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Strategies for integrating literacy into a science classroom

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Abstract

A science reading course offers opportunities for students to develop their scientific literacy by delving into current topics in science through reading and writing. Due to the nature of the course, students could be enrolled for one semester or for the whole year. Through differentiation, Science Reading is accessible for a variety learning and interest levels. This creative component lays the groundwork for the development of a science reading course by providing examples of topics, methods, lesson activities, and assessments that could be incorporated into a Science Reading curriculum. The project recognizes the resources that are available to educators and includes a series of ideas or starting points for others to develop their own units or courses that embrace literacy in the science classroom.

Strategies for Integrating Literacy into a Science Classroom

A Creative Component
Submitted
in Partial Fulfillment
Of the Requirements for the Degree
Master of Arts
In
Science Education

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April 26, 2017

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CHAPTER 1

INTRODUCTION AND FRAMEWORK

The 21st century is an exciting time to be a science educator. Critical to 21st century science education is intersecting scientific literacy with experiential learning. Science is a dynamic enterprise that involves conjecture, debate, verification, reanalysis, and political influence, and is relevant to the lives and problems of individuals as well as societies (Linn and Songer, 1991). “In an age fueled by information and driven by technology, understanding the concepts and process of science is as indispensable as knowing how to read, write, speak, and listen... Adults in the twenty-first century...will need to be scientifically literate-possess a set of skills that marries knowledge of science concepts, facts, and processes with the ability to articulate and communicate about ideas” (Thier & Daviss, 2002, p. 1). Therefore, upon the completion of any science program, students should walk away with a knowledge base and experiences that allow them to live life to the fullest. Furthermore, students should be given opportunities to make connections between their knowledge and skills with the world around them. As students construct these connections, they will also develop problem solving skills that they will be able to use in their everyday lives.

The media today bombards society’s citizens with shouts about cloning, stem cell research, pandemics, cancer treatments, gene therapy, global warming, alternative energy sources, nanotechnology, genetically modified

foods, and other “hot” topics in science. With this noise, comes a need for citizens to possess a basic understanding of the science concepts underlying these issues. It is the responsibility of science educators to provide the background information for students to be able to keep up with the fast pace changes of today and tomorrow. For example, as a consumer, one must form opinions and make decisions about what to purchase at a car dealership, the gas station, the pharmacy, and even the grocery store. The decisions of hybrid vs. traditional automobiles, ethanol vs. gasoline, vaccinating or not vaccinating, organic vs. non-organic produce require an informed consumer. One must determine the cost and tradeoffs of these products and decide if the advertised benefits of a cleaner environment and better general health of the consumer outweigh the costs and tradeoffs.

Students and citizens who are scientifically literate are able read, understand, and interpret science in the popular media as well as have the ability to communicate more coherently in their professional and personal lives. Science educators need to provide students with the experiences to develop these modes of communication through a variety of means so that students have the skills to apply their understanding to other situations. For instance, there is not a single one of us that has not been affected or know someone affected by cancer or some other debilitating disease. Being able to visit a physician and communicate one’s symptoms effectively often allows for early detection and successful treatment.

Just the nature of science suggests, students should learn to do science not simply do school. Students should learn science by designing solutions, performing experiments, analyzing data, arguing from evidence, and simply asking questions. Students should have the opportunity to develop the skill of making claims and providing evidence for those claims. Students should demonstrate their communication skills through a variety of channels in the classroom (i.e. oral, written, or group presentations). These opportunities will allow students to make arguments and back those arguments with data and observations from experimenting or research. The ability to make a sound argument serves as a foundation for developing the skill of evaluating an argument or claims when looking at consumer advertisements or in other realms in the real world.

Throughout their lives, students will be asked to determine the validity of arguments as they make decisions as consumers, patients, voters, parents, or simply members of society. In order to develop the analytical skills needed to evaluate an argument, students need to have an experiential science education that moves away from direct instruction to a more student centered education. When students are allowed to be actively involved in their learning, they are more likely to conceptualize experiences and apply prior understanding to new situations. Considering that we do not even know the problems that will exist tomorrow, it is pertinent that science educators provide their students with an understanding of basic science principles, skills necessary to think

scientifically, and overarching themes that appear in scientific world as well as problem solving skills needed to tackle those problems.

In order to offer such a quality science education to all students, a joint effort between the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve produced the Next Generation Science Standards (NGSS). The adoption of the Next Generation Science Standards throughout the nation fills some educators with a sense of overwhelming dread and resistance and others with jubilation that they finally have a platform on which to base their education philosophies. In fact, the adoption of NGSS has inspired and fueled many aspects of the planning and development of this curriculum project. Although this project is not intended to be an aligned curriculum for a required class for all students, it is definitely based on the ideas of three-dimensional learning where students are engaged in the themes, content, and practices of science collectively. This project outlines the process that one might take in developing curriculum that intertwines the three dimensions of the NGSS (Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts) and scientific literacy. As suggested by the National Research Council (2015), science students in a science reading course will spend less time with rote memorization, listening to direct instruction, completing worksheets, and answering the end of the chapter questions. Instead, students will participate in science in ways that align more with the new vision of science

education. Students will learn terminology as needed to explain and argue from evidence in multiple modes, develop systems models of their thinking, and engage in science and engineering practices while learning to obtain, evaluate and communicate information from a variety of texts (NRC, 2015).

A science reading course offers opportunities for students to develop their scientific literacy by delving into current topics in science through reading and writing. Due to the nature of the course, students could be enrolled for one semester or for the whole year. Through differentiation, Science Reading is accessible for a variety learning and interest levels. This creative component lays the groundwork for the development of a science reading course by providing examples of topics, methods, lesson activities, and assessments that could be incorporated into a Science Reading curriculum. The project recognizes the resources that are available to educators and includes a series of ideas or starting points for others to develop their own units or courses that embrace literacy in the science classroom.

Chapter 2

Relevance and Literature Review

Science and Literacy in the Same Classroom

At this point, you might be asking yourself what is the point of having a course that purposefully links science and literacy practices on a daily basis? Why not simply introduce students to the “hot topics” in science and allow them to inquire and explore the new science concepts through lab activities and experiments that incorporate science and engineering practices and not worry about the literacy skills involved? Why not leave the language lessons for the English teachers? First of all, reading, writing, and oral communication are critical literacy practices for participation in a global society (Krajcik & Sutherland, 2010). By allowing students to develop and use literacy skills, this course becomes applicable to other disciplines and to students’ personal lives. Secondly, Science Reading follows the “New Vision” for science education in the nation by offering students the opportunity to practice many of the science skills that scientists use such as arguing from evidence, communicating and evaluation information, and constructing explanations. Lastly, and perhaps most importantly, incorporating literacy in science improves students’ metacognition and understanding of science concepts. In fact, the skills of reading and writing can serve as dynamic vehicles for learning science meaningfully (Glynn & Muth, 1994).

Science is an ideal context for students to explore social, environmental, and political issues at local, national, and global levels. By integrating literacy skill development into the science curriculum, students will be able to build their capacity to transfer their learning about scientific concepts and practices to real world problems. Because language (particularly the construction and critique of evidence-based explanations and arguments) has been identified as an essential aspect of doing science (Ford, 2008), students enrolled in this course will be exploring the language and concepts of science simultaneously. By incorporating science text and reading, the social practices that make science possible can be engaged;

“recording and preserving data: encoding accepted science for anybody’s use, reviewing of ideas by scientists anywhere; reexamining ideas at any point in time; connecting ideas to those developed previously (intertextuality); communicating ideas between those who have not met or lived at the same time; encoding variant positions; and focusing attention on a text for the purpose of interpretation, prediction, explanation, or test” (Hand et al., 2003).

These social practices can be employed in any discipline of science or study as well as in day to day life fostering the development of scientifically literate citizens capable of fully participating in the workplace and civic demands of the 21st century (Pearson, Moje, & Greenleaf, 2010).

Incorporating literacy into the science classroom not only supports the social practices of science but it also aligns with science education reform sweeping through the nation. The release of the Next Generation Science Standards in 2013 served as the catalyst for educators to consider the New

Vision for Science Education (NRC, 2015, p. 8-9). The New Vision focuses more students practicing science instead of learning about science. The New Vision involves systems thinking and modeling, conducting investigations, reading multiple sources, and making and evaluating arguments based on evidence (NRC, 2015, p. 8-9). Basically, the New Vision encourages the development of scientific literacy, being able to communicate and evaluate science.

Comparatively, this is what scientists do on a daily basis, write, speak, debate, visualize, listen, and read about their specialties. By integrating reading and writing activities within Science Reading, students will be able to hone in on their literacy skills. Reading and discussion skills help students recognize the utility of science in their lives. If students develop positive attitudes toward science and become confident of their ability to understand it, students will continue to learn science outside the classroom. They will be able to understand how science interacts with social issues and will be able to apply those skills in their personal lives. Students will benefit from grappling with ideas, sharing their thoughts, and solving problems (Hicks & Ewing, 2003).

Integrating literacy activities into a science classroom can play a vital role in achieving a minds-on or metacognitive approach to the learning of science. Reading and writing activities can support active inquiry, and problem solving as well as help students to cover science content in greater depth, focusing on related content and cross cutting themes. Through reading and writing, students can build upon their prior learning and make real-world

connections (Glynn & Muth, 1994). Making these connections allow students to move their knowledge into long term memory where they store memorable and applicable schema or representations of concepts until they need to retrieve it at a later date. The use of literacy skills while learning science content also extends and expands students' scientific reasoning skills. In fact, a growing body of research and practice in science instruction indicates language is essential in science learning and improves achievement in literacy and science (Hapgood & Palincsar 2007, Keil, Haney, & Zoffel, 2009, Ostlund, 1998, and Romance & Vitale, 1992). This is no surprise because language allows students to clarify their ideas, make claims, present evidence based arguments, and record and present findings (J. Winokur, Worth, & M. Winokur 2006).

There are many parallels between learning science and learning to become a better reader, but many students make little use of reading as a tool for thinking and learning. Students often want to skim for answers without engaging in the text, or find ways to circumvent content literacy tasks (R. Vacca, J. Vacca, & Mraz, 2011 p. 1). From habit, students wait for teachers to provide the necessary information through direct instruction instead of delving into a task to broaden their learning. "When students become too dependent on teachers as their primary source of information, they rarely engage actively to think and learn" (R. Vacca, et al., 2011 p.1). This, coupled with content knowledge not being the only factor necessary in improving student achievement, begs for a curriculum that pairs science and content literacy strategies.

Scientific Literacy Defined and How to Incorporate It

Now that we have seen how well science and literacy blend together, an exploration of how scientific literacy is defined and how to implement it in the classroom is in order. The definition of literacy in the 21st century is drastically different than that of years past. No longer is it enough to simply read and write. Being scientifically literate is more than being able to “read” science texts and recognize scientific vocabulary, rather it is the ability to comprehend, interpret, analyze, and critique texts and actively engage in the discourse of science (Norris & Phillips, 2003). The National Science Education Standards' definition of science literacy emphasizes the connection between understanding science concepts and literacy skills and a more current explanation of literacy in the classroom:

"Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately" (National Research Council, 1996).

In short, being scientifically literate means that a person can use science content and practices in their real personal world.

Teachers can promote the development of scientifically literate citizens by helping students become part of society's science conversations by using real-world applications of science in instruction and by inviting students to discuss and debate relevant and motivating content (Grant & Lapp, 2011). Grant and Lapp suggest four actions that help teachers foster scientifically literate students who can use critical problem skills to make decisions affecting their personal and civic lives. These actions include identifying science topics of interest to students, engaging students in reading of scientific research, teaching students to read like scientists, and guiding students to evaluate data (Grant & Lapp, 2011).

Action 1: Topic Selection

There are multiple ways to gauge student interest on specific topics including classroom discussion, student question generation, or encouraging students to bring in current events articles. Another method of providing student ownership of the topics for a science reading class is a survey. This allows the teacher to guide students towards topics for which the instructor has already prepared curriculum (for an example see Appendix A). The goal of enlisting student interest in the topics is to make them see the connections between the classroom and the real world as well as increase the amount of student engagement within the course. The closer that literacy activities match students' values, needs, and goals the greater the likelihood that students will expend effort and sustain interest in them (Pitcher, et al., 2007).

Action 2: Engaging Students into Reading the Research

As students read scientific research, a link between a student's foundation of prior knowledge and new knowledge is created. This process also addresses any science content preconceptions they may have. Prior knowledge forms a cornerstone of all subsequent learning and thus should be tapped into to guide students into understanding how concepts and prior ideas are connected to their everyday lives (Krajcik & Sutherland, 2010). However, many students struggle with the traditional textbooks or scientific articles because the ideas are usually presented as isolated fragments of information rarely showing the connections to specific overarching concepts or they are written at a level that students do not comprehend (Koppal & Caldwell, 2004). Therefore, curriculum should have a variety of texts to help students build common experiences. Through reading quality texts on a variety of science topics and applying relevant reading strategies, students broaden their domain knowledge about science, deepen their inquiry learning, and foster reading habits that can last a lifetime. They also learn to synthesize, analyze, and critique the information presented in science texts in ways that real scientists do. (Fang & Schlepegrell, 2010). These texts can include fiction, science fiction, or nonfiction books; journal, newspaper, or magazine articles; blog entries; articles written for a science website such as *Science Daily* or *Inside Science* (see Chapter 2 section D).

Action 3: Teaching Students to Read like Scientists

Although a variety of texts can pique students' interest as well as meet different reading levels to develop comprehension skills, it is not enough for students to merely have a handful of topic-related readings to peruse. They must also develop the ability to read and think like scientists. This means developing strategies for reading scientific writing and building a deep understanding of related vocabulary (Grant & Lapp, 2011). One way to encourage reading and thinking like a scientist is to ask interesting questions and have students respond with asking more questions. Instruction needs to be driven by questions that students find meaningful and engaging. When engaging questions are used in the curriculum students are given the opportunity to set boundaries between what is known and unknown, just as real scientists do in their research (Krajcik & Sutherland, 2010).

Another important aspect to reading and thinking like a scientist is to connect multiple representations into a compilation of ideas that explain a scientific phenomenon. It is important for students to make connections between graphics, models, simulations, etc. with textual information. Students rarely spontaneously integrate information presented in isolation. Therefore, instruction needs to focus students on constructing integrated understanding while supporting them in the process of developing those integrations (Linn & Songer, 1991). Teachers can support their students by asking them to write and share about their reading and use textual information.

Action 4: Guiding Students to Evaluate Data

The fourth action required by teachers to groom scientifically literate students is to teach them to evaluate real world data. Students need to develop skills to evaluate the accuracy and reliability of data. They need to be exposed to multiple sources of real data (Grant & Lapp, 2011). With this data, students can engage in the science practice of arguing from evidence. Krajcik and Sutherland (2010) suggest that students should be provided with opportunities to use science ideas to engage in argumentation from evidence. “Students need to articulate, represent, critique, apply, and extend their emerging understandings about science, using what they learn to make sense of new situations and solve new problems” (p. 458). By arguing from evidence, students have to synthesize information to make claims and provide explanations for phenomena, assess data to use as evidence, make connections between accepted scientific concepts with their data, and evaluate others’ arguments. The development of these literacy skills assist students in making meaning of the science concepts and help facilitate the transfer of their learning to new situations. Although most students will not pursue careers in scientific field, most will read science-related materials throughout their lives during which they will be able to use their literacy skills to understand the material, evaluate the validity of the information, and make informed decisions (Krajcik & Sutherland, 2010).

In conclusion, texts form a powerful tool that support the acquisition of scientific knowledge while more effectively teaching concepts and principles in

science. When students construct a coherent mental representation of a science concept using both relevant background knowledge and textual information to a point that even corrects student preconceptions, learning has taken place (Van den Broek, 2010). Science students that are given the opportunity to develop reading skills, thus remember and learn more from texts and classroom activities than those students with fewer reading skills.

Content Literacy Strategies

As stated before, simply assigning reading (even if it is from a variety of sources) in a science course is not adequate for students to become effective readers that can utilize the text to delve deeper into the science content. In fact, scholars have argued, “Without systematic attention to reading and writing within subjects like science and history, students will leave schools with an impoverished sense of what it means to use the tools of literacy for learning or even to reason within various disciplines” (Pearson, 2010, p. 460). According to Hand, Prain, & Yore (2001), teachers need to be proficient in facilitating the development of the sophisticated skills needed to read texts and write within their content. Content area teachers play critical roles in helping students to think critically, learn effectively, and communicate with texts (R. Vacca, J. Vacca, & Mraz, 2011 p. 1). There are many content reading and writing strategies teachers can use to help their students develop effective literacy skills used to learn science. Some of the strategies that can be used in Science Reading include

annotation of text, anticipation reading guides, reflection on learning and notebooking, and utilization of graphic organizers such as frayer models or concept maps, and summarization and synthesis of information. These strategies are by no means an exhaustive list of strategies that could be used in a science reading course, but these strategies are showcased in the curriculum portion of this project. These strategies were specifically chosen to highlight because not only do they incorporate reading and writing, they mesh well with both literacy standards as well as the Science and Engineering Practices of the Next Generation Science Standards (Appendix F found at www.nextgenscience.org)

Although there is no right or wrong context for using any of the above strategies, in order to be effective in teaching students a specific strategy, teachers must understand the strategy's purpose and how to instruct and model the use of the strategy to students. Most content literacy strategies have been around for decades, however many teacher preparation programs, professional development programs, and curriculum design exclude explicit instruction in how to use or model these strategies in the classroom. Fortunately, using reading and writing in the classroom to help students to learn does not require specialized training only a willingness to consider how and when to implement these strategies within the instruction (R. Vacca, et al., 2011 p. 5).

Annotation

Annotation is a writing to learn strategy that deepens the level of student engagement during reading by having students make markings in the text in

places where they make connections or have questions. Markings including symbols, phrases, and reflections are typically written in the margins or within the text. This strategy provides students with a visible record of their thoughts that students can utilize to respond, summarize, and reflect upon their learning. David Stuart Jr., in his 2014 blog “Purposeful Annotation: ‘A Close Reading’ Strategy that Makes Sense to my Students” suggests, “What we do when reading should align with why we are reading in the first place, and what we are going to do with the reading when we are done.” By requiring students to annotate their reading, students begin to see reading as an active process of comprehension or a way of learning. It slows the reading down allowing students to discover or uncover ideas that would not emerge otherwise (O’Donnell, 2004). Learning about a specific topic, responding to a specific prompt, and synthesizing information across multiple texts are all student purposes for reading certain text within a science reading course. To incorporate annotation into the curriculum, start with a short story or article that can be read in less than a class period. The “Story of Science” by Joy Hakim and “The Best American Science and Nature Writing 2016” by Amy Stewart and Tim Folger or any article from Biologynews.net, Science Daily, New York Times Science, Newsela, or Popular Mechanics serve as good sources to introduce the strategy of annotation to students. However, annotation will become a more powerful tool when it is incorporated in a full unit where students utilize their annotations before, during, and at the conclusion of a unit to demonstrate their learning and understanding.

Some teachers and their students find it useful to have a bookmark of symbols that represent categories of annotations they use to guide their reading (An example bookmark can be found in Appendix B). Other teachers suggest reading a practice excerpt and collectively as a class creating annotation categories in which they place each type of their annotations. Students tend to categorize their annotations into making predictions, asking questions, making connections, defining vocabulary, analyzing or evaluating the author's craft, stating opinions, reflecting on content, and patterns or trends in the reading. If students do not come up with the categories needed in a particular course, teachers can guide them to the categories that match the course or content purpose (Porter-O'Donnell, 2004). To ensure that students take ownership in their learning using annotation, students should be required to use their annotations upon completion of reading (once again this speaks to the purpose of annotating) by reflecting on their annotations through writing or oral discussion. This strategy fosters stronger and more efficient post reading responses than simply expecting students to synthesize information from simply reading text (Stuart, 2014).

Anticipation Reading Guides

Prior to annotating texts, teachers can utilize anticipation reading guides to activate students' prior knowledge and focus their reading while stimulating discussion about a specific topic. Anticipation reading guides provide students practice in finding supporting evidence concerning controversial topics. Before

reading, teachers challenge students to agree or disagree to a series of statements and justify their opinions in writing. Students identify their prior knowledge, reveal preconceptions, and prepare to read with understanding. After students have committed to their opinions or positions, an initial class discussion can ensue. This discussion can be enhanced later on after students read, react, and justify or revise their positions from supporting evidence from the text (Martin, 2002).

Even students who are strong readers can struggle with finding the key ideas and relating details to larger conceptual structures in science texts (Lawrence Hall of Science, 2014 and Adams & Pegg, 2012). Reading scientific texts can be challenging for students due to the high concentration of abstract ideas, technical vocabulary, and various text forms (Barton and Jordan 2001, p. 10, 12, & 96). By using anticipation guides to engage with and reflect upon key ideas, students grapple with obtaining, evaluating, and communicating essential information from complex science texts as well as arguing from evidence. Anticipation reading guides can be utilized with a variety of texts and topics to scaffold these skills of scientific argumentation and communication. As students work with their peers to anticipate and revise their ideas based on evidence the curriculum becomes more meaningful because it is student-centered and engaging instead of teacher directed. (Lawrence Hall of Science, 2014 and Adams & Pegg, 2012).

In order to incorporate anticipation reading guides, Lawrence Hal of Science (2014) suggests that teachers need to:

- choose a topic, text, and goals for the reading that are written at an appropriate level for their students
- write statements and introduce the text and anticipation reading guide (see below for further instructions)
- allow students to complete the anticipation reading guide
- encourage students to share their initial ideas (reasons agreeing or disagreeing) with a partner
- provide time for students to read the text making annotations of supporting or contradictory evidence for their initial positions
- revisit the anticipation reading guide with the students in pairs
- facilitate a group discussion of revised positions
- summarize the key ideas from the text
- assign an individual extension activity or reflective response that requires students to apply the information obtained from reading

When writing anticipatory statements, include only 4-8 statements (it takes a lot longer to read when searching for evidence) of both true and false statements, focus on the key information you want students to understand from the text, and look for ideas that might be surprising or interesting to students. Be sure to include statements that are relatable to students prior to reading and can be supported or refuted by evidence from the text. Provide adequate space for students to agree or disagree both prior to and after reading as well as space for

their evidence and justification or reasoning for their agreement or disagreement (Adams & Pegg, 2012).

Effective anticipatory statements reflect state or national standards as well as common preconceptions students have about a particular scientific topic or concept. They also should require students to synthesize information from various places in the texts including the tables, charts, and figures. The statements should require inference and focus on the main concepts and not be based on explicit factual information found within the text. Anticipatory statements that generate debate or argument because there is no right or wrong answer encourage students to read critically, interpret what they read, and support their claims with evidence. Anticipation reading guides serve to motivate students to actively read texts and develop reading comprehension skills that will be useful in many areas of their lives (Adams & Pegg, 2012). Students should discuss and share their positions from their anticipation reading guide in small groups and with their whole class.

Reflections

After these discussions, student individual reflection encourages students to think about and articulate what they have learned during the process. Reflection helps students analyze and clarify their thinking and synthesize their ideas while communicating them to others. Reflecting provides students with written or oral record of the learning that can be returned to, responded to, and revised (www.exploratorium.edu).

Reflections are a writing to learn strategy that can be used prior to, during, or after any type of learning activity. Student reflections help students remember details of what and how they learned, generate meaning for future assignments or learning, and develop insight and critical thinking skills. When students reflect on the learning objectives and outcomes of learning activities, students are able to scaffold and link current and previous learning. In this process, students use both cognitive and emotional information while utilizing a variety of visual, auditory, kinesthetic, and tactile sources to construct meaning from their experiences (Costa and Kallick, 2009). As students are engaged in the science practices such as planning and conducting investigations, developing and using models, arguing from evidence, or analyzing and interpreting data, reflections become useful to teachers, peers, and themselves for demonstrating how student ideas and thinking emerge and evolve throughout a lesson or unit. Effective reflection is more likely to occur if students have had interesting experiences and investigations to write about and the tone for reflection has been set by the teacher (www.exploratorium.edu). Some teachers turn on music or ask for silence while student reflection occurs. If there is not a change in tone of the room, students have difficulty transitioning from the normal active noise of the classroom to individual introspection (Costa and Kallick, 2009).

Teachers can also support student reflection by providing prompts or questions that clearly relate a writing task to a particular science phenomenon or experience (See Appendix C for a list of useful questions). Providing students

with time to discuss their ideas during and immediately after an activity allows students to collect, organize, and clarify their ideas before they start to write. Students should be encouraged to use everyday language and sketches or diagrams to help illustrate their ideas to their audience (www.exploratorium.edu).

Traditionally, student reflections are written pieces of work. However, some studies have shown that oral reflections, specifically ones using video, are more authentic and meaningful (Rose, Sierschynksi, & Bjorling, 2016). Written reflections are limited because they are geared towards the student and produced solely for the teacher. When utilizing video reflections, the sense of audience broadens to include more external members. Often times, students' motivation and/or underdeveloped skills to write also impede self expression during reflection time (Rose, et. al, 2016). Therefore, allowing students to use a variety of modes of reflection provides them with opportunities to develop reflective skills without the fear of failure.

In order to monitor student progress in constructing reflections independent of the mode of reflection, teachers should provide constructive feedback that encourages students to expand their thinking. Teachers can document student progress by keeping a notebook tabbed with each student where they record reflections that demonstrate growth and development of student reflection and writing as well as places where transfer of learning across contexts occurs. Student notebooking and journaling is a strategy that students

can use to compile their learning and understanding so that they can utilize it for future learning.

Graphic Organizers

Student notebooking can be enhanced with the use of graphic organizers. Graphic organizers are visual and spatial representations of information and relationships found within text. They are typically a one page combination of words and diagrams that assist students to build upon prior knowledge, chunk and store information, build bridges in learning, and create new mental schema or pathways of understanding. Utilizing graphic organizers in a science reading class as a reading strategy can motivate student engagement, boost comprehension skills, and develop students' abilities to make predictions and identify patterns (Manoli & Papadopoulou, 2012). They can be employed during all stages of reading (pre-reading, during reading, or post-reading) to sequence information into a hierarchy, brainstorm concepts, analyze processes or relationships in the information, or convey meaning of the text.

There are a variety of ways to incorporate graphic organizers into a curriculum. However, they are most effective if the teacher scaffolds and models how to use them with a variety of contexts. Teachers should begin by modeling the use of specific graphic organizers, no matter if they are flow charts, Venn diagrams, t-chart, or concept maps. They need to consider the specific content in the text and the author's organizational patterns when choosing an appropriate graphic organizer (Fisher, 2001). Students should have independent practice

with teacher feedback to develop their skills in using graphic organizers. Although this type of modeling is pertinent to meeting the needs of students, graphic organizers are even more effective in promoting comprehension if students are allowed to construct their own graphic representation (Cox, para. 2). Therefore, after students are versed in the types of graphic organizers, they should be encouraged to determine which organizers to construct to represent their thinking and learning.

Summarization and Synthesis

Another content literacy strategy that is important for students to develop is the ability to synthesize and summarize text. These skills are necessary in order to use the other strategies already discussed, annotating text, constructing reflection or graphic organizers, and responding to anticipation reading guides. Summarization and synthesis are also necessary for students to persuasively demonstrate mastery of the science and engineering practices of the NGSS. For instance, to argue from evidence, students must be able to summarize and condense their evidence in their own words and synthesize and compile information from texts to provide justification and reasoning for their evidence. While both summarization and synthesis require students to find the important ideas within texts, synthesis also involves analyzing and evaluating information and divergent perspectives from multiple sources to make connections between prior and new learning. Synthesis is “the ability for people to assimilate information into coherent personal strategies and is perhaps the

most critical modern survival skill (Johnson, p. 601). It is vital in developing effective writing and communication skills. In order to effectively synthesize information, students need to be able to paraphrase sources, make accurate inferences, recognize an author's purpose or tone, and determine the validity and reliability of the information (Lundstrom, Diekema, Leary, Haderlie, & Holliday, 2015).

Again, for this strategy to be effective, educators must explicitly instruct students on how to put multiple sources together in a way that establishes connections between those sources and allows the students to develop their own ideas and arguments (Silva, 2013). Silva suggests that educators should start their instruction with an explanation on synthesis. Teachers could use a jigsaw puzzle as an analogy for how synthesis works. The pieces by themselves do not show the big picture but are important in the overall development of the puzzle. The next step in a synthesis lesson would be to participate in a shared reading and discussion of student/teacher responses based on that text. To further develop synthesis skills, students should then take part in a read aloud of a different text and practice reflecting upon the new text. Finally, students should be provided with feedback concerning an independent quick write or think aloud where students model their thinking; a graphic organizer such as a concept map is one way for students to organize their thinking and synthesis of texts. After students practice synthesizing in with the guidance of teacher instruction and

feedback, students should be given opportunities to develop their skills throughout the course of a class.

Purposeful planning of which and when to use each of the above or other content literacy strategies by instructors is necessary for students to build capacity so students take ownership of their reading or writing to learn. Each strategy requires explicit instruction and modeling by the instructor to be effective. However, students need to further practice each of them in authentic ways in order to advance their literacy skills in a way that they are able to individually choose specific strategies that work for them when constructing meaning from different texts and instruction.

Sources of Reading in Science

Because texts are written for different purposes and audiences, students should have the opportunity to obtain information and learning from a variety of texts. Using a variety of texts supports and encourages questioning, research, comparing multiple perspectives, and presenting information in the content areas (Barnatt, 2011). Reading multiple texts also facilitates critical thinking by providing conflicting or supporting evidence or positions, giving students the opportunity to compare and contrast and synthesize information across texts. In fact, the integration of diverse and abundant types of resources and texts has been shown to increase science achievement (Guthrie, Schafer, Von Secker, & Alban 2000).

However, offering multiple texts on a specific topic will not guarantee that students read any more critically for understanding. Educators need to purposefully choose the types of texts and provide students with strategies that align well with the text. In addition to the content literacy strategies already discussed, students need instruction in determining the credibility of the text (author and publication), contextualization (noting when and why the text was written), and corroboration with other texts (Shanahan, 2010).

Diverse research based text types are available for educators to employ in a Science Reading course. Trade books, case studies, nonfiction books, fiction books (including science fiction), journal articles, and websites or blogs can all be used to effectively increase students' literacy skills (Cervetti, Pearson, Bravo, & Barber, 2006; Young, Moss, & Cornwell 2007; Czerneda, 2006; Brownstone & Klein, 2006; and Greenleaf, et al. 2011). Using a variety of these types of texts also empowers students, build relationships between teachers and students due to meaningful classroom discussions, and develops student independence (Skeeters, et al., 2016). Similar to content literacy strategies, educators need to consider when and how to incorporate the different types of texts.

Case Studies

Case studies encourage active learning as students see how scientific and engineering concepts apply to real world situations. Case studies (descriptions of real world scenarios) come in many formats including single questions such as "What would you do?", detailed descriptions of a situation with questions to

analyze, descriptions with data to interpret, clicker cases (descriptions of situations that unfold slowly with opportunities for students to respond to questions or statements intermittently), or scenarios that require students to design and evaluate solutions. Instructors can write their own case studies or utilize books or online databases such as the National Center for Case Study Education out of Buffalo, New York.

Because many students reason more inductively than deductively, meaning that they transfer their learning more effectively from working through real life examples than from logical development as the lessons progress, case studies serve as excellent text sources. Case studies allow students to vicariously experience situations while developing their problem solving and analytical tools. Through the use of case studies, students gain the ability to cope with ambiguities and make decisions concerning complex situations (Using Case Studies to Teach, n.d, para. 1 & 7).

Case studies require active engagement of students and facilitate the development of analytical and problem solving skills whether students work independently or collaboratively through the elements of case studies. Most case studies include the following elements:

1. A decision maker who is confronting a question or problem
2. A context for the case (legal, family, or social issue)
3. Supporting data (testimonies, research or medical data, etc.)

requiring students to analyze and interpret information (Using Case Studies To Teach, n.d).

Following a systematic approach to analyze a case study where students put the issue in their own words, annotate the reading to denote key facts and the context, and consider alternatives when making their recommendations can support student learning with case studies. Educators need to choose case studies that provide adequate information for students to figure out solutions and then transfer their learning to other similar situations or case studies. Case studies can be especially effective if they are paired with other case studies or other readings that support the study with explanation of a concept or additional data that applies to the case and the current learning targets of the unit (Using Case Studies To Teach, n.d). Depending on the complexity of the case study, students may also need supplemental support from the instructor on how interpret and analyze the data.

During a case study session, instructors need to keep the discussion flowing and students engaged in the work. Students should be actively involved in the presentation of their positions, decisions, or solutions whether they are presenting their information orally, comparing their answers with others, or independently turning in a written response. Using whiteboard presentations or gallery walks where one student stays to present the information while others rotate throughout the other groups comparing their analysis or solution is one technique that ensures all students are involved. This method also allows

students to evaluate their decisions or solutions, therefore allowing them to practice their skills of science and engineering practices.

Nonfiction

Reading a variety nonfiction sources such as literary nonfiction essays; biographies and autobiographies; journals and technical manuals; and charts, graphs, and maps serve as other media through which students can employ practices such as searching for supporting evidence and evaluating claims. Also, there is a greater emphasis on nonfiction reading and text complexity in the Iowa Core and Common Core Literacy Standards. These standards suggest that students need to be able to comprehend informational texts as often and fluently as narrative texts (Goodwin & Miller, 2012-2013) in order to be able to identify key ideas and details, analyze the author's craft and structure, read texts at different levels and complexity, and integrate knowledge and facts into their background knowledge.

Nonfiction texts allow students to develop a foundation of background knowledge that can be used as a context to represent or transfer learning from one situation to another. Because the level of background knowledge can show as much as thirty-three percent variance in student achievement (Marzano, 2000), it is important for curriculum to include informational text reading. Fisher, Frey, and Lapp (2012) suggest that "Reading is an excellent, indirect way to build background knowledge. Through books, readers meet people otherwise

would never have met, visit places and times that they would not otherwise been able to visit, and interact with ideas that shape their understanding of the world.”

Reading nonfiction texts, in turn, promotes a continuous learning that focuses on evaluating, validating, and extending an individual’s background knowledge. If you are concerned about the complexity of scientific nonfiction articles and sources, trade books can be a powerful addition to your repertoire of instructional resources. Trade books are short, visually impactful, relatively inexpensive, and written for the general public, and therefore can be engaging and confidence building for struggling readers. Also, students are never too old to be read to and students actually find it exciting and interesting.

The National Science Education Standards state: “Science content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting, and relevant to students’ lives” (NRC 1996). Reading trade books, nonfiction books about specific scientific topics written for the general public aloud can serve as a springboard to inquiry and deeper understanding of disciplinary content and scientific themes Trade books can also be an invaluable way to introduce a new topic or scenario in a way that spark students’ interest in learning about that particular topic (Bircher, 2009). Because trade books are advertised as nonfiction, do not succumb to the pitfall that all trade books are equal in terms of scientific accuracy. The NSTA compiles an annual list of vetted trade books on their website called “Outstanding Science Trade Books for Students K-12” to assist you in your search of trade book titles.

Evaluate your sources prior to passing them off as an informational source. If they are less than accurate, encourage students to find these inaccuracies as another opportunity to evaluate the scientific accuracy of a particular source.

Fiction

Although not scientifically accurate, Kailey Rhodes (2016), a writer for Rubicon International and Julie Czerneda (1999) suggest that pop culture, fiction, and science fiction can be another useful source for developing a student's background knowledge and engaging students in a scientific topic or phenomenon. They can provide a common experience that is accessible and less threatening to students. Often times, students face the fear of being incorrect or not having all of the answers in science. They do not realize that the nature of science involves sharing thoughts, making mistakes, and redesigning and rethinking of ideas. The "What if?" motif found in fiction conveys a low stakes context for students where they can speculate about what could happen if a certain aspect of science or technology existed—or did not exist. By bringing science into the realm of students' lives, these stories are thought experiments about anything we can imagine, from global warming to evolution or epigenetics (Czerneda, 2006).

Fiction is also moldable (there are numerous books and novels being published at a variety of reading levels) and allows for multiple projects that can even be cross-curricular in nature (Rhodes, 2016). For instance, students who read "Deadly" or "The Hot Zone" get a look at the history of the development of

treatments for infectious diseases while looking at societal issues that are discussed in social studies such as sanitation and health, economic and political ramifications of large scale emergencies. Because fiction and science contain a great deal of prediction, inference, and speculation, they can also serve as a media to improve literacy and critical-thinking skills whether in an English or science course. Julie Czerneda (2006), states:

“Literacy concerns the communicating of ideas from one mind to another, including component skills such as vocabulary, language structure, reading, and writing to elicit comprehension. Critical thinking blends with literacy in the interpretation and extrapolation of ideas. There should be an understanding of source as well as context, which is particularly important to students sifting their way through myriad print and visual resources on science.”

Through utilizing and analyzing a variety of text sources (whether fiction or nonfiction, excerpts or whole pieces), students can begin to develop and fine tune critical literacy skills including analysis and evaluation, similar to what scientists do in their own research and study. However, instructors should take note that simply providing the reading material is not enough to ensure literacy development, they must carefully consider which texts and content literacy strategies to incorporate for each unit or topic (See Appendix D for a list of possible text sources).

Phenomena Driven Instruction

One of the first steps, in creating a curriculum for a science reading class or infusing literacy into any science class is selecting the topics for instruction. Since the adoption of the Next Generation Science Standards, phenomena

based instruction has resurfaced to the forefront. Phenomena, observable events in nature that we can use our science skills and knowledge to explain or predict the world around us, serve as excellent contexts for science education. Anchoring learning in phenomena creates a focus shift from teaching general knowledge about science to motivating students to figure out why or how something happens (nextgenerationscience.org, 2016). For example, instead of learning about mitosis or cell division, students are engaged in evidence based lessons and activities that help them figure out how stem cell therapies work to combat a disease.

Furthermore, students who begin to understand how science ideas can help explain and model phenomena related to real world situations, also learn to appreciate the social relevance of science. The NGSS are the infrastructure that can help students to make sense of phenomena in their world. “Learning to explain phenomena and solve problems is the central reason students engage in the three dimensions of the NGSS.” (“Next Generation Storylines, 2016). The science and engineering practices allow students to analyze and explain the phenomena while the disciplinary core ideas and crosscutting concepts link student claims, analyses, and interpretations to scientific and social ideas. Throughout a lesson or unit, students thus work to explain the science concepts behind the phenomena in their own words.

There are two types of phenomena, anchoring phenomena or lesson level phenomena. Anchoring phenomena, which can be a driving question, require an

entire unit for students to synthesize multiple sources and lessons in order to explain the science behind the phenomena while lesson level phenomena are shorter and allow students to explain smaller pieces of the overall puzzle (Maltese & McKenna, 2016). For instance, presenting students with the question, “Why can’t I just get a pill for that?” referring to the millions of people in the world who face incurable or debilitating diseases and disorders could open a “can or worms” of cross curricular concepts. Educators can guide students through the unit with lesson level phenomena such as nanoparticles used to deliver drugs to cancer cells or the development and distribution process of the flu vaccine to help students develop a schema to deeply understand multifaceted science concepts. Classrooms that allow students to determine which lesson level phenomena are necessary to explain the overall anchoring phenomena, more effectively use phenomena. In this manner, student generated questions drive the instruction causing them to be more engaged in their learning, reflection, and monitoring processes throughout the unit not just in disconnected pieces (nextgenscience.org).

Phenomena, whether anchor or lesson level, can be found all around us. They do not need to be flashy; phenomena only need to be observable and not deeply understood without exploration and investigation. Magazine or journal articles, chapters in fiction books, claims on social media, popular movies, occurrences in nature you see on the way to school are all sources that can be used to find phenomena. William R. Penuel and Philip Bell from Research +

Practice Collaboratory, a group of researchers building relationships between their research and practicing teachers, suggest that instructional sequences are more coherent when students are actively engaged in science and engineering practices while investigating compelling phenomena (Penuel & Bell, 2016).

Connections to Next Generation Science Standards

In addition to phenomena, there are many connections between developing an elective science reading class curriculum and the Next Generation Science Standards. For example, the science and engineering practices of the NGSS cohesively align with many literacy strategies. To better understand science content, students must gain an appreciation for how scientific knowledge is produced, communicated, and accepted within scientific communities (Gaskins, et. al, 1994). Incorporating the NGSS science and engineering practices allow students to hone in on those critical thinking and communication skills that scientists practice. The science and engineering practices that make a larger appearance in a science and literacy focused classroom include asking questions; arguing from evidence; constructing explanations and designing solutions; analyzing and interpreting data; developing and using models; and obtaining, evaluating, and communicating information (Appendix F from nextgenerationscience.org).

When students are arguing from evidence, they are practicing how to ask relevant questions, make predictions, acquire information from many sources,

weigh alternatives, and reach defensible explanations. Argumentation from evidence is the means that scientists use to make their case for new ideas (Osborne, Donovan, Henderson, MacPherson, & Wild 2017, p. 3). Because there are often multiple explanations that compete amongst practicing scientists, students need to be able to summarize and synthesize information in a way that students can make their own claims based on scientific evidence and reasoning. Annotation of resources can assist students in picking out evidence for an argument as well as construct an explanation about a scientific concept.

Explanations are not the same thing as arguing from evidence, however, constructing explanations requires similar summarizing and synthesizing of information skills. Students are more comfortable with providing explanations that demonstrate their understanding than with making claims about the world. This is due to the fact that explanations are usually concerning concepts that already established, have one accepted answer. Therefore, students often limit their arguments to what they already know whether inaccurate or not. To convince students that their argument or explanation is flawed based on their evidence, teachers may have to support them with instruction that includes more applicable or accurate evidence (Osborne, et. al., 2017 p. 9).

When students are developing their arguments or explanations, they may have to analyze and interpret data, ask questions about bias to evaluate sources, or reflect upon their understanding from different sources. By developing graphic organizers, such as flowcharts or tables with columns for both contradicting and

supporting evidence, students can organize and evaluate their evidence while putting all of the pieces together to make an argument. These graphic organizers can serve as models to assist students in explaining their reasoning for their claim and evidence. Students can also develop models to assist them in communicating their ideas or evaluating counter arguments.

Science is a dynamic process in which students must be actively involved, constructing and revising their understanding. In addition to utilizing the science and engineering practices to fuel communication and negotiate their arguments, students need to be immersed in the cross cutting concepts of the NGSS. Students need to practice reflective learning where they detect patterns, describe systems and system models in different scales, proportions, and qualities to describe how the natural world changes and remains stable at the same time (for a complete list of cross cutting concepts go to Appendix G at nextgenscience.org). Such an integrated approach places a premium on students developing the disposition to manipulate and critique what they read and write in order to apply their understandings to real-life problems (Gaskins, et. al. 1994).

Achieve, a nonprofit education reform organization, partnered with the National Science Teachers' Association to develop a rubric and more recently a Lesson Screener for educator to use to evaluate and design curriculum materials aligned with the Next Generation Science Standards. To ensure that educators are incorporating relevant phenomena; the three dimensions; connections

between math, science, and literacy for all levels of student learning, they can utilize either the EQuIP (Educators Evaluating the Quality of Instructional Products) Rubric (Version 2.0 available in Appendix E) or the NGSS Lesson Screener (both available at [www. nextgenscience.org](http://www.nextgenscience.org)) while designing or compiling a curriculum for a science reading course. The Lesson Screener's purpose is to quickly review a lesson to see whether a lesson being developed or used is on the right track to being aligned or if the lesson warrants further review using the EQuIP. The EQuIP, on the other hand, is more useful for evaluating whole units and contains more criteria (nextgenerationsscience.org). The power of using the Lesson Screener and the EQuIP appears to be in the reflections, collaboration, and conversations educators can have around a unit or lesson. An adapted version of both tools were used during the development of the example unit in Chapter 3.

Understanding By Design and Curriculum Planning

One of the primary goals of education is the effective transfer of learning. Therefore, the most successful teaching begins with thinking about desired outcomes and student evidence that will show how that transfer of learning has occurred. Understanding by Design (UbD) is a curriculum planning framework that focuses on developing students' deep understanding of concepts and places assessment of those desired outcomes first and foremost. UbD converges learning and assessment of understanding research with curriculum

writing. As a framework, UbD assists teachers in purposefully planning curriculum in a way that students transfer their gained knowledge and skills in a variety of contexts and situations. Traditionally, science education has focused on knowledge acquisition where students are assessed on discrete often unconnected facts they easily forget after the assessment. The aim of using UbD as a framework is that students are more likely to gain long term understanding (the ability to make meaning of learning via big ideas) when this curriculum development format is employed (Wiggins & McTighe, p. 3). Therefore, UbD assigns teachers the role of coaches of understanding and not as purveyors of content.

During the process, teachers first unpack standards into what students need to know, understand, and able to do. Then teachers plan their instruction in a backward fashion such that they analyze long-term desired results prior to designing activities or day to day instruction. This type of planning shifts the focus from what the teacher is doing to what the student is learning and what evidence students can provide to demonstrate that learning has occurred. Teachers develop an UbD learning plan that includes a number of ways students are formatively assessed so teachers can utilize this performance data to inform them concerning needed adjustments in real time. The UbD framework calls for regular reviews of curriculum against standards to ensure curricular quality and effectiveness. of transferrable concepts and processes. (Wiggins & McTighe, p. 4).

Research on how people learn supports this type of understanding-based approach to instruction and assessment (Bransford, Brown, and Cocking 2000). Effective learning requires a balanced focus on students gaining understanding of underlying concepts, application of gained knowledge, and drill and practice (Wiggins & McTighe, p. 5). An expert learner develops an understanding of the problems, challenges, and big ideas while novice learners approach understanding problems by trying to find the one quick answer or formula. Deep coverage of content develops connected knowledge so students have a treasure trove of skills to use in new situations. Assessment, especially summative assessment, should thus measure whether students know when and why to use those learned skills.

Whenever new material is presented in a way that allows students to recognize patterns and relationships, they generate more brain cell activity and achieve more successful long-term memory storage and retrieval. Experiential learning about phenomena that stimulates multiple senses is both engaging and the most likely to be stored in long term memory (Wiggins & McTighe, p. 5). Therefore, the best remembered concepts are learned through multiple exposures of a variety of texts followed by learners reflecting and synthesizing the knowledge in new, authentic situations. Because UbD advocates for this type of curriculum, it is an optimal framework to utilize as a guide when creating a curriculum for a science reading class. The following chapter delineates a curriculum planning process that compiles all of the strategies above.

CHAPTER 3

PROJECT

The serendipitous nature of new discoveries in science is often mirrored in the inspiration of new units in a Science Reading and Research class. When developing curriculum for a class that combines three-dimensional learning in science with literacy, one must look at all aspects of life for phenomena or unit topic ideas. While watching television, scrolling through social media, listening to the radio or conversations at the lunch table, a vision of possible unit topics can surface. If a book title, article, or a television show causes a sense of wonderment and questioning, it might just be the hook that evokes student curiosity. Effective phenomena and units motivate students to figure something out with a sense of urgency. Often times, looking for the controversial issues in science that have multiple perspectives or claims reported serve as good anchoring phenomena with which to begin the curriculum writing process. Once a seed is planted for an idea about the unit, an instructor can start to develop a driving or essential question(s) that students try to answer throughout the unit. For instance, “Are we ready for a pandemic in the U.S.?”

After a unit topic is developed, an instructor should consider what a student needs to know, understand, and be able to do in regards to the anchoring phenomena or driving question as suggested by the UbD framework. To do this, I recommend a quick write for each category on the unit planning template prior to searching the internet and texts for types of information

available concerning the topic. Instructors should consider the preconceptions students may have concerning the topic. Once the quick write is finished, a survey for information about the understanding of the topic by students can occur. Page Keeley (2005) has written a book to support teachers' survey of student learning on a topic called the "Science Curriculum Topic Study: Bridging the Gap Between Standards and Practice". Although this book is useful for many topics related to disciplinary core ideas, it does not cover more recent technological and scientific discoveries. Therefore, instructors would need to search through scholarly articles and internet sites to glean information about student preconceptions and what they might need to know, understand, and be able to do.

Coordinating the research information and the quick write with the three dimensions of the NGSS comes next. If teachers chose more "hot" topics in science, the unit topic may not match the NGSS performance expectations specifically. However, teachers can choose the science and engineering practices, disciplinary core ideas, and crosscutting concepts that seem to be most related or necessary for students to demonstrate understanding of a specific topic or phenomenon. When choosing specific pieces of the dimensions, instructors should consider that there may be both primary and auxiliary parts that students may utilize at different points within the unit.

According to the UbD framework, instructors should next begin the development of assessments (both formative and summative) that allow students

to demonstrate evidence of their learning and understanding. Scaffolding formative assessments to ensure skill and content or theme development is more effective than only planning one summative assessment at the end of the unit that synthesizes all of the information into one assessment. However, developing a cumulative synthesizing task that connects all of the learning, understanding, and three dimensions of the NGSS can also be developed at this time. While the UbD framework stresses the importance of keeping the desired outcomes at the forefront, choosing texts, resources, and media that often serve as subordinate phenomena might need to happen concurrently with assessment writing.

The search for texts, resources, and media that support the learning necessary to perform proficiently on the selected disciplinary core ideas and crosscutting concepts can seem daunting at times. However, being on the lookout during internet searches, bookstore visits, or media updates can assist teachers in finding appropriate texts. Remember, the NRC suggests utilizing a variety of texts allows students to develop science and literacy practices. Thus, selecting texts in each of the categories (nonfiction (books, excerpts, or journal articles), fiction, case studies, and video or film) discussed in Chapter 2 is one way that instructors can ensure effectual variety of texts.

Once the texts and media have been selected, instructors choose content literacy strategies that cohesively align the resources with the NGSS science and engineering practices. For example, an anticipation reading guide or annotative note taking can help students identify evidence they can use to make a claim to

argue from evidence. The final step in curriculum planning is to design or modify lessons and assessments for a daily learning plan. Learning cycles such as the 5E learning cycle that includes engagement, exploration, explanation, elaboration, and evaluation are effective tools to organize and plan daily instruction. An adapted table of the phases that demonstrates both student and teacher actions for each of the phases of the cycle can be found in the book “More Picture-Perfect Science Lessons” in chapter 4 (Ansberry & Morgan, 2007).

The daily learning plan should coherently link and scaffold what the students need to know, understand and do with the three dimensions of the NGSS, texts and resources, and content literacy strategies. The following template is a compilation of UbD (original UbD Template available in Appendix E), 5E learning cycle, content literacy strategies, and phenomena driven instruction that is useful in developing this coherency. An example of a unit plan for the phenomena or driving question: “Are we ready for a pandemic that reaches the U.S.?” follows the blank template. After the example unit template, a “Connections and Alignment Notes” is included. This chapter ends with an adapted version of the EQuIP Rubric and Lesson Screener from the Next Generation Science Standards that were used during the curriculum design process of a classroom infused with literacy.

Unit Planning Template

Phenomena/Unit Topic:			
Science & Engineering Practices <ul style="list-style-type: none"> • Asking Questions & Defining Problems • Developing & Using Models • Planning & Conducting Investigation • Analyzing & Interpreting Data • Using Mathematical & Computational Data • Constructing Explanations & Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, & Communicating 	Disciplinary Core Ideas <ul style="list-style-type: none"> • PS1.A Structure & Properties of Matter • PS1.B Chemical Reactions • PS1.C Nuclear Processes • PS2.A Forces and Motion • PS2.B Types of Interactions • PS3.A Definitions of Energy • PS3.B Conservation of Energy & Energy Transfer • PS3.C Relationships Between Energy & Forces • PS3.D Energy in Chemical Processes • PS4.A Wave Properties • PS4.B Electromagnetic Radiation • PS4.C Information Technologies & Instrumentation • LS1.A Structure & Function • LS1.B Growth & Development of Organisms • LS1.C Organization for Matter & Energy Flow in Organisms • LS2.A Interdependent Relationships in Ecosystems • LS2.B Cycles of Matter and Energy Transfer in Ecosystems 	Disciplinary Core Ideas <ul style="list-style-type: none"> • LS2.C Ecosystem Dynamics, Functioning & Resilience • LS2.D Social Interactions & Group Behavior • LS3.A Inheritance of Traits • LS3.B Variation of Traits • LS4.A Evidence of Common Ancestry & Diversity • LS4.B Natural Selection • LS4.C Adaptation • LS4.D Biodiversity and Humans • ESS1.A The Universe & Its Stars • ESS1.B Earth & The Solar System • ESS1.C The History of the Earth • ESS2.A Earth Materials & Systems • ESS2.B Plate Tectonics & Large-Scale System Interactions • ESS2.C The Roles of Water in Earth's Systems Processes • ESS2.D Weather & Climate • ESS2.E Biogeology • ESS3.A Natural Resources • ESS3.B Natural Hazards • ESS3.C Human Impacts on Earth Systems • ESS3.D Global Climate Change • ETS1.A Defining and Delimiting Engineering • ETS1.B Developing Possible Solutions • ETS1.C Optimizing the Design Solution 	Cross Cutting Concepts <ul style="list-style-type: none"> • Patterns • Cause and Effect • Scale, Proportion, and Quantity • Systems and System Models • Energy and Matter • Structure and Function • Stability and Change

NGSS/3D Connections (what students should know, understand, and be able to do)

Student Preconceptions:

3D Assessments:

Texts, Media, and Resources:

Content Literacy Strategies:

Annotations:

Anticipation Reading Guide:

Graphic Organizers:

Reflections:

Summarization/Synthesis

Daily Learning Plan (Based on 5E learning Cycle):

Unit Planning Template

Phenomena/Unit Topic/Driving Question: Are we prepared for a pandemic?
 *Immunology including Disease Transmission *Drug/Vaccine Development
 and Epidemic Preparedness *Response to Disease Outbreaks

Science & Engineering Practices	Disciplinary Core Ideas	Disciplinary Core Ideas	Cross Cutting Concepts
<ul style="list-style-type: none"> Asking Questions & Defining Problems Developing & Using Models Planning & Conducting Investigation Analyzing & Interpreting Data Using Mathematical & Computational Data Constructing Explanations & Designing Solutions Engaging in Argument from Evidence Obtaining, Evaluating, & Communicating 	<ul style="list-style-type: none"> PS1.A Structure & Properties of Matter PS1.B Chemical Reactions PS1.C Nuclear Processes PS2.A Forces and Motion PS2.B Types of Interactions PS3.A Definitions of Energy PS3.B Conservations of Energy & Energy Transfer PS3.C Relationships Between Energy & Forces PS3.D Energy in Chemical Processes PS4.A Wave Properties PS4.B Electromagnetic Radiation PS4.C Information Technologies & Instrumentation LS1.A Structure & Function LS1.B Growth & Development of Organisms LS1.C Organization for Matter & Energy Flow in Organisms LS2.A Interdependent Relationships in Ecosystems LS2.B Cycles of Matter and Energy Transfer in Ecosystems 	<ul style="list-style-type: none"> LS2.C Ecosystem Dynamics, Functioning & Resilience LS2.D Social Interactions & Group Behavior LS3.A Inheritance of Traits LS3.B Variation of Traits LS4.A Evidence of Common Ancestry & Diversity LS4.B Natural Selection LS4.C Adaptation LS4.D Biodiversity and Humans ESS1.A The Universe & Its Stars ESS1.B Earth & The Solar System ESS1.C The History of the Earth ESS2.A Earth Materials & Systems ESS2.B Plate Tectonics & Large-Scale System Interactions ESS2.C The Roles of Water in Earth's Systems Processes ESS2.D Weather & Climate ESS2.E Biogeology ESS3.A Natural Resources ESS3.B Natural Hazards ESS3.C Human Impacts on Earth Systems 	<ul style="list-style-type: none"> Patterns Cause and Effect Scale, Proportion, and Quantity Systems and System Models Energy and Matter Structure and Function Stability and Change

		<ul style="list-style-type: none">• ESS3.D Global Climate Change• ETS1.A Defining and Delimiting Engineering• ETS1.B Developing Possible Solutions• ETS1.C Optimizing the Design Solution	
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NGSS/3D Connections (what students should know, understand, and be able to do):

Know: The immune system responds with both innate and adaptive responses.

Modes of transmission of diseases include contact (direct, indirect, and droplet) and non-contact (airborne, vehicle, and vector borne).

Pathogens are agents that can cause diseases and can include bacteria, viruses, or other microorganisms.

Understand: The human immune system is a series of organs, tissues, and cells that work together to fight against disease and maintain homeostasis.

There is an interconnected network of scientists, professionals, and agencies involved in preventing or responding to the transmission of disease (each with different responsibilities and duties).

The prevention, preparation, and removal of an outbreak is a multifaceted operation affected by the resilience and adaptability of pathogens.

Pathogens (zoonoses) can jump from one species to another.

Do: Analyze and interpret data about disease transmission and outbreaks to determine the agent of infection.

Develop and use models to describe how diseases are spread.

Evaluate sources to determine reliability.

Develop a PSA that explains the importance of vaccinating children.

Argue from evidence that vaccines are a safe method of disease prevention.

Develop a detailed plan for preparing for and reducing the impacts of an outbreak.

Synthesize information from multiple sources.

Student Preconceptions:

- a. Viruses are identical to cells or bacteria.
- b. All microbes have negative impacts on humans.
<http://www.cosee-west.org/Mar262011/01MisconceptionsAboutMicrobes.pdf>
- c. Vaccines have negative side effects that outweigh the benefits.
(<http://www.publichealth.org/public-awareness/understanding-vaccines/vaccine-myths-debunked/>)
- d. Ebola can be transmitted through the air.
<http://www.npr.org/sections/goatsandsoda/2014/12/01/364749313/ebola-in-the-air-what-science-says-about-how-the-virus-spreads>

3D Assessments:**Formative:**

- Lesson 2: 3-2-1 Disease Transmission and Prevention
- Lesson 3: History of Epidemics Reflection Paragraph
- Lesson 4: Disease Transmission Graphic Organizer
- Lesson 5: Immune System Response Post-Model
- Lesson 6: Superbug Explanation
- Lesson 7: Pandemic Response Analysis

Summative:

- Lesson 6: Vaccine Safety/Antibiotic Resistance/ Public Service announcement
- Lesson 7: Pandemic Response One Page Drawing
- Lesson 8: Book Review

Texts, Media, and Resources:

Lesson 1: Hot Zone Excerpt by Richard Preston

<http://www.pbs.org/newshour/extra/wp-content/uploads/sites/2/2014/09/Excerpt-from-The-Hot-Zone-for-PBS-NewsHour-Education.pdf>

Lesson 2: Ebola Articles:

1. Drake, N. (2014, October 03). Ebola Explained: What You Should and Shouldn't Worry About. Retrieved April 17, 2017, from <https://www.wired.com/2014/10/ebola-virus-infection-transmission-death-explained/>
2. Tam, R. (n.d.). This is how you get Ebola, as explained by science. Retrieved April 17, 2017, from <http://www.pbs.org/newshour/updates/know-enemy/>

3. Raloff, J. (2016, July 31). Explainer: What is Ebola? Retrieved April 17, 2017, from <https://www.sciencenewsforstudents.org/article/Explainer-what-ebola>

Lesson 3: Epidemics in History

1. "5 Top Deadliest Diseases" by SciShow
2. <https://emergency.cdc.gov/recentincidents/index.asp>.

Lesson 4 Types of Disease Transmission/Mapping Disease Transmission

1. <http://phprimer.afmc.ca/Part3-PracticeImprovingHealth/Chapter11InfectiousDiseaseControl>
2. <http://www.pbs.org/wgbh/nova/body/herd-immunity.html>,
3. http://www.who.int/influenza/resources/documents/pandemic_phase_descriptions_and_actions.pdf.
4. Solve the Outbreak- CDC app
(<https://www.cdc.gov/mobile/applications/sto/web-app.html>)
5. How Many Ebola Patients Have Been Treated Outside of Africa? - NY Times Interactive
(<https://www.nytimes.com/interactive/2014/07/31/world/africa/ebola-virus-outbreak-qa.html>)
6. WHO Pandemic Phase Descriptions and Actions by Phase
(http://www.who.int/influenza/resources/documents/pandemic_phase_descriptions_and_actions.pdf)

Lesson 5: Immune System Response

1. HHMI Immune System Interactive
(<http://www.hhmi.org/biointeractive/cells-immune-system>)
2. Haspi Vaccination Module
http://www.haspi.org/uploads/6/5/2/9/65290513/00_vaccination_module_final.pdf)

Lesson 6: Vaccines/Antibiotics Suggested Articles:

Lesson 7: A Case Study, a Movie, and a Board game to Explain the Interconnected System of Preparing for and Stopping a Pandemic

1. Something Wicked -
<https://www.cdc.gov/careerpaths/scienceambassador/documents/hs-something-wicked-ebola-response-2015.pdf>
2. Contagion (2011)
3. Pandemic (board game)

Lesson 8: Summative Assessment:**Non-Inclusive List of Books (Student Choice):**

Fever 1793

Hot Zone by Richard Preston

The Cobra Event by Richard Preston

Malaria Capers: Tales of Parasites and People by Robert Desowitz

Pandemic: Tracking Contagions, from Cholera to Ebola and Beyond by Sonia Shah

Pandemic by Scott Sigler

The Plague Tales by Anne Benson

Nemesis by Philip Roth

A Death-Struck Year by Makiia Lucier

The Last Town on Earth by Thomas Mullen

Deadly by Julie Chibbaro

Content Literacy Strategies:

Annotated Notes: Ebola Articles (Lesson 2)

Vaccine Safety/Antibiotic Resistance (Lesson 6)

Anticipation Reading Guide: Ebola Articles (Lesson 2)

Graphic Organizers: Disease Transmission (Lesson 4)

Vaccines and Antibiotics Venn Diagram (Lesson 6)

Reflection: Hot Zone Excerpt (Lesson 1)

History of Epidemics/Disease Transmission (Lesson 3)

Book Review (Lesson 8)

Summarizing and Synthesizing: Vaccine Safety/Antibiotic Resistance (Lesson 6)

Preparing for a Pandemic (Lesson 7)

Daily Learning Plan (Based on 5E learning Cycle):**Lesson 1 (Engage): Hot Zone Excerpt and Reflection Questions:**

A. Students read the excerpt from the following site:

<http://www.pbs.org/newshour/extra/wp-content/uploads/sites/2/2014/09/Excerpt-from-The-Hot-Zone-for-PBS-NewsHour-Education.pdf>. After reading the excerpt, students answer **HOT ZONE REFLECTION QUESTIONS** concerning the disease transmission, prevention, and treatment of a disease (Appendix F).

B. Student read jacket summaries from the list of fictional books that include pandemics, epidemics, or bioterrorism. Students must choose one book for outside of class reading to review for the final assessment (from the list or from their own choosing as long as it is approved by the teacher).

Differentiation Note: The books included in the list are written at different reading levels. Guiding students in making appropriate choices of books to read.

Lesson 2 (Explore): Ebola Article with Anticipation Reading Guide:

A. Students complete the **EBOLA ARTICLE ANTICIPATION READING GUIDE** (Appendix F) and read an article from Wired Magazine, PBS NewsHour Extra, or Science News for Students (see the texts and resources section above for links). While reading the article, students annotate the article utilizing their annotation bookmark (Appendix B). The students review their anticipation guide to see if their answers were supported in the article. They will then discuss their answers with a small group made up of students that have different articles. This will give them a chance to compare their textual evidence for their answers. Note: Some questions are only able to be supported with evidence from only 1-2 articles. Therefore, some of the students answers will not be corroborated prior to this small group collaboration. Students will then come together for a large group discussion of their learning about disease transmission, prevention, and treatment of Ebola.

B. Formative assessment called a 3-2-1. Students should write 3 things they learned about how Ebola is transmitted, 2 ways that Ebola can be prevented or treated, and 1 question they still have about Ebola or the transmission of disease?

Differentiation Note: The articles were purposefully chosen based on differing lengths. This is an opportunity for differentiation based on fluency abilities of students.

Lesson 3 (Explore/Explain): Epidemics in History

A. Students watch a video entitled “5 Top Deadliest Diseases” by SciShow. They then complete Table 1 on the student handout HISTORY OF EPIDEMICS about the symptoms, causes, mortality rates, and treatments or preventions of 5 infectious diseases. Students also research three of the more recent outbreaks in the world and complete Table 2 on the student handout concerning the causes, symptoms, transmission, and number of infected people using the CDC website (<https://emergency.cdc.gov/recentincidents/index.asp>).

B. Students participate in a model epidemic activity (DISEASE TRANSMISSION LAB) during which they locate patient zero.

Formative Assessment: Students reflect upon their learning by discussing the patterns of disease transmission seen amongst the diseases in their HISTORY OF EPIDEMICS tables and in the DISEASE TRANSMISSION LAB in a written paragraph.

Differentiation Note: Students can be given a set of sentence frames or a list of guiding questions from the sample reflection questions (Appendix C)

Lesson 4 (Explain): Types of Disease Transmission/Mapping Disease Transmission

A. Students fill in the **DISEASE TRANSMISSION GUIDED NOTES** (found in Appendix F) by reading and answering questions from the following websites and handouts:

<http://phprimer.afmc.ca/Part3-PracticeImprovingHealth/Chapter11InfectiousDiseaseControl>

<http://www.pbs.org/wgbh/nova/body/herd-immunity.html>,

http://www.who.int/influenza/resources/documents/pandemic_phase_descriptions_and_actions.pdf.

B. Students play the CDC's Solve the Outbreak app and sift through the data concerning the 2014 outbreak of Ebola in Africa found at <https://www.nytimes.com/interactive/2014/07/31/world/africa/ebola-virus-outbreak-qa.html> to develop an understanding of the professionals and agencies that are involved in tracking an epidemic. Students complete the SOLVE THE OUTBREAK (found in Appendix F) handout as they are engaged with these two interactives.

C. Formative Assessment: Students create a graphic organizer (concept map) demonstrating their understanding of how a disease spreads, the agencies, professionals, and methods involved in tracking a disease, and methods of prevention of the spread of disease.

Differentiation Note:

These activities work best if completed in groups of 2-3 so that they can see the computer app at the same time. Heterogeneous groups based on skill and interest levels should be created.

Lesson 5 (Explain): Immune System Response

A. Students are presented with the question: How does your body fight off the measles? They then make a pre-learning model representing the parts and functions of the immune system. These models are created in small groups of 3-4 students.

B. The students participate in a series of interactive reading and lab activities about immunity and vaccinations put together by the Howard Hughes Medical Institute (<http://www.hhmi.org/biointeractive/cells-immune-system>) and Health and Science Pipeline Initiative

(http://www.haspi.org/uploads/6/5/2/9/65290513/00_vaccination_module_final.pdf). After each section of the lessons used, students are given the opportunity to update their models.

C. Formative Assessment: Upon the completion of the activities, students will make a post-model that represents how the body fights off measles?

Lesson 6 (Explain/Elaborate): Vaccine Safety and Antibiotic Resistance

A. Students complete a WebQuest to gain a basic understanding of what a vaccine, how vaccines are made, and how antibiotics work. Students complete a Venn diagram as a graphic organizer to compare vaccines and antibiotics.

B. Students are confronted with the question: What role does our society play in the development of Superbugs? Students then research the controversies surrounding the safety and side effects of vaccines, the inappropriate use of antibiotics, and the role that humans play in the development of Superbugs on the internet. Students annotate their articles in order to help them complete the **SUPERBUGS RESEARCH ORGANIZER** (found in Appendix F). In small groups, students share their research findings and together evaluate their sources and evidence.

C. Students participate in a bacterial transformation activity where they create and grow an antibiotic resistant bacteria lab grade bacteria.

D. Formative Assessment: Students construct an explanation by synthesizing and summarizing their resources and learning from previous lessons for how Superbugs come into existence based on antibiotic resistance and vaccine use.

E. Students use their explanation to develop a Public Service Announcement (PSA) about either vaccine safety or antibiotic resistance geared for parents of small children.

Differentiation Note: Providing students with appropriate articles (content and reading level) may be necessary for some or all students.

Lesson 7 (Evaluate): A Case Study, a Movie, and a Board game to Explain the Interconnected System of Preparing for and Stopping a Pandemic

A. Students participate in a series of activities that develops students understanding of the public health response system that is involved in the management of an outbreak found at <https://www.cdc.gov/careerpaths/scienceambassador/documents/hs-something-wicked-ebola-response-2015.pdf>

B. Students watch the popular fictitious movie “Contagion” (released in 2011) which follows public health individuals as they identify and contain a virus. Students complete the “**CONTAGION**” **STUDENT HANDOUT** as they view the movie.

C. Students play the cooperative strategy board game “Pandemic” and record their decisions (moves) on the “**PANDEMIC**” **STRATEGY STUDENT HANDOUT** (found in Appendix E). Pandemic is based on the premise that four diseases have broken out all of the world; the players act as set of professionals needed to work together to strategically eradicate the diseases from the planet.

D. Students research a career available at the CDC website (<https://jobs.cdc.gov/>) based on salary, qualifications, job duties, and what role this position would play in the prevention and management of disease transmission.

E. Formative Assessment: Students synthesize and reflect upon what they have learned from each of the above learning activities in the **PANDEMIC “FACT or FICTION”** while evaluating the portions of each activity represent things that happen or do not happen when facing an outbreak.

F. Summative Assessment: **One Pager (YOUR PANDEMIC UNDERSTANDING ON ONE PAGE)** - students create a one page poster that represents all their understanding of the systems in place (healthcare management and physiologically within our bodies) that allow us to prepare for a pandemic Students are given the following problem to serve as their case study: Several students at your high school have come down with respiratory symptoms including a cough, tightness in their chests, and a high fever. They are also extremely tired and cannot stay awake in their super engaging biology class. The Department of Health has issued a notice that there is a new strain of influenza that has been confirmed in 8 cases in the county. The news has been running segments about the new bird flu strain. Students use this information as a platform to display all the learning about disease identification, transmission, management, and prevention.

Differentiation Note: Students may need a word or topic list to get them started on some of the assignments in this lesson series.

Lesson 8: Summative Assessment:

A. Book Review: Students review their book of choice following a set of tips and guidelines found in the **BOOK REVIEW GUIDELINES** (found in Appendix F). In one of the paragraphs, student delineate how their book supports their learning and understanding of how disease is transmitted, prevented, and managed.

Alignment and Connections Notes

This section reveals the thought process about how this unit aligns to the three dimensions of the NGSS, how things are scaffolded for learning, and helpful notes for teachers.

NGSS/3D Connections:

Know: Students may need extra support throughout the unit concerning the types of pathogens. There is not a learning activity about the differences between bacteria, viruses, and other pathogens such as prions. This could be included within the WebQuest concerning vaccine and antibiotics. I have completed an activity called “The Good, The Bad, and The Ugly” that allows students to research a specific group of pathogens but also other organisms within the same group that are beneficial to humans.

Understand: Students could be formatively assessed on the performance expectation HS-LS-1-2 (Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms). Additional learning activities may be necessary if students struggle or continue to have misconceptions about zoonoses.

Do: These student actions were explicitly chosen because of how they align to the science and engineering practices of the NGSS. Several actions including synthesizing information from multiple sources align to literacy standards as well.

Student Preconceptions: More student preconceptions may become evident throughout the unit.

3D Assessments: A pre/post assessment was not included in this unit because Lesson 1 and 2 and Lesson 8 were chosen and developed to sift through student preconceptions and assess how their understanding developed because of the unit. As teacher learning and professional development increase concerning three-dimensional assessment, this might need to be adjusted. Students should be assessed on their literacy skill development as well as on their understanding and knowledge about pandemics.

Text, Media, and Resources: A variety of texts and resources was explicitly used, however, many more are available and could be used depending on access (especially the list of books for the summative assessment). Although the focus of this unit is Ebola and Ebola like viruses, the Zika virus, HIV virus, or the Bird Flu could be the highlighted pathogen utilizing different texts. Some of the texts can be rewritten or are available for a variety of reading levels.

Content Literacy Strategies: The plan only highlights the strategies discussed in the literature review in Chapter 2. Others are incorporated into the lessons such as Argumentation and Writing to Learn. Depending on district initiatives, the highlighted strategies may change. The content literacy strategies were chosen specifically to partner with the “Do’s” from the NGSS/3D Connections box. For instance, the graphic organizers connect with the develop and use a model.

Learning Plan: The first lessons in the unit plan cover how diseases are transmitted through a population. Students apply their understanding of how diseases move through a population in lesson 4 by using the CDC’s Solve the Outbreak app. Students may go through as many cases as time permits. This app is also a precursor to lesson 7. The students can use their knowledge and strategies from using this app when they play the board game. Lesson 5 interactives may not be sufficient for students to know and understand how the immune system works. Direct instruction may need to take place for groups of students.

As stated before, types of pathogens may need covered prior to lesson 6. Depending on student preconception and family understanding and values, lesson 6 may be controversial. A pre-survey about vaccinations might be helpful to help teachers prepare for the sensitivity needed for this topic. A template or sentence frames for the PSA might be helpful to students. Find an outlet (whether simply video or a board meeting, etc.) for students to share their work.

Lesson 7 and 8 include several learning activities that are fictitious in nature. Students will need extra support to apply these activities to their prior learning. Encourage student talk, ask specific questions about the connections and relationships, and encourage students to use cross cutting concepts such as systems, patterns, and cause and effect as they interact with the information and each other during the activities.

NOTE: This unit plan could take up to 8 -9 weeks depending upon what is assigned for homework, how quickly students gain their understanding and work through the learning activities, and how much extra support or activities need to be added to the unit.

Using the EQuIP Rubric for Lessons and Units for Science as a Design Tool

(Adapted from EQuIP Rubric for Lessons and Units for Science pages 2-3 found at <https://www.nextgenscience.org/sites/default/files/EQuIPRubricforSciencev3.pdf>)

I. NGSS 3D Design	II. NGSS Instructional Supports	III. Monitoring NGSS Student Progress
<p>The lesson/unit is designed so students make sense of phenomena and/or design solutions to problems by engaging in student performances that integrate the three dimensions of the NGSS..</p> <p>A. Explaining Phenomena/Designing Solutions: Making sense of phenomena and/or designing solutions to a problem drive student learning.</p> <p>i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.</p> <p>ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.</p> <p>iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.</p> <p>B. Three Dimensions: Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to</p>	<p>The lesson/unit supports three-dimensional teaching and learning for ALL students by placing the lesson in a sequence of learning for all three dimensions and providing support for teachers to engage all students.</p> <p>A. Relevance and Authenticity: Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.</p> <p>i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).</p> <p>ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.</p> <p>iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.</p> <p>B. Student Ideas: Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and to respond to peer and teacher feedback orally and/or in written form as appropriate.</p>	<p>The lesson/unit supports monitoring student progress in all three dimensions of the NGSS as students make sense of phenomena and/or design solutions to problems.</p> <p>A. Monitoring 3D student performances: Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.</p> <p>B. Formative: Embeds formative assessment processes throughout that evaluate student learning to inform instruction.</p> <p>C. Scoring guidance: Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.</p> <p>D. Unbiased tasks/items: Assesses</p>

<p>aid student sense-making of phenomena and/or designing of solutions.</p> <p>i. Provides opportunities to develop and use specific elements of the SEP(s).</p> <p>ii. Provides opportunities to develop and use specific elements of the DCI(s).</p> <p>iii. Provides opportunities to develop and use specific elements of the CCC(s).</p> <p>C. Integrating the Three Dimensions: Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.</p>	<p>C. Building Progressions: Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers: i. Explicitly identifying prior student learning expected for all three dimensions ii. Clearly explaining how the prior learning will be built upon</p> <p>D. Scientific Accuracy: Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.</p> <p>E. Differentiated Instruction: Provides guidance for teachers to support differentiated instruction by including:</p> <p>i. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers, etc.) for students who are English language learners, have special needs, or read well below the grade level.</p> <p>ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.</p> <p>iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.</p> <p>F. Teacher Support for Unit Coherence: Supports teachers in facilitating coherent student</p>	<p>student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.</p> <p>E. Coherent Assessment system: Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.</p> <p>F. Opportunity to learn: Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.</p>
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	<p>learning experiences over time by:</p> <p>i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.).</p> <p>ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions. G. Scaffolded differentiation over time: Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.</p> <p>G. Scaffolded differentiation over time: Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.</p>	
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Note: This adapted version of the EQuIP Rubric is utilized while developing curriculum units infused with literacy. The headings and criteria are referred to during the planning process.

NGSS Lesson Screener

A Quick Look at Potential NGSS Lesson Design for Instruction and Assessment

Is the lesson designed to engage all students in making sense of phenomena and/or designing solutions to problems through student performances that integrate the three dimensions of the NGSS?

(Adapted from the NGSS Lesson Screener page 2 found at
<https://www.nextgenscience.org/sites/default/files/NGSSScreeningTool.pdf>)

NGSS SHIFTS

A. Explaining Phenomena or Designing Solutions: The lesson focuses on supporting students to make sense of a phenomenon or design solutions to a problem.

B. Three Dimensions : The lesson helps students develop and use multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs), which are deliberately selected to aid student sense-making of phenomena or designing of solutions.

C. Integrating the Three Dimensions for Instruction and Assessment: The lesson requires student performances that integrate elements of the SEPs, CCCs, and DCIs to make sense of phenomena or design solutions to problems, and the lesson elicits student artifacts that show direct, observable evidence of three-dimensional learning.

FEATURES OF QUALITY DESIGN

D. Relevance and Authenticity: The lesson motivates student sense-making or problem-solving by taking advantage of student questions and prior experiences in the context of the students' home, neighborhood, and community as appropriate.

E. Student Ideas: The lesson provides opportunities for students to express, clarify, justify, interpret, and represent their ideas (i.e., making thinking visible) and to respond to peer and teacher feedback.

F. Building on Students' Prior Knowledge: The lesson identifies and builds on students' prior learning in all three dimensions in a way that is explicit to both the teacher and the students.

NOTE: Note: This adapted version of the NGSS Lesson Screener is utilized while developing stand alone lessons infused with literacy. The headings and criteria are referred to during the planning process. This is a shorter version of the EQuIP and is a useful abbreviation that serves more of a checklist during the design process.

CHAPTER 4

Reflection

With the adoption of the Next Generation Science Standards, many school districts and teachers are considering realigning their instruction and courses. Integrating life, physical, and earth science as well as math and literacy standards into curriculum that is packaged in new ways has become an enticing solution for districts during implementation. Because the NGSS are a set of performance expectations for all students, making decisions to find the time to ensure three-dimensional learning continues in elective courses becomes challenging. This project delineates a process for developing a curriculum for an elective class on reading science that incorporates both three-dimensional learning and literacy into the lessons. The cohesiveness for science and literacy along with the examples of content literacy strategies, types of texts, and literacy based assignments demonstrated by this project give teachers an opportunity to pick and choose elements to build their own literacy infused science course. In addition to designing elective courses that align with the NGSS, these features can work with required courses in bits and pieces as time and appropriateness allow. The examples of the EQuIP rubric, Lesson Screener, and Alignment and Connections sections reveal the thought processes that occurred during the development of the curriculum.

Although educators often look for an aligned prepared lesson or curriculum to employ in their classroom to save time, deep understanding of the

three dimensions and ownership of unit development create more effective and meaningful instruction and learning. Educators who delve into researching the topics, standards, and student preconceptions have a better grasp on how to formatively assess their students throughout the unit as well as how to use that assessment to drive their day to day instruction. Therefore, while this curriculum development project demonstrates how one teacher goes about developing curriculum infused with literacy, only sections of one example unit is highlighted.

In planning for the remainder of my yearlong Science Reading class, I plan to use the same development process (search for phenomena and texts, decide on content literacy strategies, write assessments, build a scaffolded map of daily lessons, and modify/write three-dimensional lessons) to build cohesive units that allow students to figure out their natural world. My goals for this project were to: describe how I have revised and refined my curriculum development process by incorporating current research on both literacy and science learning; develop a system of teaching integrating all aspects of the three dimensions of the NGSS; and to provide examples of a more formal way to incorporate literacy into a science classroom for other teachers to use. The unit planning template may be missing sections or need to be revised to increase the coherence of the unit with a specific phenomenon. To truly allow a phenomenon to drive instruction, educators must allow students to grapple with ideas and decide the direction and degree of scaffolding needed for tomorrow's lesson. Therefore, this project is, as is any curriculum development project, a work in progress.

Developing a curriculum writing process allowed me to merge my learning and professional development opportunities from the past several years concerning Understanding by Design, the Next Generation Science Standards, and Content Literacy with my educational philosophies. Several years ago, I realized that I identify with Lev Vygotsky and Jean Piaget's ideas about how knowledge is socially constructed. Social constructivism argues that social interaction is fundamental to learning and development. Jean Piaget's belief that knowledge is acquired as a result of lifelong constructive processes in which we try to organize and reorganize our experiences in light of existing schemes (Brooks, 1999) resonates well with my philosophies and served as the platform for the creation of a science reading class.

By first searching for a "hot topic", which I now refer to as a phenomenon, I am really looking for a common experience or topic for my students. I prefer phenomena students may have heard about in the news or on social media especially controversial ones. Therefore, students must decide metacognitively if the text and resources they are using in class fits with their current understandings. If the information does not fit, they are sent into a state of disequilibrium until their questions about their experiences can be resolved. As a reaction to disequilibrium, students can do one on three things: they can shut down because they cannot see the relatedness to their current schema, accommodate the phenomena into a currently existing schema, or integrate the phenomena into their schema in a way that a new equilibrium of understanding

exists. This new equilibrium comes about when students restructure their thinking to integrate the new information during a process called accommodation (Kober, 2015, p. 70). The ultimate goal is for my students to assimilate their new learning in such a way that they are able to transfer their learning effectively in other applications. With the literacy strategies and sample lessons provided in the project, I have demonstrated ways that I remove some of the barriers for my students that lead them to simply shutting down or assimilating their understanding into their current schema to new realms of confronting the world.

As I become more familiar with the process of developing curriculum using UbD and intertwining the three dimensions of the NGSS in lessons and assessments, I continually see how interconnected curriculum can be. For instance, the science and engineering practices read very similarly to the Common Core and Iowa Core reading and writing standards and provide me with ideas for ways for students to provide evidence of their learning. As I continue to organize and reorganize my schemes of understanding concerning the three dimensions and incorporating literacy into my classroom, I have developed an appreciation, almost insatiable need, for collaboration. The conversations with other teachers and colleagues have been invaluable to the evolution of my teaching to support a more student centered learning.

From this point forward, I plan to finish the curriculum plan for the Are we ready for a Pandemic? by creating rubrics and plans for instruction for each of the student assessments, create unit for the remainder of my Science Reading

course (including one about personalized medicine and climate change), incorporate the planning strategies into my required courses of biology and environmental science on a smaller scale, and assist my district's elementary science teachers with their implementation of the NGSS and content area literacy. I currently present the science professional development for my small district. The elementary teachers have been receptive to integrating the science and engineering practices and crosscutting concepts with their literacy standards. I hope to collaborate with them and other teachers on ways to incorporate content literacy into their classrooms especially with the literature they already use in their curriculum.

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Appendix A- Student Interest Survey

Student Pre-Interest Survey

1. How do some bacteria become resistant to medicines developed to fight them?

Not at all interesting ----->Very Interesting
0 1 2 3 4

2. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

3. Why are some diseases more common among some groups of people than in others?

Not at all interesting ----->Very Interesting
0 1 2 3 4

4. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

5. What diseases run in families?

Not at all interesting ----->Very Interesting
0 1 2 3 4

6. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

7. How does a "Superbug" produce an epidemic that affects a whole population?

Not at all interesting ----->Very Interesting
 0 1 2 3 4

8. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

9. Why do some members of a species survive when the conditions in the environment change, while others go extinct?

Not at all interesting ----->Very Interesting
 0 1 2 3 4

10. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

11. How are different species of animals related (i.e. wolves and dogs)?

Not at all interesting ----->Very Interesting

0 1 2 3 4

12. How much time would you like to spend investigating the above question?

a. 0 days (this isn't interesting to me at all)

b. 1-2 days

c. 1 week

d. 2 weeks

13. What are the implications of storing one's baby's cord blood?

Not at all interesting ----->Very Interesting

0 1 2 3 4

14. How much time would you like to spend investigating the question above?

a. 0 days (this isn't interesting to me at all)

b. 1-2 days

c. 1 week

d. 2 weeks

15. How does science become medicine (how do treatments/medicines come about)?

Not at all interesting ----->Very Interesting

0 1 2 3 4

16. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

17. How do cancer stem cells differ from other stem cells?

Not at all interesting ----->Very Interesting
0 1 2 3 4

18. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

19. If you could clone your favorite pet, would it have the same personality?

Not at all interesting ----->Very Interesting
0 1 2 3 4

20. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

21. How many of these currently can be treated with or cured with gene or stem cell therapy?

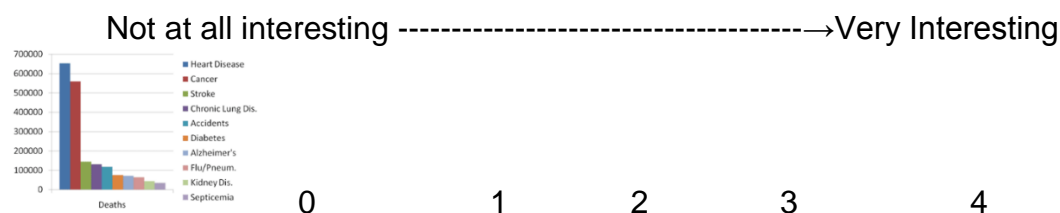


Table Retrieved From: <https://sites.google.com/site/healthwebsite14/leading-cause-of-death>

22. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

23. How are scientists trying to get around the ethical concerns about the use of embryonic stem cells in research and medicine?

Not at all interesting ----->Very Interesting

0 1 2 3 4

24. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

25. How does nanotechnology contribute to personalized medicine?

Not at all interesting ----->Very Interesting

0 1 2 3 4

26. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

27. What are the connections between therapeutic cloning and organ transplantation?

Not at all interesting ----->Very Interesting
0 1 2 3 4

28. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

29. How is the field of epigenetics (how genes are expressed) changing what we know about genetics?

Not at all interesting ----->Very Interesting
0 1 2 3 4

30. How much time would you like to spend investigating the above question?

- a. 0 days (this isn't interesting to me at all)
- b. 1-2 days
- c. 1 week
- d. 2 weeks

APPENDIX B - ANNOTATION BOOKMARK

Annotation Bookmark

ANNOTATE!	ANNOTATE!	ANNOTATE!
★ Star the Important Ideas	★ Star the Important Ideas	★ Star the Important Ideas
<div style="border: 1px solid black; display: inline-block; padding: 2px;">Box</div> key words or phrases	<div style="border: 1px solid black; display: inline-block; padding: 2px;">Box</div> key words or phrases	<div style="border: 1px solid black; display: inline-block; padding: 2px;">Box</div> key words or phrases
Use a ? for any questions you have about the text	Use a ? for any questions you have about the text	Use a ? for any questions you have about the text
Use a to make a prediction.	Use a to make a prediction.	Use a to make a prediction.
↔ Use a double-sided arrow when you make a connection with prior knowledge	↔ Use a double-sided arrow when you make a connection with prior knowledge	↔ Use a double-sided arrow when you make a connection with prior knowledge
"X" the text that provides examples	"X" the text that provides examples	"X" the text that provides examples
Number 1. arguments/key ideas and 2. supporting evidence	Number 1. arguments/key ideas and 2. supporting evidence	Number 1. arguments/key ideas and 2. supporting evidence

APPENDIX C: STUDENT REFLECTION QUESTIONS

Student Reflection Questions

Adapted from "The 40 Reflection Questions" by Edutopia

The following questions will help you reflect about your prior, current, and future learning. Use the questions as prompts to include in your notebook journaling, online discussions, and/or video reflections as assigned by your teacher.

1. What did you know about the topic or concept prior to starting on this learning activity?
2. Outline the steps that you took to complete this learning activity.
3. Have you completed other work or learning about this topic in a previous grade or class?
4. What resources did you use in order to complete this learning activity?
5. What strategies did you use in order to complete this learning activity (such as making predictions or inferences, scanning and skimming text, summarizing and synthesizing text, or manipulating variables)?
6. What was the objective or learning purpose for this learning activity?
7. Did you meet the objectives for this learning activity? If not, what obstacles caused you to stumble?
8. With which parts of your finished product are you most satisfied or confident?
9. What parts do you feel need to be improved and why?
10. What parts of the learning activity frustrated or confused you? What questions do you still have?
11. In what ways did you act like a real scientist? What science and engineering practices were involved?
12. What big ideas or themes (cross cutting concepts) were explored or applied in this learning activity?
13. What changes in your thinking about this concept have changed?
14. What does your finished product tell yourself about how you learn?
15. What differences and similarities exist between how you and other people completed the learning activity?
16. If you were a teacher, what feedback, comments, or grade would you give your finished product?
17. How would you rank your group members based on their engagement, flexibility, and efficiency in learning?
18. In what ways did you meet the standards of this learning activity?
19. What is one thing that you would like your teacher or classmates to notice about your finished product?
20. What are some things or ways that your finished product can be revised?
21. What are some resources or information that you need in order to make those revisions?
22. What do you predict might be the learning objective or purpose of the next learning activity?

23. What do you still need to know or be able to do to understand the phenomena?
24. What is one thing that you see in a classmate's finished product that you admire and would like to try next time?
25. What goal(s) do you have for the next learning activity?

APPENDIX D- BOOK LIST OF FICTION AND NONFICTION TEXTS

Book List

These texts can be utilized in a science reading course or as supplements to any science course. Texts on disease and pandemics, bioterrorism, climate change, environmental issues, genetics, natural selection, nanotechnology, chemistry, cells, and the nature of science are included.

<p><u>FICTION</u></p> <p>2312 (Robinson)</p> <p>A Death-Struck Year (Lucier)</p> <p>Clan of the Cave Bear (Auel)</p> <p>Deadly (Chibbaro)</p> <p>Fever 1793 (Anderson)</p> <p>House of the Scorpion (Farmer)</p> <p>Micro (Preston & Crichton)</p> <p>Nemesis (Roth)</p> <p>Next (Crichton)</p> <p>Pandemic (Sigler)</p> <p>Pandemic: Tracking Contagions, from Cholera to Ebola and Beyond (Shah)</p> <p>Plague Maker (Downs)</p> <p>Prey (Crichton)</p> <p>Tentacles (Smith)</p> <p>The Andromeda Strain (Crichton)</p> <p>The Cobra Event (Preston)</p> <p>The Greening of Mars (Allaby & Lovelock)</p> <p>The Last Town on Earth (Mullen)</p> <p>The Lord of Opium (Farmer)</p> <p>The Plague Tales (Benson)</p> <p>The Wind Up Girl (Bacigalupi)</p> <p>Undetected (Henderson)</p> <p>Wild Trees (Preston)</p> <p><u>NONFICTION</u></p> <p>100 Heartbeats (Corwin)</p> <p>A Short History of Nearly Everything (Bryson)</p> <p>Abraham Lincoln's DNA (Reilly)</p> <p>And the Water Turned to Blood (Barker)</p> <p>Flu: The Story of the Great Influenza Pandemic of 1918 and the Search for the Virus That Caused It (Kolata)</p> <p>Friend-fluence (Flora)</p> <p>Genome: The Autobiography of a Species in 23 Chapters (Ridley)</p>	<p>Gulp (Roach)</p> <p>Junk DNA (Carey)</p> <p>Microbe Hunters (de Kruiff)</p> <p>Napoleon's Buttons (LeCouteur)</p> <p>Packing for Mars (Roach)</p> <p>Panic in Level 4 (Preston)</p> <p>Sand County Almanac (Leopold)</p> <p>Serendipity Accidental Discoveries in Science (Roberts)</p> <p>Silent Spring (Carson)</p> <p>Spillover: Animal Infections and the Next Human Pandemic (Quammen)</p> <p>Stiff (Roach)</p> <p>Survival of the Sickest: A Medical Maverick Discovers Why We Need Disease (Moalem)</p> <p>That's the Way the Cookie Crumbles (Schwarz)</p> <p>The Beak of the Finch (Weiner)</p> <p>The Coming Plague: Newly Emerging Diseases in a World Out of Balance (Garrett)</p> <p>The Dance of Molecules (Sargent)</p> <p>The Demon Haunted World: Science as a Candle in the Dark (Sagan)</p> <p>The Disappearing Spoon (Kean)</p> <p>The Ecological Rift (Foster, Clark, & York)</p> <p>The Epigenetics Revolution (Carey)</p> <p>The Gecko's Foot (Forbes)</p> <p>The Hot Zone (Preston)</p> <p>The Immortal Life of Henrietta Lacks (Skloot)</p> <p>The Lives of a Cell (Lewis)</p> <p>The Poisonwood Bible (Kingsolver)</p> <p>The Seven Daughters of Eve (Sykes)</p> <p>The Wolverine Way (Chadwick)</p> <p>The Woman with a Worm in Her Head & Other True Stories of Infectious Disease (Nagami)</p> <p>Zoobiqumity (Natterson-Horowitz & Bowers)</p>
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APPENDIX E: ADAPTED RESOURCES FOR CURRICULUM DEVELOPMENT PROCESS

UbD Template 2.0

Retrieved From:

https://jaymctighe.com/wordpress/wpcontent/uploads/2011/04/UbD_Template_2.docx

Stage 1 Desired Results		
ESTABLISHED GOALS <type here>	Transfer	
	<i>Students will be able to independently use their learning to...</i> <type here>	
	Meaning	
	UNDERSTANDINGS <i>Students will understand that...</i> <type here>	ESSENTIAL QUESTIONS <type here>
	Acquisition	
	<i>Students will know...</i> <type here>	<i>Students will be skilled at...</i> <type here>
Stage 2 – Evidence		
Evaluative Criteria	Assessment Evidence	
<type here>	PERFORMANCE TASK(S): <type here>	
<type here>	OTHER EVIDENCE: <type here>	
Stage 3 – Learning Plan		
<i>Summary of Key Learning Events and Instruction</i> <type here>		



EQuIP Rubric for Lessons & Units: Version 2.0

The Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric for science provides criteria by which to measure the alignment and overall quality of lessons and units with respect to the Next Generation Science Standards (NGSS). The purposes of the rubric and review process are to: (1) review existing lessons and units to determine what revisions are needed; (2) provide constructive criterion-based feedback and suggestions for improvement to developers; (3) identify exemplars/models for teachers' use within and across states; and (4) to inform the development of new lessons and units.

To effectively apply this rubric, an understanding of the National Research Council's *A Framework for K–12 Science Education and the Next Generation Science Standards*, including the NGSS shifts (appendix A of the NGSS), is needed. Unlike the EQuIP Rubrics for mathematics and ELA, there is not a category in the science rubric for shifts. Over the course of the rubric development, writers and reviewers noted that the shifts fit naturally into the other three categories. For example, the blending of the three-dimensions, or three-dimensional learning, is addressed in each of the three categories; coherence is addressed in the first two categories; connections to the Common Core State Standards is addressed in the first category; etc. Each category includes criteria by which to evaluate the integration of engineering, when included in a lesson or unit, through practices or disciplinary core ideas. Another difference between the EQuIP Rubrics from mathematics and ELA is in the name of the categories; the rubric for science refers to them simply as *categories*, whereas the math and ELA rubrics refer to the categories as dimensions. This distinction was made because the Next Generation Science Standards already uses the term *dimensions* to refer to practices, disciplinary core ideas, and crosscutting concepts.

The architecture of the NGSS is significantly different from other sets of standards. The three dimensions, crafted into performance expectations, describe what is to be assessed following instruction and therefore are the measure of proficiency. A lesson or unit may provide opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts as foundational pieces. This three-dimensional learning leads toward eventual mastery of performance expectations. In this scenario, quality materials should clearly describe or show how the lesson or unit works coherently with previous and following lessons or units to help build toward eventual mastery of performance expectations. The term *element* is used in the rubric to represent the relevant, bulleted practices, disciplinary core ideas, and crosscutting concepts that are articulated in the foundation boxes of the standards as well as the in the NGSS appendices on each dimension. Given the understanding that a lesson or unit may include the blending of practices, disciplinary core ideas, and crosscutting concepts that are not identical to the combination of practices, disciplinary core ideas, and crosscutting concepts in a performance expectation, the new term *elements* was needed to describe these smaller units of the three dimensions. Although it is unlikely that a single lesson would provide adequate opportunities for a student to demonstrate proficiency on every dimension of a performance expectation, high-quality units are more likely to provide these opportunities to demonstrate proficiency on one or more performances expectations.

There is a recognition among educators that curriculum and instruction will need to shift with the adoption of the NGSS, but there is currently a lack of NGSS-aligned materials. The power of the rubric is in the feedback and suggestions for improvement it provides curriculum developers and the productive conversations educators have while evaluating materials (i.e., the review process). For curriculum

developers, the rubric and review process provide evidence on the quality and alignment of a lesson or unit to the NGSS. Additionally, the rubric and review process generate suggestions for improvement on how materials can be further improved and more closely aligned to the NGSS. As more NGSS lessons and units are developed, this rubric may change to meet the evolving needs of supporting both educators in evaluating materials and developers in the modification and creation of materials. Additionally, support materials will be developed to complement the use of this rubric, such as a professional development guide, a criterion discussion guide, and publishers' criteria that will be more focused on textbooks and comprehensive curriculums.

Directions

The first step in the review process is to become familiar with the rubric, the lesson or unit, and the practices, disciplinary core ideas, and crosscutting concepts targeted in the lesson or unit. The three categories in the rubric correspond to: alignment to the NGSS, instructional supports, and monitoring student progress. Specific criteria within each category should be considered separately as part of the complete review process and are used to provide sufficient information for determination of overall quality of the lesson or unit. For the purposes of using the rubric, a lesson is defined as: a coherent set of instructional activities and assessments aligned to the NGSS that may extend over a few to several class periods or days and a unit is defined as: coherent set of lessons aligned to the NGSS that extend over a longer period of time.

Also important to the review process is feedback and suggestions for improvement to the developer of the resource. For this purpose a set of response forms is included so that the reviewer can effectively provide criterion-based feedback and suggestions for improvement for each category. The response forms correspond to the criteria of the rubric. Evidence for each criterion must be identified and documented and criterion-based feedback and suggestions for improvement should be given to help improve the lesson or unit.

While it is possible for the rubric to be applied by an individual, the quality review process works best with a team of reviewers, as a collaborative process, with the individuals recording their thoughts and then discussing with other team members before finalizing their feedback and suggestions for improvement. Discussions should focus on understanding all reviewers' interpretations of the criteria and the evidence they have found. The goal of the process is to eventually calibrate responses across reviewers and to move toward agreement about quality with respect to the NGSS. Commentary needs to be constructive, with all lessons or units considered "works in progress." Reviewers must be respectful of team members and the resource contributor. Contributors should see the review process as an opportunity to gather feedback and suggestions for improvement rather than to advocate for their work. All feedback and suggestions for improvement should be criterion-based and have supporting evidence from the lesson or unit cited.

Note: This rubric will eventually have scoring guidelines for each category, as well as for an overall rating. However, given the current lack of NGSS-aligned materials, rather than focusing on ratings at this point in time, the focus should be on becoming familiar with the rubric and using it to provide criterion-based feedback and suggestions for improvement to developers and make revisions to existing materials.

Step 1 – Review Materials

The first step in the review process is to become familiar with the rubric, the lesson or unit, and the practices, disciplinary core ideas, and crosscutting concepts targeted in the lesson or unit.

- Review the rubric and record the grade and title of the lesson or unit on the response form.
- Scan to see what the lesson or unit contains, what practices, disciplinary core ideas, and crosscutting concepts are targeted, and how it is organized.
- Read key materials related to instruction, assessment, and teacher guidance.

Step 2 – Apply Criteria in Category I: Alignment to the NGSS

The second step is to evaluate the lesson or unit using the criteria in the first category, first individually and then as a team.

- Closely examine the lesson or unit through the “lens” of each criterion in the first category of the response form.
- Individually check each criterion on the response form for which clear and substantial evidence is found and record the evidence and reasoning.
- As a team, discuss criteria for which clear and substantial evidence is found, as well as criterion-based suggestions for specific improvements that might be needed to meet criteria.

If the lesson or unit is not closely aligned to the Next Generation Science Standards, it may not be appropriate to move on to the second and third categories. Professional judgment should be used when weighing the individual criterion. For example, a lesson without crosscutting concepts explicitly called out may be easier to revise than one without appropriate disciplinary core ideas; such a difference may determine whether reviewers believe the lesson merits continued evaluation or not.

Step 3 – Apply Criteria in Categories II and III: Instructional Supports and Monitoring Student Progress

The third step is to evaluate the lesson or unit using the criteria in the second and third categories, first individually and then as a group.

- Closely examine the lesson or unit through the “lens” of each criterion in the second and third categories of the response form.
- Individually check each criterion on the response form for which clear and substantial evidence is found and record the evidence and reasoning.
- As a team, discuss criteria for which clear and substantial evidence is found, as well as criterion-based suggestions for specific improvements that might be needed to meet criteria.

When working in a group, teams may choose to compare ratings after each category or delay conversation until each person has rated and recorded input for the two remaining categories. Complete consensus among team members is not required but discussion is a key component of the review process.

I. Alignment to the NGSS	II. Instructional Supports	III. Monitoring Student Progress
<p>The lesson or unit aligns with the conceptual shifts of the NGSS:</p> <p>A. Grade-appropriate elements of the science and engineering practice(s), disciplinary core idea(s), and crosscutting concept(s), work together to support students in three-dimensional learning to make sense of phenomena and/or to design solutions to problems.</p> <ul style="list-style-type: none"> i. Provides opportunities to develop and use specific elements of the practice(s) to make sense of phenomena and/or to design solutions to problems. ii. Provides opportunities to develop and use specific elements of the disciplinary core idea(s) to make sense of phenomena and/or to design solutions to problems. iii. Provides opportunities to develop and use specific elements of the crosscutting concept(s) to make sense of phenomena and/or to design solutions to problems. iv. The three dimensions work together to support students to make sense of phenomena and/or to design solutions to problems. <p>A unit or longer lesson will also:</p> <p>B. Lessons fit together coherently targeting a set of performance expectations.</p> <ul style="list-style-type: none"> i. Each lesson links to previous lessons and provides a need to engage in the current lesson. ii. The lessons help students develop proficiency on a targeted set of performance expectations. <p>C. Where appropriate, disciplinary core ideas from different disciplines</p>	<p>The lesson or unit supports instruction and learning for all students:</p> <p>A. Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world and that provide students with a purpose (e.g., making sense of phenomena and/or designing solutions to problems).</p> <ul style="list-style-type: none"> i. The context, including phenomena, questions, or problems, motivates students to engage in three-dimensional learning. ii. Provides students with relevant phenomena (either firsthand experiences or through representations) to make sense of and/or relevant problems to solve. iii. Engages students in multiple practices that work together with disciplinary core ideas and crosscutting concepts to support students in making sense of phenomena and/or designing solutions to problems. iv. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to their own experience. v. When engineering performance expectations are included, they are used along with disciplinary core ideas from physical, life, or earth and space sciences. <p>B. Develops deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts by identifying and building on students' prior knowledge.</p> <p>C. Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.</p> <p>D. Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written</p>	<p>The lesson or unit supports monitoring student progress:</p> <p>A. Elicits direct, observable evidence of three-dimensional learning by students using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.</p> <p>B. Formative assessments of three-dimensional learning are embedded throughout the instruction.</p> <p>C. Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.</p> <p>D. Assessing student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.</p> <p>A unit or longer lesson will also:</p> <p>E. Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.</p> <p>F. Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.</p>

<p>are used together to explain phenomena.</p> <p>D. Where appropriate, crosscutting concepts are used in the explanation of phenomena from a variety of disciplines.</p> <p>E. Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.</p>	<p>form as appropriate to support student's three-dimensional learning.</p> <p>E. Provides guidance for teachers to support differentiated instruction in the classroom so that every student's needs are addressed by including:</p> <ul style="list-style-type: none"> i. Suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate. ii. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers) for students who are English language learners, have special needs, or read well below the grade level. iii. Suggested extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the performance expectations. iv. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts. <p>A unit or longer lesson will also:</p> <p>F. Provides guidance for teachers throughout the unit for how lessons build on each other to support students developing deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts over the course of the unit.</p> <p>G. Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.</p>	
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I. Alignment to the NGSS

The lesson or unit aligns with the conceptual shifts of the NGSS:

Criteria		Specific evidence from materials and reviewers' reasoning	Suggestions for improvement
<input type="checkbox"/>	<p>A. Grade-appropriate elements of the science and engineering practice(s), disciplinary core idea(s), and crosscutting concept(s), work together to support students in three-dimensional learning to make sense of phenomena and/or to design solutions to problems.</p> <p>i. Provides opportunities to develop and use specific elements of the practice(s) to make sense of phenomena and/or to design solutions to problems.</p> <p>ii. Provides opportunities to develop and use specific elements of the disciplinary core idea(s) to make sense of phenomena and/or to design solutions to problems.</p> <p>iii. Provides opportunities to develop and use specific elements of the crosscutting concept(s) to make sense of phenomena and/or to design solutions to problems.</p> <p>iv. The three dimensions work together to support students to make sense of phenomena and/or to design solutions to problems.</p>		

A unit or longer lesson will also:

Criteria		Specific evidence from materials and reviewers' reasoning	Suggestions for improvement
<input type="checkbox"/>	<p>B. Lessons fit together coherently targeting a set of performance expectations.</p> <p>i. Each lesson links to previous lessons and provides a need to engage in the current lesson.</p> <p>ii. The lessons help students develop proficiency on a targeted set of performance expectations.</p>		
<input type="checkbox"/>	C. Where appropriate, disciplinary core ideas from different disciplines are used together to explain phenomena.		
<input type="checkbox"/>	D. Where appropriate, crosscutting concepts are used in the explanation of phenomena from a variety of disciplines.		
<input type="checkbox"/>	E. Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.		

If the lesson or unit is not closely aligned to the Next Generation Science Standards, it may not be appropriate to move on to the second and third categories. Professional judgment should be used when weighing the individual criterion. For example, a lesson without crosscutting concepts explicitly called out may be easier to revise than one without appropriate disciplinary core ideas; such a difference may determine whether reviewers believe the lesson merits continued evaluation or not.

II. Instructional Supports

The lesson or unit supports instruction and learning for all students:

Criteria	Specific evidence from materials and reviewers' reasoning	Suggestions for improvement
<input type="checkbox"/> A. Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world and that provide students with a purpose (e.g., making sense of phenomena and/or designing solutions to problems). i. The context, including phenomena, questions, or problems, motivates students to engage in three-dimensional learning. ii. Provides students with relevant phenomena (either firsthand experiences or through representations) to make sense of and/or relevant problems to solve. iii. Engages students in multiple practices that work together with disciplinary core ideas and crosscutting concepts to support students in making sense of phenomena and/or designing solutions to problems. iv. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to their own experience. v. When engineering performance expectations are included, they are used along with disciplinary core ideas from physical, life, or earth and space sciences.		
<input type="checkbox"/> B. Develops deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts by identifying and building on students' prior knowledge.		
<input type="checkbox"/> C. Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.		
<input type="checkbox"/> D. Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate to support student's three-dimensional learning.		
<input type="checkbox"/> E. Provides guidance for teachers to support differentiated instruction in the classroom so that every student's needs are addressed by including: i. Suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate. ii. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers) for students who are English language learners, have special needs, or read well below the grade level. iii. Suggested extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the performance expectations. iv. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.		

A unit or longer lesson will also:

Criteria		Specific evidence from materials and reviewers' reasoning	Suggestions for improvement
<input type="checkbox"/>	F. Provides guidance for teachers throughout the unit for how lessons build on each other to support students developing deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts over the course of the unit.		
<input type="checkbox"/>	G. Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.		

III. Monitoring Student Progress

The lesson or unit supports monitoring student progress:

Criteria		Specific evidence from materials and reviewers' reasoning	Suggestions for improvement
<input type="checkbox"/>	A. Elicits direct, observable evidence of three-dimensional learning by students using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.		
<input type="checkbox"/>	B. Formative assessments of three-dimensional learning are embedded throughout the instruction.		
<input type="checkbox"/>	C. Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.		
<input type="checkbox"/>	D. Assessing student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.		

A unit or longer lesson will also:

Criteria		Specific evidence from materials and reviewers' reasoning	Suggestions for improvement
<input type="checkbox"/>	E. Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.		
<input type="checkbox"/>	F. Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.		

Overall Summary Comments:

APPENDIX F: INSTRUCTIONAL MATERIALS FOR PANDEMICS UNIT

“Hot Zone” by Richard Preston Excerpt Reflection Questions

1. Describe what you think might be the cause of the events on the plane?
2. What did you know about the viruses, epidemics, and pandemics prior to starting on this learning activity?
3. Describe the signs and symptoms of this particular disease. What patterns do healthcare providers need to look for when diagnosing patients? What body systems are being affected?
4. Make a prediction about what is going to happen next in the book.
5. What science and engineering practices need to be employed in this situation?
6. What do you think the term “patient zero” means?

7. What are some questions you have about the remainder of this book or pandemics that you would like to investigate the phenomena further?
8. How do your predictions and questions compare to your table group?
9. What are some resources or information you might need in the upcoming learning activities to help answer your questions?
10. When choosing your own book to read for this unit, what features would you want it to include?

EBOLA ANTICIPATION READING GUIDE

Directions: Prior to reading your article mark whether you agree or disagree with each of the statements below. Read your individual article, using your annotation bookmark to make note of text that you think may be useful in providing evidence for your position on the statements. Upon completing the reading, mark whether you agree or disagree with the statements. Some of the statements you may not be able to provide evidence for your position. Your tablegroup may have that evidence in their article. Reconvene with your tablegroup and discuss whether or not you agree with your positions (citing textual evidence as you share your position). Come to a consensus on your position as a tablegroup, and be ready to share your consensus with the whole class.

Before Reading (Agree/Disagree)	Statement	After Reading (Agree/Disagree)
	Ebola is airborne, waterborne, or contracted through casual contact.	
	It is likely that a person would contract Ebola by sharing an airplane with an infected person.	
	People in the United States should not be afraid about contracting Ebola.	
	Until a person is not showing symptoms of Ebola, they are not contagious.	
	Ebola kills over 90 percent of the people infected with it.	
	Even after a person dies from Ebola, they are still contagious.	
	There is a vaccine for Ebola.	
	One obstacle to creating treatments for Ebola is that it can change forms.	
	Ebola causes internal organs to liquefy and people to bleed from their orifices.	
	Ebola is carried by mosquitoes and “hides” in them between human outbreaks.	

Resources: <https://www.wired.com/2014/10/ebola-virus-infection-transmission-death-explained/>, <https://www.sciencenewsforstudents.org/article/explainer-what-ebola>, <http://www.pbs.org/newshour/updates/know-enemy/>

Disease Transmission Guided Notes

PART A: Infectious Disease Control

Go to the following site to answer these questions: <http://phprimer.afmc.ca/Part3-PracticeImprovingHealth/Chapter11InfectiousDiseaseControl>

Describe the 5 causes of an infectious disease epidemic in your own words.

- a. Increased Virulence
- b. Organism Entering and New Setting
- c. Enhanced Transmission
- d. Change in Host Susceptibility
- e. New Portals of Entry

Which agency can declare a pandemic?

Why is important to define a “case” by determining patterns of disease transmission?

What are some science and engineering practices that clinicians employ to track a disease?

What is an epidemic curve? What types of patterns can be extracted from analyzing the data from an epidemic curve?

Compare the typical precautionary measures according to route of transmission.

Summarize the agent-host-environment model? (Hint: More information available by clicking on the Chapter 2 link)

Develop a model of the “Epidemiological Triad of Agent, Host, and Environmental factor for the common cold.

Match each of the following characteristics of transmissible diseases with its definition.

- | | |
|-----------------------------------|---|
| 1. ____ Attack Rate | a. The amount of time between infection and appearance of the first symptoms and signs. |
| 2. ____ Case Fatality Rate | b. The time between infection and when the disease can be detected |
| 3. ____ Herd Immunity | c. The length of time in which a person can transmit a disease |
| 4. ____ Incubation Period | d. The resistance of a group or community to invasion and spread of an infectious agent |
| 5. ____ Pathogenicity | e. The proportion of people who contract the disease and die from it |
| 6. ____ Period of Communicability | f. The severity of a disease or illness |
| 7. ____ Virulence | g. The proportion of persons who develop clinical disease (with recognizable symptoms) |
| 8. ____ Window period | h. The proportion of exposed persons who get infected |

Compare the three different types of contact transmission.

Zika virus is carried by mosquitoes. Describe its mode of transmission and thus how it is controlled.

There are two problems associated with medical care discussed in Chapter 11, nosocomial infections and antimicrobial resistance. Define each in your own words and discuss how physicians and medical staff should counteract these problems.

Part B: Describing and Responding to Pandemics

Refer to the World Health Organization (WHO) Pandemic Phase Descriptions and Main Actions by Phase found at

http://www.who.int/influenza/resources/documents/pandemic_phase_descriptions_and_actions.pdf for the following question.

Describe the pandemic or epidemic found in your book of choice that you are reading outside of class. Discuss the phase that your disease is in according to where you are in the book and how that phase has changed throughout the book. How have the actions by the professionals in the book compared to the main actions described by the WHO table?

Why are the actions on the bottom row of the WHO table important to the management system of professionals that deal with pandemics?

Part C: Herd Immunity

Use the article found at <http://www.pbs.org/wgbh/nova/body/herd-immunity.html> to answer the following questions.

What is herd immunity?

What are two ways that people can become immune to an infectious disease?

How do vaccinated individuals protect others from getting an infectious disease?

What are the factors that need to be considering when calculating the immunity threshold?

How has the increase in mobility of humans contributed to herd immunity over the years?

SUPERBUG RESEARCH GRAPHIC ORGANIZER

SOURCE:
EVIDENCE/NOTES:
SOURCE:
EVIDENCE/NOTES:
SOURCE:
EVIDENCE/NOTES:
SOURCE:
EVIDENCE/NOTES:

“Contagion” Movie Guide

Who is patient zero? Why did her husband not get infected with the virus?

There is a system of agencies (CDC, WHO, private industry, hospital staff, etc.) that work to locate and deal with the outbreak throughout the movie. Describe these agencies (parts of the system) and the role they play in the management of the outbreak?

What were the origins of this virus? Was it a zoonotic infection? A fomite infection?

What were the modes of transmission of this disease?

Would this virus be categorized as an emerging virus? Why? or Why Not?

The first scene of the movie starts out on Day 2. Make a claim based on evidence from the movie about what happened on Day 1. What patterns in symptoms would be useful in determining a case definition for this viral infection?

What was the differential diagnosis of patient zero?

Explain what R-0 means? Describe how the R-0 changes throughout the movie.

When studying infectious agents, such as the virus in the film, the CDC classifies these agents by "Biosafety Levels." The virus in the film was classified at a Biosafety _____. Research the characteristics of each of the CDC Biosafety Levels. Describe what causes a disease to be classified in each of the levels.

Describe thoroughly how at least three science and engineering practices are carried out in the movie; discuss which agencies or individuals use each of the practices you describe.

Research and delineate the steps involved in creating a vaccine. Which steps in the process were not followed in the movie? What effects did this have on the development of the vaccine?

Why does it take months and months before a vaccine can be released to the public? What other obstacles to developing the vaccine occurred during the movie? How were these overcome?

Create a model (flowchart) of the transmission of the virus throughout the world. Include an explanation for how the disease can travel hundreds of miles.

What parts of the movie relate factually to outbreaks and the system of agencies involved in the management of those?

Reflect upon your learning by answering a few more questions about this activity:

- a. What strategies did you use in order to complete this learning activity (such as making predictions or inferences, scanning and skimming text, summarizing and synthesizing text, or manipulating variables)?
- b. What big ideas or themes (cross cutting concepts) were explored or applied in this learning activity?
- c. What do you still need to know or be able to do in order to explain the classification, management, and prevention of outbreaks?

“Pandemic” Strategy Sheet

Part 1: During this learning activity, you will be modeling the CDC’s system of management of an outbreak. As you play the board game “Pandemic” and strategize with the other players, summarize 2 of the strategies discussed. Record your final decision in the last column of the table. Place an asterisk (*) by any of the final decisions that mirror decisions or responses that have been modeled in other learning activities in this unit.

Round	Possible Move 1	Possible Move 2	Final Decision

Part 2: Career Research - Research 5 careers that are available at the CDC. Which role from the board game is most related to each career?

Career	Salary	Qualifications	Job Duties	Connection to Role Card

Part 3: Reflection on Learning - Answer the following questions concerning your learning during this activity.

1. What was the objective or learning purpose for this learning activity?
2. What parts of the learning activity frustrated or confused you? What questions do you still have?
3. How would you rank your group members based on their engagement, flexibility, and efficiency in learning?
4. What resources did you use in order to complete this learning activity?
5. What strategies did you use in order to complete this learning activity (such as making predictions or inferences, scanning and skimming text, summarizing and synthesizing text, or manipulating variables)?
6. In what ways did you act like a real scientist? What science and engineering practices were involved?

Pandemic Fact or Fiction

“Something Wicked” Case Study

1. What was the objective or learning purpose for this learning activity?
2. What connections between this learning activity and other activities in this unit can you make?
3. In what ways did you act like a real scientist? What science and engineering practices were involved?
4. Make a claim about which parts of this learning activity were scientifically accurate? What resources or evidence do you have that support your claim?
5. Which parts of this learning activity were exaggerated or untrue?

“Contagion” Movie

6. What was the objective or learning purpose for this learning activity?
7. What connections between this learning activity and other activities in this unit can you make?
8. In what ways did you act like a real scientist? What science and engineering practices were involved?

9. Make a claim about which parts of this learning activity were scientifically accurate? What resources or evidence do you have that support your claim?

10. Which parts of this learning activity were exaggerated or untrue?

“Pandemic” Board Game

11. What was the objective or learning purpose for this learning activity?

12. What connections between this learning activity and other activities in this unit can you make?

13. In what ways did you act like a real scientist? What science and engineering practices were involved?

14. Make a claim about which parts of this learning activity were scientifically accurate? What resources or evidence do you have that support your claim?

15. Which parts of this learning activity were exaggerated or untrue?

Management of Pandemics One Pager

Several students at your high school have come down with respiratory symptoms including a cough, tightness in their chests, and a high fever. They are also extremely tired and cannot stay awake in their super engaging biology class. The Department of Health has issued a notice that there is a new strain of influenza that has been confirmed in 8 cases in the county. The news has been running segments about the new bird flu strain. Use this information as a platform to display all of the learning about disease identification, transmission, management, and prevention you have learned in this unit.

Directions:

1. Create a one page poster that represents all their understanding of the systems in place (healthcare management and physiologically within our bodies) that allow us to prepare for a pandemic.
2. A one pager is a single-page response to a compilation of learning activities on the response and management on pandemics. It is a way of synthesizing and modeling your unique understanding. Be creative and respond imaginatively and honestly. You only get one page so make sure you compress your thoughts.
3. The purpose of a one-pager is make connections between the learning activities in this pandemic unit. You best provide evidence of your learning when you notice patterns and make your own connections between each of the activities.
4. Your one pager should include each of these:
 - A. Main idea (as a title) that appears in all or many of the activities (this should be in a prominent location with supporting ideas clustered around it)
 - B. Visual images that capture the attention of your audience (color and shading of information is important)
 - C. Main learning objectives and your understanding of them from each of the learning activities
 - D. Supporting information with resource citations
5. Fill the entire page.

Pandemic/Epidemic Book Review

Task: Choose a fiction book about a pandemic, epidemic, or bioterrorism outbreak. As you read your book, be sure to annotate your impressions, important events, and any sections appearing to be an explanation of how diseases are transmitted, prevented, or managed. There will be a list of books provided to you. However, it is acceptable for you to locate your own title if you approve it with your teacher. Follow the guidelines and tips below to construct a well written book review.

Book Review Guidelines:

Title of Review: The title of your review should include the title of the book and convey your overall impression of the book in a catchy way. Do not be overly general. Phrases such as “nail-biter”, “full of action”, “unexpected twists”, “lackluster”, etc. are useful to demonstrate your feelings.

1st Paragraph: The first paragraph should include a short synopsis of the book. Do not give away too many details, and do NOT spoil the ending of the book for others. Using quotes from the book, interesting facts about the book, or the explanation of a scientific term in the title of the book are good ways to start the first paragraph. Make a quick connection to our phenomenon, “Are We Ready for a Pandemic?”

2nd Paragraph: The second paragraph covers the general information about the book and author. Use the following questions to guide your writing:

1. How long is the book?
2. How does this book compare to other related books?
3. Is this book part of a series?
4. Is the author an expert in a scientific field?
5. Is the book easy to read?
6. What is the setting of the book?

3rd Paragraph: The theme, characters, and plot are described in the third paragraph. Writing about these can be the trickiest part because you do not want to give away too much information. Describe the major premise, theme, or conflict in the story while describing how the characters are involved throughout the story.

4th Paragraph: The fourth paragraph analyzes the scientific accuracy of the book. Describe the mode(s) of transmission, incubation period, mortality rate, etc. for the disease in the book. A description of how the outbreak is responded to and managed should also be included. Do the details the book relate to any of the learning activities done in class? If so, which ones? Which parts appear to be realistic or scientifically accurate, and which parts seem exaggerated? Provide textual evidence to support your claim.

5th Paragraph: The last paragraph is a conclusion to the review. Let your audience know if this book is worth reading. Include a personal response to the book.

General Tips:

1. Do assess the book's weaknesses and strengths.
2. Resist the urge to summarize the plot, theme, and characters.
3. Do NOT spoil the ending or other important parts.
4. Tell potential readers whether or not they should spend their money on this book.
5. Be clear and concise, less than 1000 words.