

Project-Based Inquiry Science: Digging In Storyline

Targeted Performance Expectations:

· MS-ESS3-3 · MS-ETS1-1 · MS-ETS1-2 · MS-ETS1-3 · MS-ETS1-4

Digging In: What's the Big Question? How Do Scientists Work Together to Solve Problems?

Storyline

In the introduction to *Digging In*, students are introduced to the *Big Question: How do scientists work together to solve problems?* This challenge encourages students to begin working on problems that engage scientists and to implement the collaborative tools that are used by professional scientists. They are told that they will work within three challenges that will help them to become a team of scientists.

Digging In: Learning Set 1 The Build a Boat Challenge

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
<p><i>Learning Set 1</i> Introduction: In <i>Digging In</i>, students begin with the Build a Boat Challenge. In this challenge, students iteratively build simple aluminum foil boats that meet the criteria and constraints of the challenge.</p> <p><i>Section 1.1:</i> First, students are introduced to the problem (in the context of a story) they need to solve: build a boat from a small piece of aluminum foil that will hold 6 keys and float for 20 seconds. From this problem they identify the criteria and constraints of the challenge. Within the boundaries of the criteria and constraints, the student scientist teams build their first boat and in doing this they learn about the materials they are to use and begin to identify some design elements that might be important to solving the problem. To support students working as scientists, they are encouraged to record their trials. Each team then shares their attempts, successes, and failures with the class. They are supported in this by model questions focused on the criteria and constraints and the successes and failures of their initial trials.</p> <p>Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) ETS1.B: Developing Possible Solutions · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4)</p>	<p>Developing and Using Models (physical model of a boat is used to describe, predict, and explain forces on the boat as well as to meet the design challenge)</p> <p>Planning and Carrying Out Investigations (each team uses their boat to plan and carry out iterative designs that meet the specifications of the challenge)</p> <p>Engaging in Argument from Evidence (sharing data and focusing on the criteria of developing a boat that will float and carry a load, creating claims about the group's boats, and sharing these ideas with others)</p> <p>Analyzing and Interpreting Data (groups collect and document boat data including time of floating, number of keys and design features, analyze and interpret the data for the goal of creating a boat that best meets the challenge criteria)</p>	<p>Learning Set Level: Cause and Effect (how changes in motion are caused based on design changes) Stability and Change (change in motion is caused by several forces)</p> <p>Section Level: System and System Models (representation of inputs and outputs in the system)</p>

<p>Section 1.2: Now that students have experience with materials and have shared their initial attempts, they continue the iterative design process and plan a better boat build, improving on their initial designs using the ideas of other groups and information they gained from their initial attempts. Again, students are encouraged to document the strengths and weaknesses of each attempt. Students provide their solutions to other groups during a <i>Solution Briefing</i> presentation in which they identify how well they have met the challenge within the context of the criteria and constraints. Students read about the differences between copying work and using others' ideas and citing the resource. They are encouraged to begin to use others' ideas and to cite them.</p>	<p>Obtaining, Evaluating, and Communicating Information (reading about forces acting on the boat and applying this information to the boat design)</p> <p>Constructing Explanations and Designing Solutions (using data and experiences along with the science knowledge to improve the design solutions in an iterative cycle)</p>	<p>Learning Set Level: Cause and Effect (how changes in motion are caused based on design changes)</p> <p>Section Level: Stability and Change (change in motion is caused by several forces) System and System Models (representation of inputs and outputs in the system)</p>
<p>Section 1.3: Now that students have experiences building the boats and documenting their results, they read about the science of boat design. Students can then use the information and language from this reading to support their understanding and to make future design changes. The reading supports students' understanding of properties of the boat (density) and the forces acting on the boat, gravity, and buoyant force, the direction and sum of these forces. Students also connect the idea of the six keys as critical to the challenge and applying a downward force in the boat. The students can use the graphics in this section to identify ways in which they can draw the forces acting on their boat with regard to direction and size.</p> <p>Disciplinary Core Ideas: ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4) 	<p>Asking Questions and Defining Problems (using criteria and constraints to define the problem, developing additional criteria and constraints with other teams)</p> <p>Using Mathematics, Information and Computer Technology, and Computational Thinking (students measure and compare their measurements to the whole class)</p>	<p>Learning Set Level: Cause and Effect (how changes in motion are caused based on design changes)</p> <p>Section Level: Stability and Change (change in motion is caused by several forces) System and System Models (representation of inputs and outputs in the system)</p>
<p>Section 1.4: Using the information from the reading, students update their boat to meet the requirements of the challenge. They then engage in a <i>Solution Briefing</i> to demonstrate their last and best solution to the challenge. In the presentation, students are encouraged to demonstrate the successes and failures and to share their documented results. Students who are in the audience are encouraged to ask questions regarding the requirements of the challenge and the ways each group met those requirements.</p> <p>Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4) 	<p>Obtaining, Evaluating, and Communicating Information (reading about forces acting on the boat and applying this information to the boat design)</p> <p>Constructing Explanations and Designing Solutions (using data and experiences along with the science knowledge to improve the design solutions in an iterative cycle)</p> <p>Asking Questions and Defining Problems (using criteria and constraints to define the problem, developing additional criteria and constraints with other teams)</p> <p>Using Mathematics, Information and Computer Technology, and Computational Thinking (students measure and compare their measurements to the whole class)</p>	<p>Learning Set Level: Cause and Effect (how changes in motion are caused based on design changes)</p> <p>Section Level: Stability and Change (change in motion is caused by several forces) System and System Models (representation of inputs and outputs in the system)</p>

<p><i>Back to the Big Question:</i> The goal of <i>Digging In</i> is to provide several contexts through which students begin to collaborate to answer questions and solve problems like scientists and engineers. All of the units learning tasks are focused on these ideas. In <i>Learning Set 1</i>, students have learned to work in small groups to solve problems collaboratively and to persevere through a design challenge, updating their own ideas with additional information and using the ideas of others when appropriate. They have used criteria and constraints to define the boundaries of the challenge and have learned the importance of record keeping. In <i>Back to the Big Question</i>, students reflect on this scientific work and begin to identify the importance of using these tools of science when they are searching for answers to questions and addressing design challenges.</p>	<p>Obtaining, Evaluating, and Communicating Information (reading about forces acting on the boat and applying this information to the boat design)</p> <p>Constructing Explanations and Designing Solutions (using data and experiences along with the science knowledge to improve the design solutions in an iterative cycle)</p> <p>Asking Questions and Defining Problems (using criteria and constraints to define the problem, developing additional criteria and constraints with other teams)</p> <p>Using Mathematics, Information and Computer Technology, and Computational Thinking (students measure and compare their measurements to the whole class)</p>	<p>Learning Set Level: Cause and Effect (how changes in motion are caused based on design changes)</p> <p>Section Level: Stability and Change (change in motion is caused by several forces) System and System Models (representation of inputs and outputs in the system)</p>
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Digging In: Learning Set 2 The Lava Flow Challenge

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
<p><i>Learning Set 2</i> Introduction: In <i>Learning Set 2</i> of <i>Digging In</i> students use the scientists' practices they have learned in <i>Learning Set 1</i> and apply them to a new challenge. Within this new challenge they learn additional practices and use them in new ways. In the introduction students are challenged to create an accurate procedure for measuring lava flow and to provide evidence that the procedure is accurate. In this <i>Learning Set</i>, the development and testing of the procedure is in the foreground. Information about lava flow and this activity as a simulation of lava flow is backgrounded.</p>	<p>Developing and Using Models (physical model of a lava is used to identify a procedure and collect lava flow data)</p> <p>Obtaining, Evaluating, and Communicating Information (students read about lava and lava flow in order to connect real-world phenomenon to the activity)</p>	<p>Section Level: System and System Models (the system model of the lava flow can be measured and a procedure can be created that allows all groups to be measuring the same quantities)</p>
<p><i>Section 2.1:</i> Students identify the criteria and constraints of the challenge and make a public list of the criteria and constraints.</p> <p>Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)</p>	<p>Developing and Using Models (physical model of a lava is used to identify a procedure and collect lava flow data)</p>	<p>Section Level: System and System Models (the system model of the lava flow can be measured and a procedure can be created that allows all groups to be measuring the same quantities)</p>

Section 2.2:

Students begin to model lava flow on a paper plate. In this challenge, dish soap provides a physical analog to lava and students measure how the soap flows down a paper plate. To begin the class creates an initial procedure for all small groups to follow and then they run their first trials using this procedure. Students are asked to collect several trials and to document their results.

A class graph is created to show the results of each trial. The graph, a line plot, shows each individual trial data point on one graph. Students analyze the class graph for information about the efficacy of their procedure. They look for reliability issues within the data by noting the range, distribution, and average of the data. From this data they recognize the need for developing a more thorough and consistently followed procedure.

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Section 2.3:

After analyzing the data and identifying issues of precision and error, students identify errors in the procedure and craft an updated procedure that will make it possible to collect more useful and accurate data.

The class procedure focuses on controlling variables and acting as groups of scientists to implement one procedure across all “scientist groups.”

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

Developing and Using Models (physical model of a lava is used to identify a procedure and collect lava flow data)

Planning and Carrying Out Investigations (students plan and carry out the investigation to measure lava flow with accuracy in order to make a recommendation of an accurate procedure)

Analyzing and Interpreting Data (small groups collect data which is then analyzed by creating a class graph using all data points. Data analysis supports students developing an accurate procedure)

Using Mathematics and Computational Thinking (students graph and then discuss the data set they created, looking for procedural issues that present themselves because the large range or outlying data points)

Section Level:

System and System Models (the system model of the lava flow can be measured and a procedure can be created that allows all groups to be measuring the same quantities)

Planning and Carrying Out Investigations (students plan and carry out the investigation to measure lava flow with accuracy in order to make a recommendation of an accurate procedure)

Section Level:

System and System Models (the system model of the lava flow can be measured and a procedure can be created that allows all groups to be measuring the same quantities)

Section 2.4:

Student groups carry out the investigation using their updated procedure and complete the activity by again creating a graph to support the analysis of the class data. They compare the data collected using the common, well-developed procedure to the data collected in the first procedure. By sharing their interpretations of the graph with the class, students determine if their procedure was more reliable.

Disciplinary Core Ideas:

ETS1.A: Defining and Delimiting Engineering Problems

· The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Back to the Big Question:

After focusing students on sharing data and creating a common, accurate, and consistently used procedure, *Learning Set 2* concludes with students returning to the *Big Question: How do scientists work together to solve problems?* In answering the *Big Question* after this *Learning Set*, students add planning and carrying out investigations, developing and following common procedures, representing and analyzing data, and drawing conclusions from data to their developing understanding of how scientists work.

Developing and Using Models (physical model of a lava is used to identify a procedure and collect lava flow data)

Planning and Carrying Out Investigations (students plan and carry out the investigation to measure lava flow with accuracy in order to make a recommendation of an accurate procedure)

Analyzing and Interpreting Data (small groups collect data which is then analyzed by creating a class graph using all data points. Data analysis supports students developing an accurate procedure)

Using Mathematics and Computational Thinking (students graph and then discuss the data set they created, looking for procedural issues that present themselves because the large range or outlying data points)

Obtaining, Evaluating, and Communicating Information (students read about lava and lava flow in order to connect real-world phenomenon to the activity)

Section Level:

System and System Models (the system model of the lava flow can be measured and a procedure can be created that allows all groups to be measuring the same quantities)

Section Level:

System and System Models (the system model of the lava flow can be measured and a procedure can be created that allows all groups to be measuring the same quantities)

Digging In: Learning Set 3 The Basketball-Court Challenge

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
<p><i>Learning Set 3 Introduction:</i> In the Basketball Court Challenge, students apply their developing understanding of challenges to a new scenario. In the introduction, students are read the problem: stop the erosion on a hillside so that a basketball court can be added to their school playground. They are provided the criteria and constraints within a letter from the school superintendent. The goal of the Learning Set is for students to develop and explain at least one way that the impact of erosion can be lessened and human impacts on a system can be minimized.</p>	<p>Obtaining, Evaluating, and Communicating Information (students are provided the challenge and criteria and constraints in a letter and identify the critical information for defining the challenge)</p>	<p>Learning Set Level: Cause and Effect (changes in a system have identifiable causes and effects that can be observed and tested)</p>
<p><i>Section 3.1:</i> Students begin the challenge by identifying the criteria and constraints of the challenge and creating a table that can be referenced and updated throughout the <i>Learning Set</i>. They then take an Erosion Walk to identify places, types and sources of erosion around their own school. Students are asked to document their observations and will use these observations later in the <i>Learning Set</i> as they apply them to meeting the challenge. Students share their observations in a conference session. By documenting these observations and the sources of erosion, all the students have access to the erosion information. Finally, students document their current understanding about erosion and develop questions they would like to investigate, related to the <i>Learning Set</i> challenge. These ideas are documented (in the <i>What do we think we know?</i> and <i>What do we need to investigate?</i> columns) on the <i>Project Board</i>, creating a public artifact of their initial ideas.</p> <p>Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)</p>	<p>Constructing Explanations and Designing Solutions (in this learning set, the design solution evolves slowly over several sections. Information gained in these sections is used later in the <i>Learning Set</i>. Using data and experiences from the Erosion Walk and the case studies, students begin to create explanations about the causes and sources of erosion)</p> <p>Analyzing and Interpreting Data (qualitative, observational data about erosion is used to identify places where erosion occurs. This information is used in designing a challenge solution)</p>	<p>Section Level: Stability and Change (changes in a system can be observed, tested and evaluated) System and System Models (systems have boundaries and within these boundaries changes to the system can be observed. Observations of systems can occur using system models that can allow for testing of some system factors)</p>
<p><i>Section 3.2:</i> Case studies provide the students with additional experiences with specific examples of erosion. Students read about case studies and learn how scientists use case studies to draw comparisons, look for patterns, and to inform their work. They also begin to apply these examples to their thinking for addressing the challenge. Student groups become experts for one of several case studies and then share what they have learned with the other groups. The case studies were selected to help students identify the impact of erosion caused by human impacts and natural systems. They learn that some examples of erosion happen slowly over long time scales and some examples happen quickly. Students synthesize what they have learned about each case study from the expert group, and document what they have learned as they update the <i>Project Board</i>. They begin to make claims about that they are learning and add those claims and the evidence to support them on the <i>Project Board</i> (in the <i>What are we learning?</i> and <i>What is our evidence?</i> columns).</p> <p>Disciplinary Core Ideas: ESS3.C: Human Impacts on Earth Systems · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) · Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MSESS3-3),(MS-ESS3-4)</p>	<p>Obtaining, Evaluating, and Communicating Information (case studies describing various erosion mitigation mechanisms are read and iteratively evaluated for applicability to the <i>Big Challenge</i>)</p>	<p>Learning Set Level: Cause and Effect (changes in a system have identifiable causes and effects that can be observed and tested)</p> <p>Section Level: Stability and Change (changes in a system can be observed, tested and evaluated) System and System Models (systems have boundaries and within these boundaries changes to the system can be observed. Observations of systems can occur using system models that can allow for testing of some system factors)</p>

Section 3.3:

Students begin to use a model to investigate factors that affect erosion. **Groups of students are assigned one of two factors: particle size and slope and how this factor affects erosion. Students are provided a procedure to follow and then are asked to analyze their results to find trends between the two variables, particle size and slope.** They make a claim about how each of these variables affects erosion, supporting their claim with evidence from their investigations.

Students then share their claims and evidence in an *Investigation Expo*, providing each group access to claims, evidence, and conclusions from both investigations.

Disciplinary Core Ideas:

ESS3.C: Human Impacts on Earth Systems

· Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)

Section 3.4:

Students evaluate and then apply the information about erosion they have gathered from several sources (case studies, investigations and the claims and evidence that they have added to the *Project Board*) to craft a **scientific explanation for causes of erosion**. Students then share their draft explanations with each other to help support explanation writing and to gain access and include others' ideas in their initial explanations.

Section 3.5:

Now that students have identified several causes of erosion, they can begin to consider ways that **erosion might be mitigated**. They again use case studies of various places in which problematic erosion, both **naturally caused and related to human impacts has been stopped**. These case studies provide a spectrum of ideas and allow the students to begin to **evaluate the best solutions for the basketball court challenge**. Students then share their claims and evidence about erosion mitigation by updating the *Project Board*.

Disciplinary Core Ideas:

ESS3.C: Human Impacts on Earth Systems

· Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)

· Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MSESS3-3),(MS-ESS3-4)

Developing and Using Models (physical model of the basketball court is used to describe, predict, and explain factors that cause erosion)

Planning and Carrying Out Investigations (each team uses their model to plan and carry out several investigations to help them identify and evaluate the factors that cause erosion)

Engaging in Argument from Evidence (sharing data and focusing on the criteria of the basketball court challenge, collecting evidence to help identify the factors that cause erosion and sharing those claims with other groups, comparing and evaluating data from several separate simulations)

Analyzing and Interpreting Data (groups collect, record, and analyze erosion data from investigations)

Constructing Explanations and Designing Solutions (based on results of the investigation, explanations about the factors that cause erosion are created and shared)

Obtaining, Evaluating, and Communicating Information (case studies describing various erosion mitigation mechanisms are read and iteratively evaluated for applicability to the *Big Challenge*)

Asking Questions and Defining Problems (using criteria and constraints to define the problem, developing additional criteria and constraints with other teams)

Learning Set Level:

Cause and Effect (changes in a system have identifiable causes and effects that can be observed and tested)

Section Level:

Stability and Change (changes in a system can be observed, tested and evaluated)

System and System Models (systems have boundaries and within these boundaries changes to the system can be observed. Observations of systems can occur using system models that can allow for testing of some system factors)

Section 3.6:

Previously, students used a model to identify factors that affect erosion (particle size and slope). Now they will use similar models to **design, test, and evaluate various ways to stop erosion**. They design a physical representation of the proposed basketball court area, carefully referring to the previous description of the area and then **apply idea(s) they have learned from the case studies to the erosion problem** as represented in their model. Students make a prediction about how they think their system will work and share their ideas with the class, gaining additional ideas from the other groups to update their mitigation plan.

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Section 3.7:

Now that students have **planned their solution to the basketball court erosion problem, they again use their model to run a simulation on their test area, recording their observations, and analyzing their data**. As they have learned to do previously, they share their results and conclusions with the class in an *Investigation Expo*. Synthesizing their conclusions, the class discusses their claims and supporting evidence and updates the *Project Board*.

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Constructing Explanations and Designing Solutions

(students create design solutions for stopping erosion and apply that solution in a simulation)

Developing and Using Models (physical model is used to simulate the design solution decided on by the group)

Planning and Carrying Out Investigations (the model is used to plan and carry out the investigation to determine the efficacy of the planned design solution)

Engaging in Argument from Evidence (sharing data and focusing on the criteria of developing the mitigation system that will be most effective)

Analyzing and Interpreting Data (groups collect data from their simulation, analyze it, and interpret it for the goal of creating the best mitigation system)

Asking Questions and Defining Problems (in the context of identifying the best mitigation system, students ask about design solutions of other groups, identify and define problems with design solutions and update the criteria and constraints as needed)

Learning Set Level:

Cause and Effect (changes in a system have identifiable causes and effects that can be observed and tested)

Section Level:

Stability and Change (changes in a system can be observed, tested and evaluated)
System and System Models (systems have boundaries and within these boundaries changes to the system can be observed. Observations of systems can occur using system models that can allow for testing of some system factors)

Section 3.8:

Students have identified and evaluated the differences among several erosion mitigation systems, now they will create a recommendation for which of these systems (or combination of systems) will best meet the design challenge and criteria and constraints of the basketball court challenge. They create a written recommendation, building from their experiences and the claims and evidence on the *Project Board*. They share their recommendation with the class and update the *Project Board* with any new ideas that have been presented.

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Section 3.9:

Following what is now a common class procedure, groups plan their basketball court solution, based on the recommendation they have written. They design and record their solution, then share their design in a *Plan Briefing*, using this opportunity to evaluate competing designs and gain feedback on their design. Students are encouraged to use this feedback to update their plan.

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Constructing Explanations and Designing Solutions (students create design solutions for stopping erosion and apply that solution in a simulation)

Developing and Using Models (physical model is used to simulate the design solution decided on by the group)

Planning and Carrying Out Investigations (the model is used to plan and carry out the investigation to determine the efficacy of the planned design solution)

Engaging in Argument from Evidence (sharing data and focusing on the criteria of developing the mitigation system that will be most effective)

Analyzing and Interpreting Data (groups collect data from their simulation, analyze it, and interpret it for the goal of creating the best mitigation system)

Asking Questions and Defining Problems (in the context of identifying the best mitigation system, students ask about design solutions of other groups, identify and define problems with design solutions and update the criteria and constraints as needed)

Learning Set Level:

Cause and Effect (changes in a system have identifiable causes and effects that can be observed and tested)

Section Level:

Stability and Change (changes in a system can be observed, tested and evaluated)

System and System Models (systems have boundaries and within these boundaries changes to the system can be observed. Observations of systems can occur using system models that can allow for testing of some system factors)

Section 3.10:

Using the design plan, students build and test their basketball court challenge solution. They are encouraged to use an iterative design model in their testing and to record all observational data that will help them support the level of effectiveness of their design solution. Using a *Solution Briefing*, students share their results and provide guidance to other groups to help them better understand their results.

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Constructing Explanations and Designing Solutions

(students create design solutions for stopping erosion and apply that solution in a simulation)

Developing and Using Models (physical model is used to simulate the design solution decided on by the group)

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Learning Set Level:

Cause and Effect (changes in a system have identifiable causes and effects that can be observed and tested)

Section Level:

Stability and Change (changes in a system can be observed, tested and evaluated)

System and System Models (systems have boundaries and within these boundaries changes to the system can be observed. Observations of systems can occur using system models that can allow for testing of some system factors)

Digging In: Address the Big Challenge Advise the School Board

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices
<p>As students conclude the <i>Learning Set</i>, they <i>Address the Big Challenge</i> – developing a recommendation to the school board about the basketball court. Students are provided an opportunity to evaluate and then update their design, based on what they learned from the <i>Solution Briefing</i> and the <i>Project Board</i>. Students then communicate any changes they make to their plan. Finally, students write a letter that contains their solution and the recommendation for the school board. They complete the challenge in a <i>Showcase</i> that provides all students an opportunity to create a substantial presentation that helps them hone and then present their final solutions.</p> <p>Disciplinary Core Ideas: ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> · Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) · The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4) 	<p>Constructing Explanations and Designing Solutions (students create final design solutions for stopping erosion and communicate that solution in a recommendation)</p> <p>Engaging in Argument from Evidence (within their written recommendation and during the <i>Solution Briefing</i>, students are asked to argue for their design solution and support their argument with evidence)</p>

Digging In: Answer the Big Question How Do Scientists Work Together to Solve Problems?

Storyline
<p>At the end of each <i>Learning Set</i>, students have reflected on what they have learned about how scientists “work together to solve problems”. They have worked collaboratively throughout the unit and have designed procedures, conducted investigations, shared their results and plans, and completed many of the tasks professional scientists and engineers complete. Now that students will be answering the <i>Big Question</i>, they begin by watching a video (IDEO) that shows adults engaged in the same processes that they have been engaged in with the focus on solving a problem. The video allows students to see that the work they have been asked to complete mirrors the work of professionals. To complete the unit, students answers questions and discuss how they have learned teamwork, sharing ideas and learning from other students, making informed, evidence-based decisions, and the importance of iteration and identifying and attending to criteria and constraints. Additional discussions around planning and carrying out investigations, the importance of modeling and simulations, and the usefulness of case studies to support reasoned decisions are also included in the <i>Answer the Big Question</i>.</p>