citizenship corresponds to the methods and goals of the NGSS and CCSS (Common Core State Standards, 2010; Next Generation Science Standards, 2012; Next Generation Science Standards, 2016; Next Generation Science Standards, n.d.a; Next Generation Science Standards, n.d.b).

Since Dewey's time, inquiry in education has been implemented in many ways. The modern variations of inquiry-based learning largely share the basic premise that students ask a question or identify a problem and do the thinking and research to answer the question, develop a solution to the problem, or construct an explanation or model (Barron & Darling-Hammond, 2008; English & Kitsantas, 2013; Hitt & Smith, 2017; Larmer et al., 2015; "Problem Based Learning Initiative - Southern Illinois University School of Medicine PBL page," n.d.; Savery, 2016; Thomas, 2000).

<u>Benefits and challenges of inquiry-based learning</u>

While some have charged that inquiry-based learning is ineffective and inefficient, there is substantial evidence that students participating in IBL with sufficient support learn the target content as well or better than peers learning in a traditional manner (Barron & Darling-Hammond, 2008; Gallagher & Stepien, 1996; Hmelo-Silver et al., 2007; Holbrook & Kolodner, 2000; Kirschner, Sweller & Clark, 2006; Thomas, 2000). IBL is a better approximation of how science, in particular, is carried out in the real world and develops logical, critical, scientific, and creative thinking as well as communication and collaboration skills (Hmelo-Silver et al., 2007; Zion & Mendelovici, 2012).

Even those who espouse the benefits of IBL admit that it comes with challenges. At a basic level, teachers and learners are generally inexperienced and uncomfortable with inquiry-based learning (Anderson, 2002; Bender 2012; Blanchard et al., 2009; Eick et al., 2005; Peters 2010). It can be overwhelming to simultaneously teach and learn both content and the skills needed for inquiry (Holbrook & Kolodner, 2000). Inquiry based learning is complex; determining when and how to introduce it to students is not always straightforward.

> The … important questions to ask are under what circumstances do these guided inquiry approaches work, what are the kinds of outcomes for which they are effective, what kinds of valued practices do they promote, and what kinds of support and scaffolding are needed for different populations and learning goals. The questions that we should be asking are complex as is the evidence that might address them. (Hmelo-Silver et al., 2007, p. 105)

As mentioned by Hmelo-Silver et al. (2007), guided inquiry is a scaffolded IBL experience intended to support students who do not yet have the skills for completely open IBL and can be used in the transition from “traditional” learning to inquiry-based learning (MacKenzie 2016; Zion & Mendelovici, 2012).

Scaffolding

Definition & benefits of scaffolding

Scaffolding is providing students with supports that assist them to achieve greater understanding and success (Jackson, Stratford, Krajcik & Soloway, 1995; Saye & Brush, 2002; Simons & Klein, 2007). Scaffolding can be tools, strategies, guides, or teacher questions and feedback (Simons & Klein, 2007). Scaffolding enables students to engage in activities that would otherwise be beyond their ability and to gain new and deeper understanding (Jackson et al., 1994). Scaffolding in inquiry serves four functions: navigating inquiry, structuring tasks, supporting communication, and fostering reflection (Hsu, Lai, & Hsu, 2015).

According to Pea (2004), the term scaffolding was first used in reference to tutoring young children. Wood, Bruner and Ross (1976) describe scaffolding as

> The adult "controlling" those elements of the task that are initially beyond the learner's capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence…. It may result, eventually, in development of task competence by the learner at a pace that would far outstrip his unassisted efforts. (p. 91)

Pea (2004) emphasizes the importance of continuous diagnosis of the learner's proficiency by the adult involved in scaffolding, as well as the appropriate adjustments in the amount and type of scaffolding. The overall goal of scaffolding for the learner is to eventually be capable of completing the task independently, without scaffolding supports (Collins, Brown & Newman, 1988; Pea, 2004).

Fading

Fading is the gradual reduction of scaffolding support by the "master" as the learner increases their mastery of the desired skill (Collins et al., 1988). Pea (2004) identifies fading as a key component of scaffolding, one which distinguishes scaffolding from tools like computing technology which also allows people to do tasks that would be impossible without the tool, but are used by masters as well; they are not intended to be removed as the learner's proficiency increases.

As learners continue to practice the skill, the amount of support they need to be successful decreases with increasing proficiency; independent practice also enables them to be more aware of their progress (self-monitoring) and what they still lack (Collins et al., 1988). Scaffolding can be faded either over the course of a single unit, a project, several projects, or the whole school year (Eick et al., 2005; English & Kitsantas, 2013; McKenzie, 2016; Zion & Mendelovici, 2012).

In order to achieve the end goal of mastery of a skill or skillset, a task requires scaffolding designed or chosen for its particular challenges. Scaffolding in inquiry serves four purposes: navigating inquiry, structuring tasks, supporting communication, and fostering reflection (Hsu, Lai, & Hsu, 2015).

Categories of scaffolding

It is useful to categorize scaffolding tools into groups with similar function or delivery. Hannafin, Land, and Oliver (1999) have developed categories for scaffolding, sorted by their function, whereas Saye and Brush (2002) have grouped scaffolding by delivery method.

Hannafin et al. (1999) defined four general categories of scaffolding: conceptual, metacognitive, procedural, and strategic. Conceptual scaffolding assists the student in deciding what information they need to consider to complete their task and supports their understanding of the relevant concepts (Hannafin et al., 1999; Simons & Klein, 2006). Examples of conceptual scaffolding includes addressing common misconceptions, providing graphics that show relationships between ideas, directing students to pertinent information, and/or manipulation tools (Hannafin et al., 1999; Simons & Klein, 2006)

The purpose of metacognitive scaffolding is to provide students with some direction in how to think about a problem. This type of scaffolding can be developed specifically for a topic being studied or might be more generally applicable (Hannafin et al., 1999). Metacognitive scaffolding is directly related to self-regulated learning and self-monitoring (English & Kitsantas, 2013; Zhang & Quintana, 2012). It helps students consider whether a tool or resource is helpful for their problem or current need, as well as realize what they already know and have accomplished and what they still need to know or do (Hannafin et al., 1999; Zhang & Quintana, 2012).

Procedural scaffolding provides support to learners in how to use the tools and resources they have available to them. Directions on how to bookmark web pages, use particular software, or use a laboratory tool are examples of procedural scaffolding (Hannafin et al., 1999). Remembering the necessary procedures for each tool or resource can be cognitively taxing, so providing a manner of delivering that information as needed by the learner is valuable (Hannafin et al., 1999).

Strategic scaffolding supports students in developing a strategy for approaching a problem, planning activities, or analyzing information collected. Strategic scaffolding can include questions that look at a problem from different perspectives, directions to use relevant tools or resources, or prompts to check for understanding against specific resources (Hannafin et al., 1999).

Saye and Brush (2002) organize scaffolding into two categories: hard and soft scaffolding. Hard scaffolding is static and designed ahead of time by instructors, based on their anticipation of student needs. Soft scaffolding, conversely, is dynamic, a result of interactions between learners and teacher; a teacher may use probing questions to understand the thought process of a student, ask questions intended to lead the student down a certain path of understanding, and then refer them to helpful resources (Saye & Brush, 2002). While prepared expert guidance embedded into an inquiry-based learning task may provide conceptual or strategic assistance, Saye and Brush (2002) maintain that the greatest value of hard scaffolding is in reducing the demand on teachers for spontaneous soft scaffolding (Simons & Klein, 2006). The cognitive challenges of the types of poorly defined problems used in inquiry-based learning may require the expert guidance of and ongoing dialog with a teacher wielding appropriate soft scaffolding, but the pre-designed hard scaffolding may sufficiently assist enough students so the teacher has the ability to assist students without a back-log of unmet student needs (Pea, 2004; Saye & Brush, 2002). In addition to the dynamic nature of soft scaffolding, it is also human, tied in to identity, community, responsibility, and caring for others, and therefore, according to Pea (2004), perhaps of greater value than hard scaffolding built into a software program or prepared curriculum.

In order to achieve the end goal of mastery of a skill or skillset, a task requires scaffolding designed or chosen for its particular challenges.

Approaches to Scaffolding in Inquiry Based Learning

The number of ways to implement and deliver the various categories of scaffolding is almost infinite; this review will limit the discussion to a handful of strategies which have been studied with middle or high school students engaged in inquiry-based learning.

Organizational

One of the challenges that face students in IBL is organizing both their efforts and their information. With a broad question to answer or problem to solve, the first step for students is to define the aspect(s) of the question or problem to be addressed, followed by finding information through reading or experimentation. Throughout this process the learners must record what they learn in a way that is usable and allows them to stay focused on their questions. Zhang and Quintana (2012) studied sixth grade students as they completed an online inquiry-based project. Half the students used Digital IdeaKeeper, a program that assisted in organization by bringing all the parts of inquiry (questions, planning, online searching, evaluation of sources, note-taking and organizing, analyzing, and synthesizing) into one digital portfolio. The other group searched online but did all other work in notebooks, without a prescribed organizational structure. The Digital IdeaKeeper groups were consistently more engaged with the content, more efficient with their time, and better at self-monitoring and self-regulation than the groups who primarily worked in their notebooks. The measurement of engagement included time spent on- or off-task, amount of consecutive time spent on individual activities, and time spent reading and taking notes on each website. The high achieving IdeaKeeper groups conducted one third fewer searches and spent at least twice as long reading each website, compared to the high achieving non-IdeaKeeper groups. The IdeaKeeper groups were more efficient, in part, because they had less time off-task and spent less time on low level activities such as recording the URL. The IdeaKeeper groups were more likely to begin the day by planning their approach, revisiting websites, and looking back at their questions to monitor their progress (Zhang & Quintana, 2012).

Based on my experiences attempting to introduce seventh grade students to IBL, this study and the idea of the Digital IdeaKeeper program stood out because it seemed likely to support my students in the tasks that were challenging to them: organizing their research process, evaluating websites for reliability, organizing their information, and knowing they still needed to do. This study tested a modified recreation of the Digital IdeaKeeper scaffolding presented by Zhang and Quintana (2012).

Pre-designed organizational scaffolding would be considered metacognitive scaffolding in the system described by Hannafin et al. (1999) and hard scaffolding according to Saye and Brush (2002). It is possible that Hannafin et al. (1999) might categorize Digital IdeaKeeper as a tool rather than scaffolding, but Zhang and Quintana (2012) refer to it directly as scaffolding. Organizational scaffolding is not the only form of scaffolding in the Digital IdeaKeeper study; built into the organizational framework are some explicit steps in the process of inquiry: planning, searching, analyzing, and synthesizing (Zhang & Quintana, 2012).

<u>Making steps of inquiry explicit</u>

One way of supporting learners new to IBL is to explicitly teach them the steps of inquiry and then walk them through the process with precise directions and support at each step, something illustrated in numerous studies (Holbrook & Kolodner, 2000; MacKenzie, 2016; Zhang & Quintana, 2012; Zion & Mendelovici, 2012). Digital IdeaKeeper incorporates this approach by dividing the online inquiry process into four major steps: planning, searching, analyzing, and synthesizing (Zhang & Quintana, 2012). It further breaks down information-gathering by providing a three-step process to evaluate each source, with multiple prompts for each step (Zhang & Quintana, 2012). A Taiwanese study that evaluated various ways to teach a geology unit on tectonic plates found that including specific instructions about the nature of inquiry improved student outcomes and cognitive growth (Hsu et al., 2015). Hitt and Smith (2017) have built on the Three Levels of Thought model designed for chemistry instruction (Johnstone, 1991) to create Three Levels of Thinking Version II. The original Three Levels of Thought model separated a concept into macroscopic (tangible, visible), sub-microscopic (atoms or molecules), and symbolic (definitions and formulas). Three Levels of Thinking Version II includes eight distinct steps, each designed by the instructor with overall and incremental goals in mind. A major part of this model is the focus on students creating their own models and explanations and to master the language used to communicate the science concept (Hitt & Smith, 2017).

One way to approach inquiry in explicit steps incorporates fading over successive inquiry units or projects. In the first stage, structured inquiry, the inquiry process is dictated by the teacher. In each successive stage, the amount of teacher-control diminishes and student-independence increases (MacKenzie, 2016; Zion & Mendelovici, 2012). In structured inquiry, all students work through the inquiry process in a step-by-step manner to answer a question posed by the teacher (MacKenzie, 2016; Zion & Mendelovici, 2012). The teacher provides explicit instructions and resources at every stage and all students produce the same product (MacKenzie, 2016; Zion & Mendelovici, 2012). Although the student work is not independent, by walking through a process that is modeled for them, they develop basic inquiry skills and gain a conceptual model that is important to building the complex skills of real inquiry (Collins et al., 1988).

The step(s) following structured inquiry begin the process of fading teacher control. In the intermediate step(s), variously referred to as controlled or guided inquiry, the teacher defines the question and procedures and may provide some of the resources, but the students determine the process to be followed (MacKenzie, 2016; Zion & Mendelovici, 2012). MacKenzie (2016) breaks this process into two steps, while Zion and Mendelovici (2012) use one step.

The last stage in this series is called open inquiry or free inquiry. In this stage, the students independently define their question, process, and product (MacKenzie, 2016; Zion & Mendelovici, 2012). Zion and Mendelovici (2012) suggest that the teacher define the general topic. Although much decreased, teacher scaffolding and facilitation is still crucial in this step (MacKenzie, 2016; Zion & Mendelovici, 2012). MacKenzie (2016) suggests that teachers frontload with planning tasks and embed checkpoints for reflection throughout the inquiry process. Zion and Mendelovici (2012) emphasize the importance of teachers asking challenging questions to guide and support students in their inquiry process, in part because the better a student can describe their thinking, the more effective they tend to be at managing their inquiry process.

These examples of breaking inquiry down into a series of explicitly taught discrete steps incorporate specific scaffolding strategies that fit into three of the four categories defined by Hannafin et al. (1999): conceptual, metacognitive, and strategic. Building explicit instruction into prepared materials is another example of hard scaffolding, but the continued dynamic support of the teacher throughout the process, the importance of which many of the studies mentioned directly, is soft scaffolding (MacKenzie, 2016; Saye & Brush, 2002; Zhang & Quintana, 2012; Zion & Mendelovici, 2012).

One way of walking students through the steps of inquiry at the beginning or before the larger inquiry unit is what is called front-loading or using a launcher unit.

<u>Front-loading or launcher unit</u>

Multiple authors demonstrate the effectiveness of introducing skills or strategies at the beginning or even before an inquiry unit is begun. Various skills can be taught before introducing the inquiry unit (Holbrook & Kolodner, 2000; Larmer et al., 2015; Peters, 2010).

Learning by Design, a particular model of IBL, utilizes a launcher unit to introduce the design process, learning and process rituals, inquiry skills, and collaborative and scientific practices (Holbrook & Kolodner, 2000). In the launcher unit, students work on a series of short design challenges applying the strategies that will be used in later, longer units. These strategies support checking progress (metacognitive scaffolding), sharing ideas (conceptual and strategic scaffolding) and exploration (Hannafin et al., 1999; Holbrook & Kolodner, 2000).

Beginning the transition to more inquiry-based, student centered learning requires both explicit instruction in how to operate as well as a gradual withdrawal of teacher-directed activities (Holbrook & Kolodner, 2000; Larmer et al., 2015; MacKenzie, 2016; Peters, 2010). In one case study, the science teacher began gradually transitioning from "cookbook labs" to more open-ended experiments where the teacher provided the question and described a possible control procedure and the students developed their own experiments (Peters, 2010). Modeling thinking about open-ended questions and the process of developing them, letting students know that the teacher will not be directing them each step of the way, and sharing the products created by previous students in inquiry-based units, all set the stage for students to open their minds to inquiry-based learning (Larmer et al., 2015).

Problem solving and critical thinking skills can be addressed ahead of the unit, as well as during it. Activities that build critical thinking, accompanied with discussion, explicit teaching of problem-solving, and brainstorming processes will prepare students to use those skills and strategies during IBL, although they will also likely need support in those areas during the process (Larmer et al., 2015).

Advanced instruction in the tools and research skills that students use during the inquiry process makes the tools more accessible to the learners as they need them. Examples of tools and skills that can be introduced ahead of time include: online searches and evaluation of sources, scientific writing, how to contact and interview and expert, and how to use particular software tools such as presentations, publishing, video, etc. (Larmer et al., 2015; Zhang & Quintana, 2012).

Regardless of the type of frontloading, many researchers and practitioners support relatively intensive scaffolding early in the process of inquiry (English & Kitsantas, 2013; Hsu et al., 2015; Larmer et al., 2015; MacKenzie, 2016; Zhang & Quintana, 2012). Initial support in the inquiry process could include feedback on such areas as question development, prompting students to identify existing knowledge, what they need to learn, and preliminary ideas of where to find that information; or it might also entail an advanced organizer directing students to the tasks to be accomplished at each step in the inquiry (English & Kitsantas, 2013; Hsu et al., 2015; Larmer et al., 2015; MacKenzie, 2016; Zhang & Quintana, 2012).

The methods depicted in this section include examples of each of the categories defined by Hannafin et al. (1999) and Saye and Brush (2002). Among the metacognitive skills that may be addressed during front-loading or launcher units can be skills related to self-regulated learning, self-monitoring, and reflection.

<u>Utilizing self-regulating, self-monitoring and reflection</u>

A key skill set in successfully navigating the inquiry process is metacognitive: knowing what is known, what needs to be known, and what thinking is occurring. English and Kitsantas (2013) declare that self-regulated learning is an invaluable component to the success of inquiry-based, student-centered learning. English and Kitsantas (2013) use Zimmerman's (1989) definition of self-regulation as the metacognitive, motivational, and behavioral engagement of a student in their own learning. Teachers can provide support to students who struggle to take responsibility for their learning by intentionally "cultivating behaviors, goals, beliefs and strategies that lead to" student-regulated learning (English & Kitsantas, 2013, p. 131).

Breaking project-based learning (PjBL, one of the common forms of IBL) into phases, English and Kitsantas (2013) propose ways teachers can provide this support in each phase. The first phase includes the introduction of driving questions and learning goals, as well as student identification of what they need to know. The teacher prompts students to identify what they already know about the topic, what they need to know, and to develop a plan to find the information they need, while simultaneously providing more support, explicit directions, and modeling for students new to PjBL. In phase two, the inquiry and product/solution phase, teachers focus on making student thinking visible, prompting students to articulate their thoughts, reasoning, and process through feedback on notes or drafts, and asking probing questions about how conclusions were reached and what evidence students have to support their conclusions (English & Kitsantas, 2013). Phase three, includes the formal presentations of student work to their teacher, peers, and possibly community members, along with a mechanism for providing feedback and opportunity for student reflections. The purpose of the teacher at this stage is to promote peer-to-peer evaluation, individual reflection, provide a chance to relate conclusions and findings back to the initial learning goal and encourage student sharing of approaches that worked as well as those that did not. Additionally, the teacher commends student effort and choices of appropriate strategies, perseverance rather than ability, and, finally, emphasizes the importance of effort and motivation for success (English & Kitsantas, 2013).

One example of a group of students developing self-regulating skills is the seventh grade class transitioning to student-centered learning as described by Peters (2010). Peters explains the gradual transition of the class as they become capable of independent research, peer support, socially constructing knowledge, and even peer regulation of off-task learners. These are all behaviors that English and Kitsantas (2013) identify as evidence of students developing the skills of self-regulated learning.

Closely related to self-regulated learning is self-monitoring, as exemplified by the study of a sixth grade online inquiry unit (Zhang & Quintana, 2011). Zhang and Quintana (2011) found that students using the Digital IdeaKeeper software were more likely to monitor their progress, which correlated with deeper engagement with the content and, theoretically, more understanding and greater success with the product, although those factors were not measured.

Reflection, another metacognitive practice important to IBL, can be defined as "The process of describing, critiquing, evaluating and discussing the whole inquiry cycle or a specific phase. Inner discussion" (Pedaste et al., 2015, p. 54). Reflection can encompass process as well as content knowledge (Larmer et al., 2015; Pedaste et al., 2015; Smith, 2010). In a study of a year-long PjBL STEM project involving both middle and high school students, Smith (2010) found that creating reflective videos about the process allowed students to identify and verbalize both their cognitive and metacognitive growth through the experience; students identified life lessons as well as content and process skills. By reflecting on the process, students make what they learned more accessible for future use.

Scaffolding to promote self-monitoring, self-regulation, and reflection all fall into the category of metacognitive scaffolding, ways in which to think (Hannafin et al., 1999). While some of these approaches can be pre-designed hard scaffolding, individual teacher-student interactions that challenge students to explain their thinking and their progress, the soft scaffolding, are an integral part of the system of student supports (English & Kitsantas, 2013; Saye & Brush, 2002).

Conclusion

Successful scaffolding systems for IBL can be complex, incorporating multiple approaches to supporting students at different points in their inquiry (English & Kitsantas, 2013; Hitt & Smith, 2017; Holbrook & Kolodner, 2000; Hsu et al., 2015; Larmer et al., 2015; MacKenzie, 2016; Pea, 2004; Peters, 2010; Simons & Klein, 2006; Zhang & Quintana, 2012). Most of the studies discussed here incorporate multiple scaffolding types and of the four general approaches highlighted-- organizational, making steps of inquiry explicit, front-loading, reflection and self-regulation and -monitoring-- there are many overlaps (English & Kitsantas, 2013; Hannafin et al., 1999; Hitt & Smith, 2017; Holbrook & Kolodner, 2000; Hsu et al., 2015; Larmer et al., 2015; MacKenzie, 2016; Pea, 2004; Peters, 2010; Simons & Klein, 2006; Zhang & Quintana, 2012).

Inquiry based learning, when done appropriately, results in at least equivalent mastery of content as well as development of higher level thinking and collaboration skills; the questions that remain about IBL relate to how best to implement inquiry and what kinds of scaffolding are most supportive in different situations with different student populations (Gallagher & Stepien, 1996; Hmelo-Silver et al., 2007; Holbrook & Kolodner, 2000; Kirschner, Sweller & Clark, 2006; Thomas, 2000). In addition to identifying what works, it is equally important to identify and study cases in which the inquiry and scaffolding design did not result in the expected results (Pea, 2004).

METHODOLOGY

Unit Development & Action Research Design

The purpose of this project was to develop an inquiry-based (non-experimental) unit for my seventh grade science classes at a school in rural Northern California, containing appropriate scaffolding to support students whose incoming IBL experience is limited to structured inquiry. My goal was to test two versions of an inquiry unit, with a difference of one scaffolding tool, by using by action research. The general topic of the unit was Natural Disasters.

In a previous attempt at an inquiry-based research project, presented without specific content and product instructions, students struggled to define their topic, to determine what exactly they needed to learn and what information to put into their product, and how to organize both the process and the product. In my experience, students who are accustomed to being told exactly what to do at every step have a hard time identifying their question, deciding how to get reliable information to answer their question, creating a complete and coherent product, and managing their time.

The unit began with the driving question: “How can death, injury, and destruction to property and the environment caused by a particular natural disaster be reduced?” that was used to write the secondary questions. The secondary questions addressed causes and likelihood of the disaster, as well as how to prepare for and act during the disaster (see

Appendix A). Those questions defined the scope of the driving question and formed the basis for developing a rubric for the project's product.

Drawing on the literature, and keeping my students' needs in mind, I incorporated multiple types of scaffolding into the unit. One approach for scaffolding this unit was inspired by the Zhang and Quintana study (2012) with sixth grade students, described in Chapter 2. The study used an organizational tool, the Digital IdeaKeeper, which helped to structure student's internet research. Based in part on the idea of the Digital IdeaKeeper, I developed an advanced organizer template (Organizer) for the Natural Disaster Unit. (I worked in Google's G Suite of apps, using Google Forms, Google Sheets, Google Slides, and Google Docs.) Using a Google Form and the Autocrat Add-On for Google Sheets, the Organizer embedded students' chosen topic into the secondary questions and inserted them as slide headings in a Google Slides file. The resulting customized Organizer indicated the content for students to include, using the driving and secondary questions, and laid out a logical order for it. The Organizer was aligned with the rubric and is an example of organizational and metacognitive scaffolding, supporting students in organizing their research and information and knowing what questions they have left to answer. While inspired by the Digital IdeaKeeper, the Organizer is simpler. The way in which the Organizer re-creates the Digital IdeaKeeper is in providing a space to collect all the information related to each sub-topic. It does not contain an embedded web browser or automatically collect search history, nor does it prompt students to evaluate websites used based on specific criteria. The Organizer also lacks the planning space for developing questions; it requires the questions to be already chosen. By containing a designated space for each sub-topic, it provides a space to organize information, an order in which to work (strategic scaffolding), and, hypothetically, a reminder of which questions have been answered and which ones have not (metacognitive scaffolding).

The unit contains front-loading, introducing skills and strategies at the beginning: it begins by introducing the rubric as a tool, a system to evaluate online sources, and a model for developing unit questions. It also contains a simplified set of explicit steps for inquiry: write the questions, find and evaluate information on each question, and put your synthesized information into an organized format that can be shared with others. Although there is an overall structure, day-to-day details are left to students; the Organizer makes self-monitoring more accessible by making visible what has been done and what has not.

I developed an action research protocol to test the impact of the Organizer. I had four seventh grade science periods (103 students) available as subjects; I divided them into two groups that were roughly equivalent in number of students, male/female ratio, current science grades, and number of students receiving free or reduced priced school lunches (see Table 1). After determining the groups, a random drawing determined which group was the intervention group (using the Organizer) and which was the control group (not using the Organizer). Periods one and six became the intervention group (see Table 1) and periods two and five were the control group.

Table 1: Make Up of Intervention and Control Groups

Grouping	Students	Females	Males	Mean grade (%)	As	Fs	Free or reduced lunch	Student Assents
control group	53	29	24	69	10	8	31	46
intervention group	50	28	22	68	8	12	31	46

It is important to note that prior to the Natural Disaster Unit, my students had experience with curricula consistent with structured inquiry, as described in Chapter 2, in which the teacher directs the inquiry process by providing the questions and resources and determining the product.

As part of the final assessment for the preceding unit, students wrote a scientific argument related to the motion of tectonic plates (which, for simplicity, will be referred to as the General Science Assessment). This was a short essay graded with a four part rubric (See Appendix C). This assessment served as a measure of both content mastery from the previous unit and the science skill of making sense of evidence. The General Science Assessment was graded anonymously, using a rubric, by my 6th and 8th grade science teacher colleagues, who were blind to the study purpose and design. The scores were used as a co-variate measure to take into account the difference in student skills and knowledge when looking at students' scores on the Natural Disaster Unit product. Scores on the unit product were used to determine the scaffolding efficacy of the Organizer.

The overall structure of the Natural Disaster Unit was the same for both control and intervention groups. The introductory lessons for the unit included an introduction to the rubric (metacognitive scaffolding), instruction on Google searches (procedural scaffolding) and evaluating websites (conceptual scaffolding), and an introduction to the unit questions (metacognitive scaffolding). Students in both groups had the freedom to choose their one to two partners or work alone, their natural hazard topic and geographic location, as well as the type of product they would produce, such as a slide presentation, brochure, poster, video, etc. The freedom of choice is an important component of IBL; it's part of being a self-directed learner. The only difference in instruction or resources between the two groups was that the intervention group received a copy of the Organizer, customized to their topic. The intent of the organizer was to provide metacognitive and strategic scaffolding by giving, in a format useful for recording and presenting their information, the list of questions students needed to answer and an organizational tool for how to order the information.

In order to create a short-term artificial separation between the two groups, the experimental group began work on their questions one day after the control group. The purpose of that was to discourage discussion of the Organizer by students from the intervention group to students in the control group (diffusion of treatment). The only other difference between the two groups was whether or not they used the Google Forms-based Organizer. Both groups had a printed close-style worksheet that contained the unit questions. When students in the experimental group had agreed on the type of natural disaster to study and the geographic region on which they wished to focus, they completed a Google Form that delivered their answers to a Google Sheet and from there, using the AutoCrat add-on, to a Google Slide file, shared with them, that served as the advanced organizer template (hard scaffolding).

The introduction to the unit took approximately 3.5 class periods. After that, students had about 8.5 periods of work time to complete their research and their product. Interestingly, at least one student began to work on a video for the project even before the class had completed the introductory lessons; he was definitely excited to be able to choose the kind of project to create. While students were working, I circulated to keep track of where kids were in the process, what they were doing, and to help them as needed (soft scaffolding). At the end of each period, students turned in a slip of paper describing what they worked on that day.

At the completion of the unit, the 6th and 8th grade science teachers at the school, who had also scored the General Science Assessment, graded student projects anonymously, using a rubric (see Appendix A).

Action Research Results

Due to many absences or unenrolling in the school, I dropped three students from the study. Ten students gave assent, but chose to work with students who had not given assent; I did not use them either, to avoid using the work from non-assenting students (in keeping with IRB protocol).

Students chose to make three different kinds of projects: posters, slides, and videos using WeVideo. These results are summarized in Table 2. Some students who created slides presentations and had time left at the end recorded narration of their slides using Screencastify (software that works with the Google Chrome browser to record the content of the browser window with narration to make a video); their scores were analyzed as slides projects.

Table 2: Types of Projects in Control and Intervention Groups

Type of Project	**Student Count**
WeVideo	
Control	0
Intervention	5
Poster	
Control	4
Intervention	12
Slides	
Control	30
Intervention	21
Slides & Screencastify	
Control	6
Intervention	2

Overall mean scores were 66.9% on the general science assessment and 65.4 % on the project. Within the control group, the general science assessment score was 65.0%; within the intervention group it was 69.0%. The mean score on the project among the students in the control group was 61.0%. The mean score on the project among the students in the intervention group was 70.1% (see Figure 1.) Both project and general science assessment were graded with multi-part rubrics on a three point scale. The rubric had four components all related to content; the project rubric had four components related to content and one for the bibliography (see Appendix A). Overall scores on the project were lower than on the general science assessment, but while the project score was four percentage points lower than the general science assessment for the control group, the project score was one percentage point higher than the general science assessment score for the intervention group, an initial indication that the Organizer may have a positive effect.

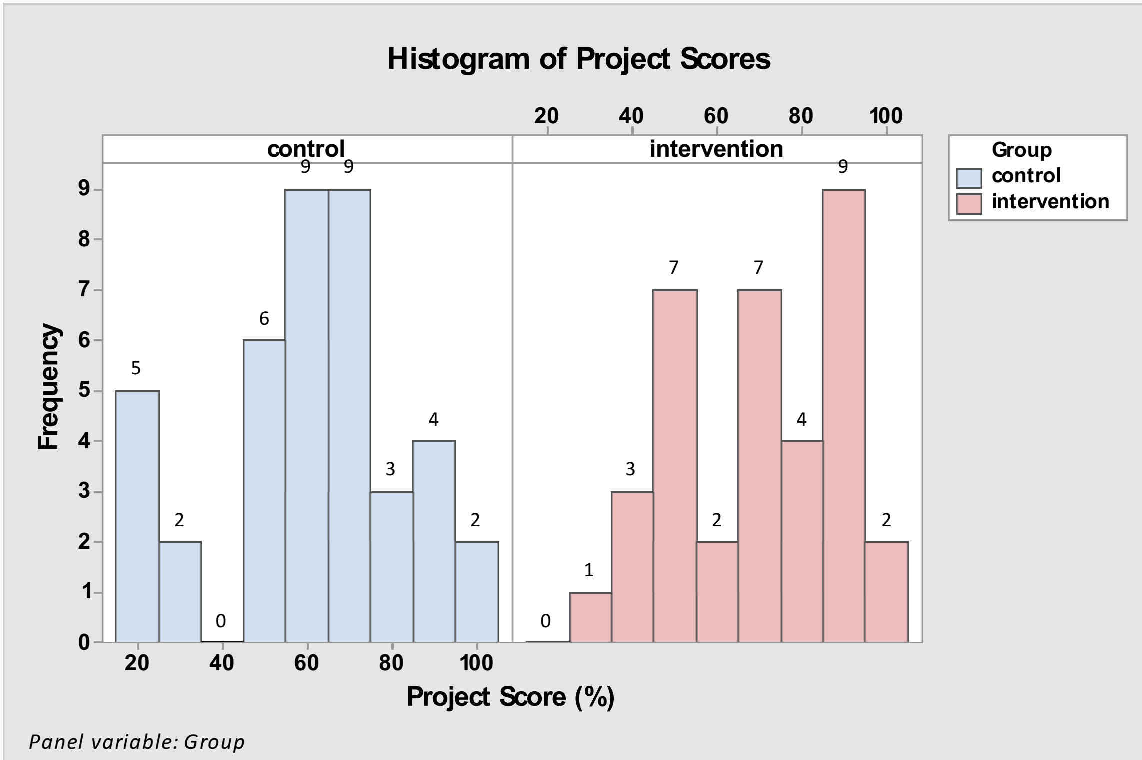


Figure 1: Histogram of Project Scores by Group

The data were analyzed using an Analysis of Covariance with Groups (control and intervention) as the Factor, General Science Assessment Score and Type of Project as Covariates, and Project Score as the dependent variable (see Table 3). Despite attempting to create matched groupings, students' academic performance in science varies; in order to see the effect of the Organizer more clearly it was important to control for that variation by including the general science assessment score as a covariate. During the course of the project, students working on different types of products (slides, posters, etc) appeared to have variations in content quality depending on their product, so project type was added as a covariate as well, in order to determine whether there was a relationship and, if so, to define it.

Because the Screencastify video products were an extension of the Slides products, with no added content, I grouped them with the Slides projects for analysis. Additionally, because the only students who used WeVideo were in the intervention group, the type of project didn't fit with either Slides or Posters, and the missing data from WeVideo projects in the control group made the analysis described above unstable, so I treated the WeVideo data as an outlier and did not includ it in the quantitative analysis.

The analysis revealed that previous student performance (General Science Assessment Score) was the best predictor of project scores, followed by the type of project students chose and whether they were in the control or intervention group (see Table 3). The results are all statistically significant, with P-values ranging from 0.000 to 0.007. These finding corroborate with other research that students' past performance is the best predictor of future performance (Plant, Ericsson, Hill & Asberg, 2005; Salanova, Schaufeli, Martínez, & Breso, 2010) and with my observations during this study.

Table 3: Analysis of Covariance

Source	**F-Value**	**P-Value**
General Science Score	13.76	0.000
Type of Project	9.60	0.003
Group (Control/Intervention)	7.77	0.007

The Organizer (study treatment) was positively associated with higher project scores (Figure 2). Also, the type of product that students chose to produce (a covariate) had a significant positive impact on the project score (see Figure 3).

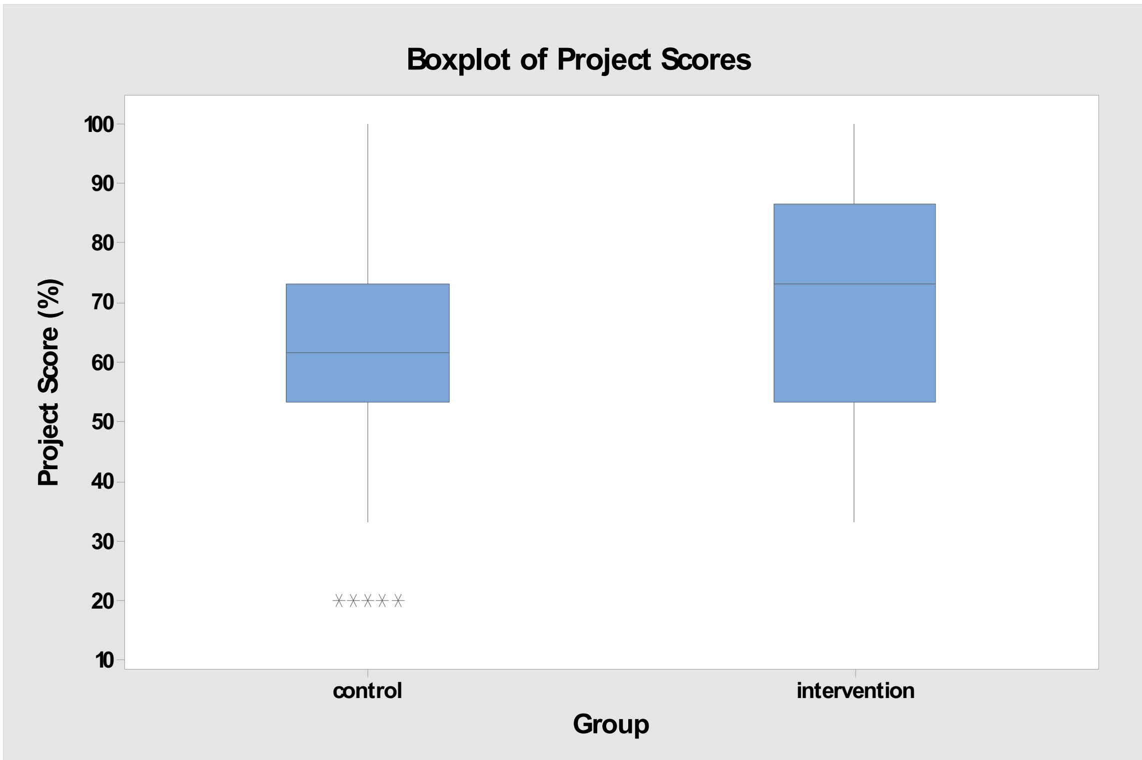


Figure 2: Boxplot of Project Scores by Group

Figure 3: Boxplot of Project Scores by Type of Project

Teacher Observations and Reflections

While teaching the unit, I noticed a number of patterns. The overwhelming majority of students, in both control and intervention groups, chose to use Google Slides to create their product. Students in both groups seemed generally happy with and interested in their topics. There were differences between groups in how they got started and how much teacher support (soft scaffolding) they needed to begin and along the way. There were also differences between groups in the manner in which they recorded the information they gathered through their online research. As mentioned above, there were differences in mean scores between products of different types.

Overall, most students created Google Slides presentations. The Organizer was a Google Slides document, which might have influenced students in the intervention group to choose Slides, so as not to need to transfer their collected information to another product. Slides, however, also made up the vast majority of projects in the control group as well. In the control group there were 18 products, of which 16 were Slides presentations (including the Slides plus Screencastify combination). In the intervention group there were also 18 products, of which 13 were Slides presentations (including the Slides plus Screencastify combination).

In both groups, students seemed generally excited to pick a natural disaster to learn about and didn’t take much time to choose. By the time classes had completed the introductory lessons for the unit, most students knew both the topic they wanted to study and who they planned to work with. When something related to their topic happened to occur during the unit (an earthquake in South Korea, a major winter storm on the Northern Great Plains, for example), students talked about it.

In general, students in the intervention group needed less teacher support both in starting their project and during the process. Using the Organizer as a starting point, they tended to launch into their research more quickly, with more confidence and less confusion than students in the control group: they started work more quickly and with fewer questions than students in the control group, more of whom asked for help figuring out how to begin.

Probably due to the availability of the Google Slides Organizer for the intervention group, there were also differences in the manner in which students recorded the information they gathered through their online research. Almost all intervention students recorded their information directly in the Organizer, but in at least one case the student didn't realize that the Organizer existed and had been shared with him. Students working in the control group used a variety of methods: some worked in their final Slides product, some worked in a Google Docs document, some took notes longhand on loose leaf paper or in their science journals.

The few groups working with WeVideo jumped right into creating videos without finishing research, despite numerous reminders to do research first. Compared to groups creating other kinds of products, their focus tilted more toward the software and its features (like selecting a song to play in the background) than the information to be included in their project. Oddly, only student groups in the intervention grouping chose to use WeVideo. Considering that students using WeVideo were more engaged with the software than with the intended content, it appears better to not allow complete freedom in product choice for a beginner inquiry-based unit. Students might be more successful in an IBL project if only permitted to use platforms with which they have developed basic competence and that are no longer a novelty.

Across both control and intervention groups Screencastify and Slides projects had a higher mean score on the product than poster projects (see Figure 4). According to Zhang and Quintana (2012), students who had to transfer information between media (computer screen and paper) had less time and depth of engagement with the content, as well as more off-task behavior. Poster products might have scored lower because after collecting and organizing their information, students then had to transfer that information from where they had recorded it to their poster. They might have missed something or been distracted. Another possibility for why the posters projects received lower scores was observed in at least one group.   Students in this group started working on their poster before they had finished their research and then alternated between research and poster, removing and rearranging items on the poster several times. Finally, perhaps those who chose to make posters were less comfortable with technology, which might have impacted their online research as well.

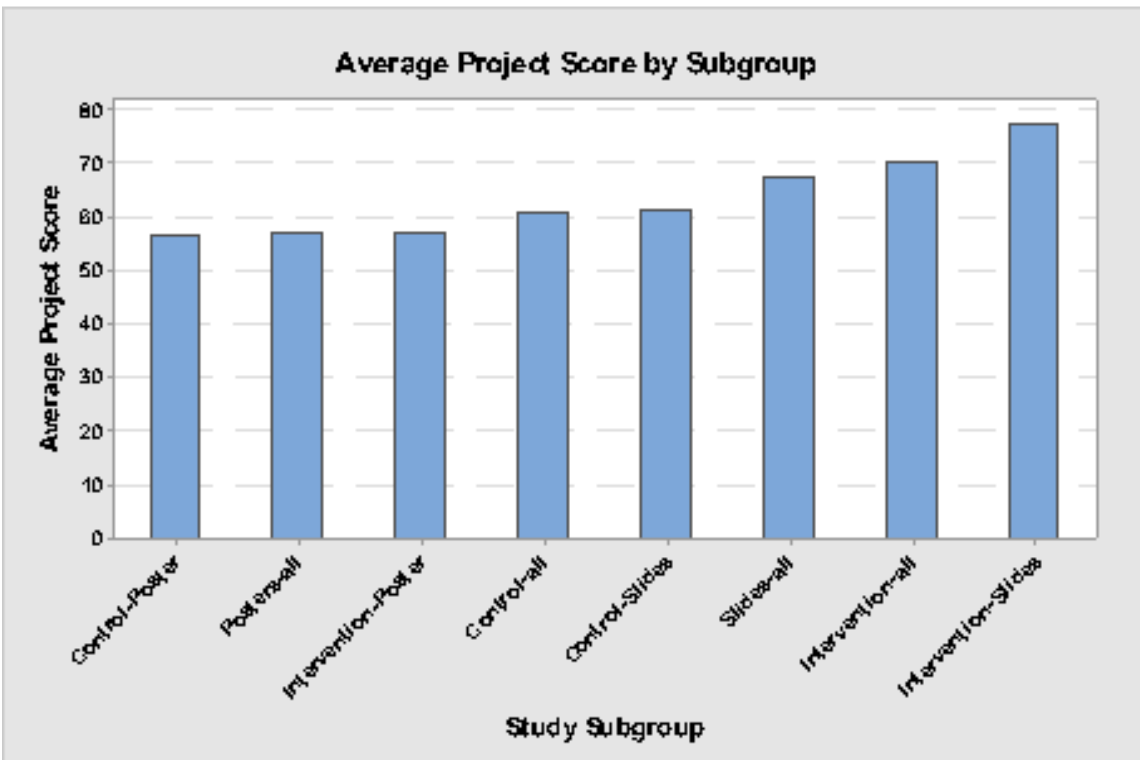


Figure 4: Average Project Score by Subgroup

Some groups whose product was a Google Slides document finished with a day or two to spare; I suggested that they explore the Chrome extension Screencastify and make a video that way. These students had already completed their research and created a finished product (Slides presentation), which they then used to make another product (a video of them narrating their Slides presentation).

The daily log was a slip of paper on which students (in both control and intervention groups) recorded what they worked on during the period and gave an estimate of the amount of class time they spent working. While I intended the daily log as an accountability tool, likely also functioned as metacognitive scaffolding by prompting students to take stock of what they had accomplished each day.

The two teachers who graded the products provided feedback about the rubric; specifically about the bibliography section and plagiarism. One teacher expressed concern about instructing students to organize the bibliography in a manner not consistent with the standard practice of alphabetizing entries. The rubric in this study called for entries to be sorted by the secondary question for which they provided information. However, she felt it was important that middle school students, who haven't used bibliographies much, create them according to standard expectations. The scoring teachers also noted that the rubric failed to address plagiarism. A lack of penalty for plagiarism gave students no reminder, and less motivation, to ensure that their product is entirely their own writing. The finalized project rubric addresses both concerns.

CONTENT

The following is the online inquiry-based unit on Natural Disaster, intended for my students and any other students in a similar place in the transition towards IBL.

Unit Introduction

This unit on Natural Disasters is intended as an almost-beginner inquiry-based learning unit for middle school science classes; it assumes that students have some experience answering defined questions based on evidence (what is sometimes called structured inquiry). It was designed to expose students to content and scientific practices emphasized in the Next Generation Science Standards (NGSS) (National Science Teachers Association, 2014). The unit introduces some of the freedom of inquiry-based learning, allowing student-directed learning, with enough structure that the openness is not overwhelming.

The rubric and the Advanced Organizer Template are scaffolding that help keep students focused on the desired content and the expectations for their product.

In the unit, students select a natural disaster to learn about, a geographic area to focus on, and the type of product they will create. The project's driving question is. "How can death, injury, and destruction to property and environment from (a particular natural hazard) be reduced?" Regardless of the natural disaster they choose to learn about, there are particular secondary questions to answer: the causes of, problems caused by, preparation for, and the aftermath of the disaster.

[Important note about technology: This unit was designed using the Google Suite of programs (including Docs, Slides, Forms, Sheets, and the AutoCrat add-on). While the unit is still possible in schools that do not use Google, the method of creating the Advanced Organizer Template will need to be adapted to the available technology.]

<u>NGSS Standards</u>

The NGSS content standards and practices addressed in this unit are:

- Asking Questions and Defining Problems
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information (NSTA, 2014)
- From MS-ESS3-2: “Analyze and interpret data on natural hazards to forecast future catastrophic events…”
    - Does not address the second part of MS-ESS3-2: “…and inform the development of technologies to mitigate their effects.” (California Department of Education, 2015)

Unit Overview

Table 4 contains a day-by-day view of the unit.

Table 4: Unit Activities by Day

Day	Activity	Notes
Day 1	Natural Disaster Brainstorm	1. Students brainstorm a list of natural disasters. 2. Students identify locations where particular natural disasters occur.
Day 1	Project Introduction	1. Broad introduction to topic and products 2. Can pick partner(s) 3. Due date
Day 1	Rubric Introduction & Practice	1. Read *Natural Disaster Project Rubric* together 2. Evaluate several products (on different topic) as class, using rubric 3. Students evaluate 1-2 products in pairs, using rubric

Day 2	Evaluating Websites	1. *Evaluating Websites* worksheet, page 1 2. Show video on evaluating Websites; students takes notes on page 2 3. *Evaluating Websites: Practice* worksheet
Day 2	Select Partners	1. Instruct students to select a partner or choose to work individually 2. End up with work groups of 1-3 students
Day 3	Introduction to Bibliographies (supplemental lesson)	1. Introduce purpose and examples of bibliography 2. Show easybib.com tutorial(s) 3. Make link to easybib.com accessible
Day 3	Presentation Rubric	1. Share *Team Points and Presentation Rubric* with students, discuss briefly

Day 3	Choosing Topic and Questions	1. Students use *Natural Disaster Project Questions* when choosing topic 2. Students decide on a product 3. Each group completes Google Form *Natural Hazards Topic* (version based on product) 4. Group receives, electronically, *Advanced Organizer Template* customized for their topic and begins work
Days 4-13	Work days	1. Students work 2. Teacher circulates and provides support 3. Day 12: Pass out copies of *Team Points and Presentation Rubric* for groups to complete 4. (extension: As students finish, introduce Screencastify to individual groups with digital products)
Days 14-15	Presentations	1. Student groups present 2. Graded using *Team Points and Presentation Rubric*

Preparation

Make copies of the following—one for each student unless otherwise indicated. (See Appendix A for Blackline Masters and Appendix B links to the digital files)

- *Natural Disaster Project Rubric*
- *Plastic Bottles Brochure* (half a class set)
- *Styrofoam Trays at JSS* (half a class set)
- *Evaluating Websites*
- *Evaluating Websites: Practice*
- *Natural Disaster Project Questions*
- *Team Points and Presentation Rubric* (One per student pair)

Make copies for grading the product:

- *Natural Disaster Project Rubric* (one per group)

  To make the advanced organizer/template
- Make digital copies of:
  - *Natural Hazards topic (booklet)* Google Form
    - Set the form to collect email addresses
  - *Natural Hazards topic (slides, etc.)* Google Form
    - Set the form to collect email addresses
  - *ND booklet template* Google Slides
  - *ND slides/poster/video template* Google Slides

To set up the Advanced Organizer Template,

- Open the Sheets affiliated with each Google Form
- In each Sheet, use the AutoCrat add-on and set it up using the appropriate Slides files as the templates. Select the option to have AutoCrat deliver the created Slides file to the student using their email account.

Ensure daily access to the internet and printing for student. Ideally, each student will have access to their own computer or chromebook with printing capability, although not all will print.

Poster groups will need poster paper or board, either supplied by the teacher or obtained on their own.

Day 1

Note: All projections described below are include in the Natural Disaster Unit slides (https://drive.google.com/open?id=1FMW6NRKJJ9bysDvfuEvrFufJQfpZlwwzS0shv98jZV8)

Natural disaster brainstorm

1. Project on your screen or write on the board: With your group, brainstorm (and record) a list of natural disasters.
2. Students answer in groups and then share with class
3. Project on your screen or write on the board: Pick two disasters from your list and record WHERE, geographically, they occur.
4. Students answer in groups and then share with class

<u>Project introduction</u>

1. Project the following, with your due date inserted:

Figure 5: Projection for Project Introduction

(Note: If your students aren't already comfortable making videos, you may want to eliminate that option.)

2. Answer student questions.

Rubric introduction & practice

1. Go over *Natural Disaster Project Rubric* together as a class

Natural Disaster Project Rubric

	3	2	1
Causes & likelihood	Thoroughly describes what causes disaster and specific factors that influence the likelihood of the disaster for a particular geographic area.	Broad discussion of causes. Not specific.	Attempt made. OR content addressed but plagiarism apparent.
Problems	Thoroughly describes concrete problems arising as a result of disaster. The problem descriptions suggest which solutions to address the problem.	Broad discussion of problems. Not specific.	Attempt made. OR content addressed but plagiarism apparent.
Recommendations: what to do in preparation	Recommendations address most of the identified problems that arise during disaster. Recommendations are specific and implementable.	Recommendations generic, broad, difficult to implement.	Not all problems addressed. OR content addressed but plagiarism apparent.
Recommendations: what to do during and immediately after disaster	Recommendations address most of the identified problems that arise during disaster. Recommendations are specific, implementable, and consider contingencies.	Recommendations are generic, broad, difficult to implement, or don't consider contingencies.	Not all problems are addressed. OR content addressed but plagiarism apparent.
Bibliography:	Entries relate to the (i) causes & likelihood, (ii) problems, and (iii) recommended solutions. Entries are complete, in the correct MLA format, and in alphabetical order There are at least 4 citations.	Entries somewhat relate to the problem statement & solution recommendations. OR Entries incomplete, incorrectly formatted, or not in alphabetical order.. OR There are fewer than 4 citations.	An attempt is made. Entries not relevant, not formatted correctly, not in alphabetical order, or there are two or fewer.

Figure 6: Natural Disaster Project Rubric

2) Evaluate several products (on different topic) as class, using the rubric.

a) Use the sample products to score as a whole class

i) Begin with a PSA video, such as those available here

(1) https://www.youtube.com/watch?v=94Ve2vctL9c (aJERKproduction, 2014)

(2) https://www.youtube.com/watch?v=hC2Zsv_LyP4 (Elliott de Neve, 2013)

(3) http://studentpsa.com/psa/ (Student PSA, n.d.)

b) Students evaluate 1-2 more products in pairs, using rubric

i) Printable samples

(1) see Preparation or Appendix C for links

(2) Plastic Bottle brochure

(3) Styrofoam Trays

ii) More from http://studentpsa.com/psa/ (Student PSA, n.d.)

Day 2

Evaluating websites

1. Begin by writing on the board or projecting the question, "How do you know if a website is trustworthy?"
2. Students complete page one of *Evaluating Websites* worksheet as a preassessment of skills. Discuss as class.
3. Teacher shows (Oregon School Library Information System, 2017). Skip the section on accuracy (5:12-6:00). Students take notes on page two of *Evaluating Websites* worksheet.
4. Students complete *Evaluating Websites: Practice* worksheet. Discuss as class.

Lesson adapted from Alison Waterman's lesson on KQED teach (Waterman, 2018)

Select partners

Students select a partner or partners to work with or choose to work individually. Given that some students will prefer to work individually and classes aren't necessarily even numbers, there may be some groups of three. Teacher facilitates partnering as needed.

Day 3

Introduction to bibliographies (supplemental lesson)

If the students do not have experience with bibliographies a brief introduction to bibliographies is necessary.

1) Project & discuss the slide titled Bibliography
2) Project & discuss the sample Bibliography
3) Show (an) easybib.com tutorial(s) such as
   a) https://www.youtube.com/watch?v=pblqsnM4bC0 (Slocum, 2017)
   b) https://www.youtube.com/watch?v=4ifUm6QxBOQ (Slocum, 2017)
   c) https://www.youtube.com/watch?v=NQVgdY7RLPA (Slocum, 2017)
4) Make link to easybib.com accessible

Presentation Rubric

1) Project or pass out *Team Points and Presentation Rubric* (Figure 7)
   a) Each group will be given a specific number of points (the number of group members times five) to divide among them.
   b) The distribution of points should reflect the amount of work that each group member contributed. For example, if all members worked equally, all should get five points. In a pair, if one person did substantially more than the other, perhaps that person would be assigned three points and the other person seven points.
   c) All group members must agree that the point distribution is fair.

d) Teacher explains that the presentation will be graded on each person's equal participation, speaking clearly and loudly, and appropriate answering of questions.

Team Points and Presentation Rubric

Total Team Points to assign:	
Period:	
Name:	**Individual Points:**

Presentation			
Name	Spoke equal amount	Spoke clearly and loudly	Answered questions appropriately

Figure 7: Presentation Rubric and Team Points

Choosing Topic and Questions

1) Teacher passes out and introduces *Natural Disaster Project Questions* (Figure 8)

Natural Disaster Project Questions

- **Project Question**: How can death, injury, and destruction to property and environment from _______________ be reduced?
- In order to answer the Project Question, answer these **Secondary Questions**:
  - Describe the **problem**:
    - What **causes** ________________?
    - How **likely** is _______________ in ____________ (specific geographic area)?
      - What specific **factors** influence the likelihood of the disaster for _____________ (geographic area)? (Explain)
    - What **specific problems** are caused by ______________?
      - How do those problems cause death, injury, and damage?
  - What can people do to **prepare** for _________________?
    - Specific, implementable recommendations.
  - What should people do **during** and in the **aftermath** of _________________?
    - Specific, implementable recommendations.

Figure 8: Project Questions

2) Project & explain the slide, “When you have your topic” (Figure 9)

When you have your topic:

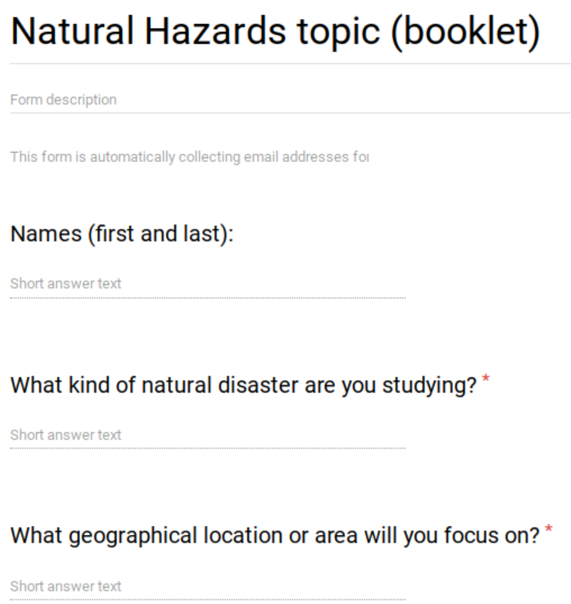
1. See (your teacher); (s)he will send you an EMAIL with a form
2. Complete and submit the form
3. Check your “Shared With Me” in the Drive for a new Google Slides file
4. Open the shared Slides file, SHARE IT WITH YOUR PARTNER(S) and look through it
5. Begin research
    a. Make sure to record your sources (URLs) for the bibliography as you research

Figure 9: Projection: When You Have Your Topic

3) Students decide on their natural disaster topic, both kind of disaster and the geographic area on which they will focus, and the kind of product they will make.

4) Creating the advanced organizer template for student groups:

    a) Teacher emails one student per group the appropriate Google Form for the group product (See Figures 10 and 11).



Natural Hazards topic (booklet)

Form description

This form is automatically collecting email addresses for

Names (first and last):

Short answer text

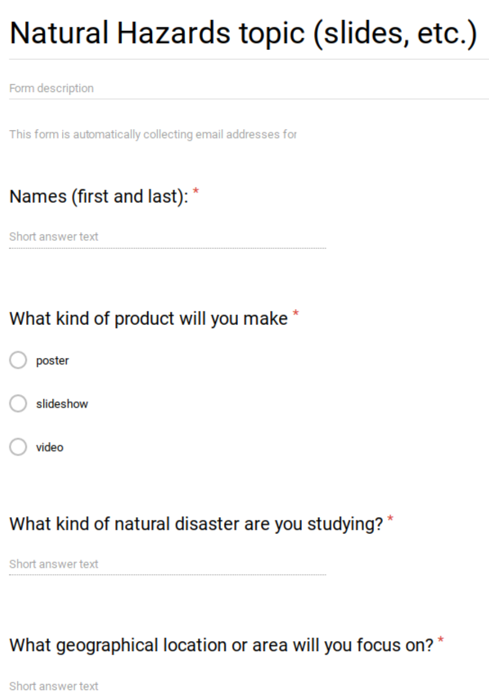
What kind of natural disaster are you studying? *

Short answer text

What geographical location or area will you focus on? *

Short answer text

Figure 10: Google Form for Booklet



Natural Hazards topic (slides, etc.)

Form description

This form is automatically collecting email addresses for

Names (first and last): *

Short answer text

What kind of product will you make *

- poster
- slideshow
- video

What kind of natural disaster are you studying? *

Short answer text

What geographical location or area will you focus on? *

Short answer text

Figure 11: Google Form for Other Projects

b) Teacher runs AutoCrat with each submission

c) Remind students to check their “Shared with Me” folder in their Google Drive to find their customized advanced organizer template (Figure 12).

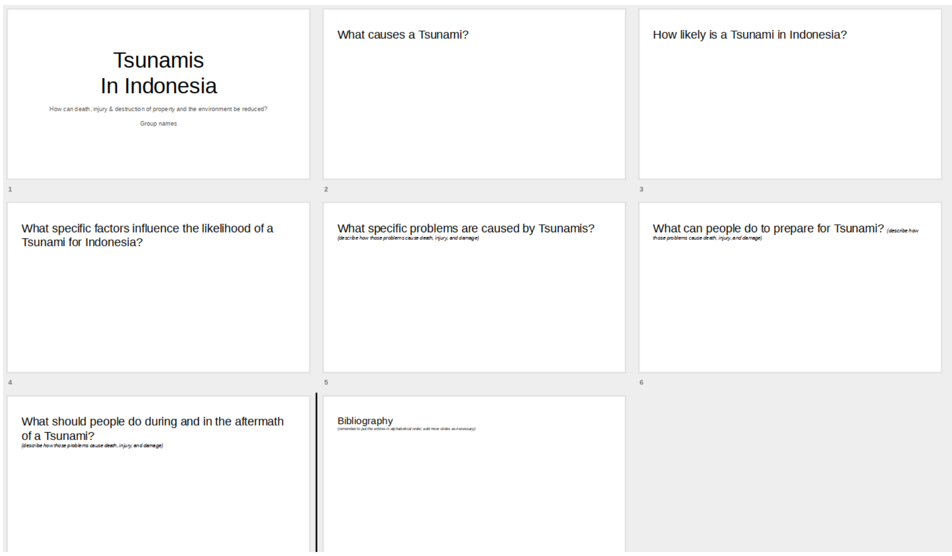


Figure 12: Sample Organizer

5) Students begin working.

Days 4-13

During the ten work days, teacher circulates in the classroom and provides support as appropriate. While it is important in inquiry-based learning to encourage students to work independently, they will also get stuck on occasion and benefit from a teacher assisting them in getting back on track.

On Day 12, distribute a copy of *Team Points and Presentation Rubric* to each group. Instruct them to complete the top portion and put their names in the bottom portion. (See discussion of Presentation Rubric in Day 3, above.) They will turn it in before they begin their presentation.

Days 14-15

Student groups give their presentations. Teacher grades presentation using the bottom portion of *Team Points and Presentation Rubric* and grades product using the *Natural Disaster Project Rubric.*

CONCLUSION

This project tested the effects of using an Advanced Organizer Template on the final project scores of students for a middle school inquiry unit intended as an introduction to inquiry-based learning. Students who used the Advanced Organizer Template had better organized research process and information. The Organizer also made visible what they had finished and what still needed attention; final project scores were higher when using the Organizer.

The Organizer was most effective, however, when the final unit product was also a Google Slides presentation: Scores were higher when students used the Organizer to collect and present information, however, scores were lower when students used the organizer to collect information but then transferred their information onto a poster. This corroborates Zhang and Quintana's (2012) observation that keeping student work in one location is beneficial. The differences in scores between the Slides projects and Poster projects and observations of the students who worked in WeVideo serve as reminders to teachers to consider the type of projects with which their beginning inquiry students are most likely to experience the greatest learning and skill development.

Despite the positive effect of using the Organizer with students, it is not a magic bullet: Prior performance, as measured by the General Science Assessment (F-value of 13.76), had a greater impact on student performance than whether or not they used the Organizer (F-value of 7.77), as did the type or project students chose to create (F-value of 9.60)

While only the intervention group used the Organizer, both groups received substantial scaffolding throughout the unit, both hard (the front-loaded lessons and the rubric) and soft. Without that scaffolding, the control group's project scores would likely have been substantially lower, but that can also be said of the intervention group.

Coming after units with structured inquiry, in which all students considered the same question using the same resources, this unit provided enough scaffolding with the increased freedom that students were fairly successful in learning both content and skills. Doing another inquiry-based unit with the same level of structure, before fading out more of the scaffolding, seems likely to allow students to develop further as self-directed learners before allowing them greater independence and responsibility in the continued transition to open inquiry.

The organizational and metacognitive scaffolding provided by the Advanced Organizer Template supported my students in their guided inquiry project, enabling them to continue in the transition toward open inquiry. The Organizer is a tool that can be adapted to other projects, both by myself and other teachers.

REFERENCES

aJERKproduction. (2012, March 4). *Student made PSA on water consumption* [Video file]. Retrieved from https://www.youtube.com/watch?v=94Ve2vctL9c

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of science teacher education*, *13*(1), 1-12.

Barron, B., & Darling-Hammond, L. (2008). Teaching for Meaningful Learning: A Review of Research on Inquiry-Based and Cooperative Learning. Book Excerpt. *George Lucas Educational Foundation*.

Bender, W. N. (2012). *Project-based learning: Differentiating instruction for the 21st century*. Thousand Oaks, CA: Corwin Press.

Blanchard, M. R., Southerland, S. A., & Granger, E. M. (2009). No silver bullet for inquiry: making sense of teacher change following an inquiry-based research experience for teachers. *Science Education*, *93*(2), 322–360. https://doi.org/10.1002/sce.20298

Boaler, J. (2002). *Experiencing school mathematics: Traditional and reform approaches to teaching and their impact on student learning, Revised and Expanded Edition*. Mahwah, NJ: Taylor and Francis. Retrieved from http://ebookcentral.proquest.com/lib/humboldt/detail.action?docID=237090

California Department of Education. (2015, March). *Next generation science standards for California public schools, kindergarten through grade twelve: grade seven-integrated course.* Retrieved from https://www.cde.ca.gov/pd/ca/sc/ngssstandards.asp

Collins, A., Brown, J. S., & Newman, S. E. (1986). *Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics* (No. 6459) (pp. 1–35). Cambridge, MA: BBN Labs Incorporated. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA178530

Common Core State Standard Initiative. (2010) *Frequently asked questions.* Retrieved from http://www.corestandards.org/about-the-standards/frequently-asked-questions/ (Links to an external site.)

de Neve, E. [Elliott de Neve]. (2014, February 14). *Safe driving (award-winning PSA)* [Video file]. Retrieved from https://www.youtube.com/watch?v=hC2Zsv_LyP4

Dewey, J. (1900). *The School and Society*. University of Chicago Press. Retrieved from https://books.google.com/books?id=5c5wDDTNHAIC&printsec=frontcover&dq=the+school+and+society&hl=en&sa=X&ved=0ahUKEwjE6NaYw-7XAhUCS2MKHST3AfwQ6AEIJjAA#v=onepage&q=the%20school%20and%20society&f=false

Duch, B. J., Groh, S. E., & Allen, D. E. (2011). *The Power of Problem-Based Learning: A Practical "How To" for Teaching Undergraduate Courses in Any Discipline*. Herndon, VA: Stylus Publishing. Retrieved from http://ebookcentral.proquest.com/lib/humboldt/detail.action?docID=4438615

Eick, C., Meadows, L., & Balkcom, R. (2005). Breaking into inquiry: scaffolding supports beginning efforts to implement inquiry in the classroom. *The Science Teacher*, 72(7), 49.

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem-and project-based learning. *Interdisciplinary journal of problem-based learning*, *7*(2). https://doi.org/10.7771/1541-5015.1339

Gallagher, S. A., & Stepien, W. J. (1996). Content acquisition in problem-based learning: depth versus breadth in American studies. *Talents and Gifts*, *19*(3), 257-275.

Hannafin, M., Land, S., & Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In C. Reigeluth, (ed), *Instructional-design theories and models: A new paradigm of instructional theory*, *2*, 115-140. Mahway, NJ: Erlbaum. Retreived from https://books.google.com/books?hl=en&lr=&id=OUq55prZIMEC&oi=fnd&pg=PT128&dq=Open+Learning+Environments:+Foundations,+methods,+and+models&ots=1LuyTyUomx&sig=Sm1uys4iwtx6mpzuYUBH7dBf9Ns#v=onepage&q=Open%20Learning%20Environments%3A%20Foundations%2C%20methods%2C%20and%20models&f=false

Hitt, A. M., & Smith, D. (2017). Filling in the gaps: an explicit protocol for scaffolding inquiry lessons. *Science Educator*, *25*(2), 133.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational psychologist*, *42*(2), 99-107.

Holbrook, J., & Kolodner, J. L. (2000). Scaffolding the development of an inquiry-based (science) classroom. In B. Fishman & S. O'Connor-Divelbiss (Eds.), *Fourth international conference of the learning sciences* (pp. 221-227) Mahwah, NJ: Erlbaum. Retrieved from https://books.google.com/books?hl=en&lr=&id=0JM5N9PUZM8C&oi=fnd&pg=PA221&dq=%22certain+terrain)+(Kolodner+et+al,+1998).+To+address+a+challenge,+class+members+develop+designs,+build%22+%22science+classes,+to+be+used+for+a+portion+of+the+school+year.+Our+current+units+cover+topics+in%22+&ots=dElWe_Izdj&sig=J25iX-bNDWNC8W25jPp2UZaqebM

Hsu, Y. S., Lai, T. L., & Hsu, W. H. (2015). A design model of distributed scaffolding for inquiry-based learning. *Research in Science Education*, *45*(2), 241–273. https://doi.org/10.1007/s11165-014-9421-2

Jackson, S. L., Stratford, S. J., Krajcik, J., Soloway, E. (1995, April). Making system dynamics modeling accessible to pre-college science students. In E. Finkel (Chair), *The ScienceWare Project: Supporting modeling and inquiry via computational media and technology.* Symposium conducted at the meeting of National Association for Research on Science Teaching, San Francisco, CA. Retrieved from http://www.umich.edu/~hiceweb/papers/1995/making_systems_dynamic_modeling/

Johnstone, A. H. (1991). Why is science difficult to learn? things are seldom what they seem. *Journal of Computer Assisted Learning*, *7*(2), 75–83. https://doi.org/10.1111/j.1365-2729.1991.tb00230.x

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational psychologist*, *41*(2), 75-86. https://doi.org/10.1207/s15326985ep4102_1

Kotb, M. (2013, August 6). [Letter to Next Generation Science Standards Writing Committee]. Retrieved from https://www.nextgenscience.org/sites/default/files/ASME_Letterofsupport_NGSS_080613.pdf

Larmer, J., Mergendoller, J., & Boss, S. (2015). *Setting the standard for project based learning*. Alexandria, VA: ASCD.

MacKenzie, T. (2016). *Dive into inquiry: Amplify Learning and Empower Student Voice.* Irvine, CA: EdTech Team Press.

Maida, C. A. (2011). Project-based learning: a critical pedagogy for the twenty-first century. *Policy Futures in Education*, *9*(6), 759-768. https://doi.org/10.2304/pfie.2011.9.6.759

Mikroyannidis, A., Okada, A., Scott, P., Russman, E., Specht, M., Stefanov, K., ... & Hetzner, S. (2013). weSPOT: A personal and social approach to inquiry-based learning. *Journal of Universal Computer Science*, *19*(14), 2093-2111.

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* National Academy Press. Retrieved from https://www.nap.edu/read/9596/chapter/1

National Science Teachers Association. (2014). *Science and engineering practices.* Retrieved April 8, 2018, from http://ngss.nsta.org/PracticesFull.aspx

Next Generation Science Standards. (2012). Science education in the 21st century: *Why K-12 science standards matter--and why the time is right to develop next generation science standards.* Retrieved from https://www.nextgenscience.org/sites/default/files/Why%20K12%20Standards%20Matter%20-%20FINAL.pdf

Next Generation Science Standards. (2016). *NGSS fact sheet 2016*. Retrieved from https://www.nextgenscience.org/sites/default/files/resource/files/NGSSFactSheet2016revised.pdf

Next Generation Science Standards. (n.d.a). *FAQs.* Retrieved May 5, 2018, from https://nextgenscience.org/faqs

Next Generation Science Standards. (n.d.b). *The need for standards.* Retrieved May 5, 2018, from https://nextgenscience.org/need-standards

Oregon School Library Information System. (2017, October 2). *Evaluating websites for elementary* [Video file] . Retrieved from https://www.youtube.com/watch?v=3y-1cpnIZxs

Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *The journal of the learning sciences*, *13*(3), 423-451.

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., … Tsourlidaki, E. (2015). Phases of inquiry-based learning: definitions and the inquiry cycle. *Educational Research Review*, *14*(Supplement C), 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Peters, E. E. (2010). Shifting to a student-centered science classroom: an exploration of teacher and student changes in perceptions and practices. *Journal of Science Teacher Education*, *21*(3), 329–349. https://doi.org/10.1007/s10972-009-9178-z

Plant, E. A., Ericsson, K. A., Hill, L., & Asberg, K. (2005). Why study time does not predict grade point average across college students: Implications of deliberate practice for academic performance. *Contemporary Educational Psychology*, *30*(1), 96-116.

Problem based learning initiative - Southern Illinois University School of Medicine PBL page. (n.d.). Retrieved December 2, 2017, from http://www.pbli.org/pbl/pblold.htm

Salanova, M., Schaufeli, W., Martínez, I., & Breso, E. (2010). How obstacles and facilitators predict academic performance: The mediating role of study burnout and engagement. *Anxiety, Stress & Coping*, *23*(1), 53-70.

Savery, J. R. (2006). Overview of problem-based learning: definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1). https://doi.org/10.7771/1541-5015.1002

Saye, J. W., & Brush, T. (2002). Scaffolding critical reasoning about history and social issues in multimedia-supported learning environments. *Educational technology research and development*, *50*(3), 77-96.

Simons, K. D., & Klein, J. D. (2007). The impact of scaffolding and student achievement levels in a problem-based learning environment. *Instructional Science: An International Journal of the Learning Sciences*, *35*(1), 41–72.

Slocum, Andrew. (2017, February 8). *Easybib tutorial 2 website* [Video file]. Retrieved from https://www.youtube.com/watch?v=4ifUm6QxBOQ

Slocum, Andrew. (2017, February 8). *Easybib tutorial 3 book* [Video file]. Retrieved from https://www.youtube.com/watch?v=NQVgdY7RLPA

Slocum, Andrew. (2017, February 8). *Easybib tutorial introduction* [Video file]. Retrieved from https://www.youtube.com/watch?v=pblqsnM4bC0

Smith, S. (2016). (Re)counting meaningful learning experiences: using student-created reflective videos to make invisible learning visible during PjBL experiences. *Interdisciplinary Journal of Problem-Based Learning*, *10*(1). https://doi.org/10.7771/1541-5015.1541

Spires, H. A., Hervey, L. G., Morris, G., & Stelpflug, C. (2012). Energizing project-based inquiry: middle-grade students read, write, and create videos. *Journal of Adolescent & Adult Literacy*, *55*(6), 483–493. https://doi.org/10.1002/JAAL.00058

Student PSA Series. (2011, March 22). *Student PSA: be a friend* [Video file]. Retrieved from https://vimeo.com/21331209

Student PSA Series. (2011, March 22). *Student PSA racism* [Video file]. Retrieved from https://vimeo.com/23068039

Student PSA Series. (2011, March 22). *Student PSA: smoking kills* [Video file]. Retrieved from https://vimeo.com/21620611

Student PSA Series. (2011, March 22). *Student PSA: texting* [Video file]. Retrieved from https://vimeo.com/21618605

Thomas, J. W. (2000). *A review of research on project-based learning*. Autodesk Foundation. Retrieved from http://www.ri.net/middletown/mef/linksresources/documents/researchreviewPBL_070226.pdf

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.

Waterman, A. (2018, January 5). *Can you believe it? Evaluating websites with TRAAP.* Retrieved April 8, 2018, from https://teach.kqed.org/lessonplan/view/can-you-believe-it-evaluating-websites-with-traap

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of child psychology and psychiatry*, *17*(2), 89-100.

Zhang, M., & Quintana, C. (2012). Scaffolding strategies for supporting middle school students' online inquiry processes. *Computers & Education*, *58*(1), 181–196. https://doi.org/10.1016/j.compedu.2011.07.016

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of educational psychology*, *81*(3), 329-339.

Zion, M., & Mendelovici, R. (2012). Moving from Structured to Open Inquiry: Challenges and Limits. *Science Education International*, *23*(4), 383-399.

APPENDIX A: Blackline MASTERS

Names: ____ Period: ________ Score: ________/ 15

Natural Disaster Project Rubric

	3	**2**	**1**
Causes & likelihood	Thoroughly describes what causes disaster and specific factors that influence the likelihood of the disaster for a particular geographic area.	Broad discussion of causes. Not specific.	Attempt made. OR content addressed but plagiarism apparent.
Problems	Thoroughly describes concrete problems arising as a result of disaster. The problem descriptions suggest which solutions to address the problem.	Broad discussion of problems. Not specific.	Attempt made. OR content addressed but plagiarism apparent.
Recommendations: what to do in preparation	Recommendations address most of the identified problems that arise during disaster. Recommendations are specific and implementable.	Recommendations generic, broad, difficult to implement.	Not all problems addressed. OR content addressed but plagiarism apparent.
Recommendations: what to do during and immediately after disaster	Recommendations address most of the identified problems that arise during disaster. Recommendations are specific, implementable, and consider contingencies.	Recommendations are generic, broad, difficult to implement, or don't consider contingencies.	Not all problems are addressed. OR content addressed but plagiarism apparent.
Bibliography:	Entries relate to the (i) causes & likelihood, (ii) problems, and (iii) recommended solutions. Entries are complete, in the correct MLA format, and in alphabetical order There are at least 4 citations.	Entries somewhat relate to the problem statement & solution recommendations. OR Entries incomplete, incorrectly formatted, or not in alphabetical order. OR There are fewer than 4 citations.	An attempt is made. Entries not relevant, not formatted correctly, not in alphabetical order, or there are two or fewer.

Name: ____ Per: _________ Date: _________

Evaluating Websites

Look at each of the websites below and rank them by how reliable and trustworthy they seem to you.

Website name (links are in Classroom)	Pacific Northwest Tree Octopus http://zapatopi.net/treeoctopus/	Fukushima Daisies http://naturalsociety.com/photos-mutant-daisies-found-in-fukushima-safe-zone/	Supermoon Trilogy https://youtu.be/A4v5YgC9vkE
Rate by reliability and trustworthiness (1-3; 1 is worst, 3 is best)			
Explain rating			

NOTES on Evaluating Websites:

When evaluating a source, digital or print, use the acronym TRAP

T

R

A

P

Category	What to look for:	What to avoid:
T		
R		
A		
P		

Name: ____ Per: _________ Date: _________

Evaluating Websites: Practice

Imagine you are researching rulers in ancient Egypt; evaluate these sources.

		Timeliness	**Relevance**	**Author/Organization**		**Purpose**	
Website URL (links are in classroom)	***Website Title***	***Publication date*** (Date site was last updated?)	***Relevance*** (Is this website relevant to your topic?)	***Author*** (Who wrote the information?)	***Publisher*** (Who publishes or sponsors the website?)	***Purpose of website*** (How can you tell?)	***Does this website seem reliable?*** (Rate 1-3 and explain.)
http://www.ancient-egypt.org/history/index.html							
http://www.umbachconsulting.com/miscellany/velcro.html							

		Timeliness	Relevance	Author/Organization		Purpose	
Website URL (links are in classroom)	***Website Title***	***Publication date*** (Date site was last updated?)	***Relevance*** (Is this website relevant to your topic?)	***Author*** (Who wrote the information?)	***Publisher*** (Who publishes or sponsors the website?)	***Purpose of website*** (How can you tell?)	***Does this website seem reliable?*** (Explain.)
http://www.history.com/topics/ancient-history/ancient-egypt							
http://www.ancientegypt.co.uk/menu.html							

Name: ________________________________ Per: ______ Date: _________

Natural Disaster Project Questions

- **Project Question**: How can death, injury, and destruction to property and environment from ________________ be reduced?

- In order to answer the Project Question, answer these **Secondary Questions**:
    - Describe the **problem**:
        - What **causes** _________________?
        - How **likely** is ________________ in ____________ (specific geographic area)?
            - What specific **factors** influence the likelihood of the disaster for _____________ (geographic area)? (Explain)
        - What **specific problems** are caused by ______________?
            - How do those problems cause death, injury, and damage?
    - What can people do to **prepare** for __________________?
        - Specific, implementable recommendations.
    - What should people do **during** and in the **aftermath** of __________________?
        - Specific, implementable recommendations.

Team Points and Presentation Rubric

Total Team Points to assign:	
Period:	
Name:	**Individual Points:**

Presentation			
Name	Spoke equal amount	Spoke clearly and loudly	Answered questions appropriately

APPENDIX B: LINKS TO DIGITAL FILES

All G-Suite files that are a part of this unit are available through Google.

Links will allow you to view and copy files.

- *ND Unit Files*: folder containing all digital files for unit
  https://drive.google.com/drive/folders/1Lqv4vjj7O1JLtge0ToKM4TAOPThDdrQ7?usp=sharing
- *Natural Disaster Unit Slides*
  https://drive.google.com/open?id=1FMW6NRKJJ9bysDvfuEvrFufJQfpZlwwzS0shv98jZV8
- *Natural Disaster Project Rubric*
  https://drive.google.com/open?id=1D3UnOmDDuKgxVDzK-kRR0yQ6gzxlN1bpBd-yB-VvC_c
- *Plastic Bottles Brochure*
  https://drive.google.com/open?id=15AQcOTeiviOahiyV9R3s3G9FHoppy2DJnWn6JUKKtLU
- *Styrofoam Trays at JSS*
  https://drive.google.com/open?id=1F1p0KenHdBXO1h3E1se-VQ_AK3uq4xmxT11ILfZYtPI
- *Evaluating Websites*
  https://drive.google.com/open?id=1Cy1rE87_D3dAIddrKlN-WWmQf9AgymCqHUK6Tl6fcAM

- *Evaluating Websites: Practice* *https://drive.google.com/open?id=1_GrR9Qv4QwHuOg3SzhT7UgvcOGv_4dx8XV6RM8j55vo*
- *Natural Disaster Project Questions* *https://drive.google.com/open?id=1meIIOJAY5XV_2onMZdLAE0omjOQb6JylAmbbhJowaLk*
- *Team Points and Presentation Rubric* https://drive.google.com/open?id=10-NKRY7KpYIoDDeZidLzvdJR_DjiKGQhX7kbmp-iYFE
- *Natural Hazards topic (booklet)* Google Form https://drive.google.com/open?id=1T--lPY5u5Z4lyMSd8UWqqHfhbTgflWJbeB8jZgnAYCU
- *Natural Hazards topic (slides, etc.)* Google Form https://drive.google.com/open?id=12btqmW1aIyJTRsjopBrAubHSMtbI6pxFnghXOvF02gA
- *ND booklet template* Google Slides https://drive.google.com/open?id=1KFqikkJhmej_QEU8mr-dO5vStRzBRvg7pKR1JXc4FfM
- *ND slides/poster/video template* Google Slides https://drive.google.com/open?id=16ZnxXORgAoSnSscA0d2gM_tTrZwp2uiMTEWQ9Tbh-_s

APPENDIX C: GENERAL SCIENCE ASSESSMENT RUBRIC

Scientific Argument Rubric

Total Score:_____/11

Criteria	Score	Description
Takes a stance Does the argument propose a claim that directly answers the question?	0	No claim is proposed, or proposed claim does not answer the question. (e.g., the claim is off-topic)
	3	Argument proposes a claim that answers the question
Explanatory Does the argument fully address the question by identifying a cause for the phenomenon and by explaining the mechanism or process by which it is a cause?	0	Argument does not offer an explanatory account to answer the question. A cause is not identified, and a mechanism is not described.
	1	Argument identifies a cause of the observed phenomenon or a mechanism, but not both.
	2	Argument proposes an explanation that identifies the cause but does not explain the mechanism in appropriate depth, or argument explains only part of the mechanism.
	3	Argument proposes a complete and thorough explanation that identifies the causes and fully describes the mechanism.
Justified by the reasoned use of evidence Is evidence connected to the claim in a way that is likely to convince the audience that the proposed explanation is the best one?	0	Argument does not support the claim with any of the available information (data or science ideas).
	1	Argument includes information to support the claim but does not explain *how* that information supports the claim.
	2	Argument includes information to support the claim and explains how some of the information supports the claim.
	3	Argument includes information to support the claim and explains how *all* the information supports the claim.
Employs high-quality information as evidence Does it use data from reliable sources?	0	Argument prioritizes information and evidence sources that are not from reliable sources presented in the unit.
	1	Argument includes high-quality information that could be used as evidence to support the claim, but misses some valuable evidence for the argument.
	2	Argument includes high-quality information that could be used as evidence to support the claim.