**Appendix: Practice Templates By Grade Band (HS; MS; 3-5; K-2) *DRAFT***

The evidence statements are based on the observable features of the science and engineering practice in the context of the students demonstrating understanding of the three dimensions. This appendix details what students are expected to be able to demonstrate by the end of each grade band with respect to each practice. Although all three dimensions are equally important aspects of the NGSS, only the practices are included in this appendix in order to describe the full scope of what students are expected to do by the end of these grade bands, as this may be difficult to fully tease out when different parts of practices are contextualized within each individual performance expectation. W**e** hope that by providing this guidance here, it will be useful in thinking about student supports and scaffolds that will be necessary to help meet students where they are, and allow them to progress to grade-band goals. This holds true for the crosscutting concepts and core ideas as well, although they are not described separately.

Here, the practices are presented in an ordered format, both for the template structure of each practice (i.e., Constructing Explanations is presented in an outline form with ‘stating the explanation’ listed first, ‘Evidence’ listed second, and ‘reasoning’ listed third.), as well as across practices (i.e., ‘Asking Questions and Defining Problems’ is presented first, followed by ‘Developing and Using Models, etc). This does not prescribe or imply an order for student performance. In other words, students are not expected to proceed linearly through the practices, nor are student performances on any one given practice expected to necessarily follow the outline, step-by-step, for that practice. The templates, and evidence statements as a whole, were presented in this way solely for organizational purposes.

**Putting the Practices Templates to Use**

It is important to note that the practice templates here, like the evidence statements and the PEs themselves, are written as end of grade band expectations (i.e., not as formative or lesson-to-lesson expectations). We hope that this these templates will be helpful for backward design of learning experiences that build toward these goals, or as checks for learning progressions as they are designed. For example, knowing the full extent of what “asking questions and designing solutions” looks like by the end of second grade may be able to help educators design a lesson sequence that builds toward part of that practice, such as asking observation-based questions with a specific informational goal in mind.

Additionally, each practice template here describes the full extent of expected performance on that practice at the end of the grade band- in other words, the practices described here include all the observable student performances necessary to do all elements of the practice as described in Appendix F of the NGSS. Because each practice as a whole is the sum of many different elements (e.g., ‘Engaging in Argument from Evidence’ as a practice encompasses a wide range of argumentation processes, including: constructing arguments; evaluating arguments; critiquing others ideas, evidence, reasoning, and designs), any given evidence statement for a specific PE that includes that practice may or may not include all of the parts listed here. For example, a PE that asks students to gather and synthesize information may include parts of the “obtaining, evaluating, and communicating information” practice language, but will likely not detail the full extent of the practice, because the emphasis of the PE is not on communicating information.

Consider this example:

PE:

|  |  |
| --- | --- |
| **MS-LS1-8.** | **Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.**[Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.] |

In this example, the accompanying evidence statement only includes an “obtaining” section and an “evaluating” section, because the PE does not explicitly ask for communication, and the evidence statements, like the PEs, describe the minimum performance necessary for proficiency. Based on this, one could design a series of assessment items, or an assessment task, to address the DCI, CCC, and practice content and knowledge indicated by this PE. Could this assessment task include a communication piece, and still be measuring proficiency?

Yes! Because communication is required by the NGSS at this grade band, students could certainly be expected to communicate the information they gather in multiple formats, clearly and concisely. That task would then assess this PE as well as additional practice elements for the grade band.

These general features, by practice, may be useful as educators think through what students should we able to do at the end of 2nd, 5th, , 8th, and 12th grade; how to build toward those performance goals; and how practices may be used in instruction, coupled with appropriate and varied DCI and CCC elements, to support diverse and deep learning opportunities.

**Grades K-2 *DRAFT***

*General observable features of the practices by the end of 2nd grade.*

**Asking Questions and Defining Problems**

1. Asking Questions
2. Addressing Phenomena
   1. Students ask questions based on observations to find out more information about the natural and designed world.
3. Identifying the Scientific Nature of the Question
4. Students ask questions that can be investigated within the scope of the classroom.
5. Defining Problems
6. Identifying the problem to be solved
7. Students identify:
8. A simple problem, based on a situation people want changed, that could be solved through the development of a new or improved object or tool.
9. Relevant scientific ideas for the problem and solution.
10. Defining the features of the design
11. Students describe the desirable features and limits for an acceptable solution to the problem.

**Developing and Using Models**

1. Using a Model: Using either a developed or given model to do the following:
2. Components of the model
   1. Students identify and describe the relevant features or factors (components) for the phenomenon, amounts, relationships, scales, proposed object, and/or patterns being modeled.
   2. Students represent actual objects, processes, and/or events as models, and distinguish between the two.
3. Relationships
   1. Students describe how components of the model relate and/or interact with each other.
4. Connections
   1. Students describe how the components and relationships relate to the phenomenon being modeled.
   2. Students distinguish between a model and the actual phenomenon, object, process, and/or event being modeled.
5. Developing a Model: Students develop a model with all of the attributes above. When developing models, students use a variety of representations (e.g., examples, analogy, abstract representation, diagrams, physical models) to describe concrete examples of phenomena and design solutions.

**Planning and Carrying Out Investigations**

1. Identifying the phenomenon to be investigated
   1. Students describe the phenomenon under investigation, question to be answered, or design solution to be tested.
2. Identifying the evidence to answer this question
   1. Students describe the evidence to be collected.

Students describe that the evidence will be relevant to the purpose of the

* 1. investigation.

1. Collaborative planning for the investigation
   1. Students develop a grade-appropriate investigation plan that details how the data will be indicated, collected, and/or measured, including number of trials.
   2. When given an investigation plan, students identify how:
      1. The data/evidence will be collected
      2. The methods are relevant to the purpose of the investigation
2. Collecting the data
   1. Students collaboratively perform the investigation, collecting and recording data systematically.

**Analyzing and Interpreting Data**

1. Organizing Data
2. Students record information using graphical or visual displays (e.g., pictures, pictographs, drawings, written observations, tables, charts) to organize data to indicate relationships.
3. Identifying Relationships
4. Students use and share organized data to find patterns.
5. Interpreting Data
6. Students use logical reasoning to interpret patterns in the data to describe phenomena and to determine if an object or tool works as it is intended to.
7. Students use data to compare predictions to actual outcomes, answer scientific questions, and solve problems.

**Using Mathematics and Computational Thinking**

1. Using Given Mathematical or Computational Representations: Using either developed or given mathematical or computational representations to do the following:
2. Representation
   1. Students describe, count, and measure quantities.
   2. Students represent relevant quantities using simple graphs.
3. Mathematical or Computational Modeling and Analysis
4. Students use simple mathematical or computational representations to:
5. Describe observable relationships and patterns.
6. Address scientific questions, phenomenon, and design solutions.
7. Compare solutions to a problem.

**Constructing Explanations and Designing Solutions**

1. Constructing Explanations
2. Explanation
   1. Students construct evidence-based accounts of phenomena based on observations.
3. Evidence to construct or support the explanation
   1. Students make observations (first-hand and/or from media) to provide evidence for phenomena.
4. Reasoning to connect the evidence to construct or support the explanation
   1. Students use reasoning to connect the evidence to construct the explanation of phenomena.
5. Designing Solutions
6. Using scientific knowledge to generate the design solution
7. Given a problem to solve, students collaboratively design a solution(s) to the problem. In the design, students:
   1. Identify the scientific information (e.g., observations, scientific knowledge, evidence) that is related to the problem.
   2. Describe a solution(s) to the problem.
   3. Specify how the design solution uses the scientific information to address the problem.
8. Describing expected features of the design
9. Students describe the desired features and limits for the solution, based on the factors presented in the problem and any resource considerations.
10. Students design a solution that is intended to meet the expected features.
11. Evaluating potential solutions
12. Students evaluate the design solution(s) by assessing whether the solution meets each feature described.
13. When appropriate, students compare design solutions to each other based on how well they meet the described features.

**Engaging in Argument from Evidence**

1. Constructing Arguments about Natural Phenomena or Evaluating Design Solutions

1. Identifying the claims or design solutions

1. Students identify the claims, explanations, or design solutions to be evaluated or supported with argumentation.
2. Students make claims about the effectiveness of design solutions.
3. Identifying scientific evidence:
   1. Students identify and describe given scientific evidence that are relevant to supporting, refuting, or evaluating claims about the particular phenomenon or design problem.
4. Evaluating and critiquing evidence: identification of the strength of the evidence used to support an argument for or against a claim or a particular design solution
5. Students evaluate whether the evidence supports logical and reasonable arguments about the claims, explanations, or design solutions.
6. Students distinguish between opinions and evidence.
7. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
8. Students use reasoning to connect the evidence and evaluation logically to construct arguments.
9. Evaluating the effectiveness of given design solutions.
10. Identifying the given solutions and information about the problem.
11. Students clearly identify:
12. The given solutions, including their relevant features.
13. The problem, including any specific relevant information.
14. Evaluating and critiquing
15. Students identify the strengths and weakness of the solution(s).
16. Students evaluate the solution(s) in terms of whether they meet the desired features and limits of the problem.
17. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
18. Students use reasoning to make a claim about the effectiveness of the solution(s) based on the strengths and weaknesses of the solution(s).

**Obtaining, Evaluating, and Communicating Information**

1. Obtaining information
   1. Students gather information from books, texts, text features, and other reliable media appropriate to the grade level.
   2. Students obtain information to answer scientific questions, and to describe scientific and engineering ideas.
2. Evaluating information
   1. Students describe how specific sources of information describe ideas from science and engineering.
3. Communicating information
4. Communication Style and Format
   1. Students communicate information orally and in written formats, including models, drawing, writing, or numbers.
   2. Students use communication that is clear and effective.
5. Connecting the Disciplinary Core Ideas (DCIs) and the Crosscutting Concepts (CCC)
   1. Students’ communication includes clear connections between the targeted DCIs and the targeted CCCs in the context of a specific question, phenomenon, problem, or solution.

**Grades 3-5 *DRAFT***

*General observable features of the practices by the end of 5th grade.*

**Asking Questions and Defining Problems**

1. Asking Questions
2. Addressing Phenomena or Scientific Theories
   1. Students ask questions that clarify qualitative relationships between features or factors. Students ask questions that allow them to:
      1. Identify and clarify what happens when something changes within the system being examined.
      2. Predict reasonable outcomes based on observable patterns (e.g., cause and effect).
3. Identifying the Scientific Nature of the Question
4. Students distinguish between scientific (testable) and non-scientific (non-testable) questions.
5. Students ask questions that can be investigated within the scope of the classroom or outdoor environment.
6. Defining Problems
7. Identifying the problem to be solved
8. Students identify:
9. A simple problem that could be solved through the development of a new or improved object, tool, process, or system.
10. Relevant scientific ideas for the problem and solution.
11. Defining the boundaries of the system
    * + - 1. Students define the limits within which the problem will be addressed.
12. Defining the criteria and constraints
13. Students identify several criteria (desirable features) for an acceptable solution to the problem.
14. Students identify the constraints (limits) for acceptable solutions to the problem, which may include:
    * 1. Time
      2. Cost
      3. Materials

**Developing and Using Models**

1. Using a Model: Using either a developed or given model to do the following:
2. Components of the model
   1. Students identify and describe the relevant variables or factors (components) for the phenomenon being modeled.
   2. When appropriate, students identify the limitations of the model.
3. Relationships
   1. Students describe how components of the model relate and/or interact with each other.
4. Connections
   1. Students use reasoning to connect the components and relationships within the model to real-world phenomena or scientific theories.
   2. Students use the model to describe and/or make predictions about phenomena.
5. Developing a Model: Students develop a model (e.g., conceptual, physical) individually and collaboratively with all of the attributes above. When developing models, students use a variety of representations (e.g., examples, analogy, abstract representation, diagrams, physical models) to describe scientific principles, phenomena, and design solutions.

**Planning and Carrying Out Investigations**

1. Identifying the phenomenon to be investigated
   1. Students describe the phenomenon under investigation, question to be answered, or design solution to be tested.
2. Identifying the evidence to answer this question
   1. Students describe the evidence from qualitative and quantitative data to be collected.
   2. Students describe how the evidence will be relevant to the purpose of the investigation.
3. Collaborative planning for the investigation
   1. Students develop an investigation plan that details how the data will be indicated, collected, and/or measured, including number of trials.
   2. Students account for fair testing in their investigation plan, and identify which variables will be controlled and which variables will be changed throughout the investigation plan.
   3. When given an investigation plan, students identify how:
      1. The data will be collected
      2. The methods are relevant to the purpose of the investigation
4. Collecting the data
   1. Students collaboratively perform the investigation, collecting and recording data systematically.

**Analyzing and Interpreting Data**

1. Organizing Data
2. Students use graphical or visual displays (e.g., tables, charts, graphs) to organize quantitative and qualitative data from multiple trials to indicate relationships.
3. Identifying Relationships
4. Students analyze data using simple quantitative (e.g., grade-appropriate mathematics and computation) and qualitative approaches, and describe observable patterns (e.g., similarities and differences) in the data.
5. Interpreting Data
6. Students use logical reasoning to interpret patterns in the data to describe phenomena and refine or evaluate design solutions.

**Using Mathematical and Computational Thinking**

1. Using Given Mathematical or Computational Representations: Using either developed or given mathematical or computational representations to do the following:
2. Representation
   1. Students measure and estimate relevant quantities of physical properties (e.g., area, volume, weight, time).
   2. Students mathematically represent relevant quantities using standard and appropriate units.
   3. Students create and/or use appropriate graphs and charts to facilitate data interpretation and analysis.
3. Mathematical or Computational Modeling and Analysis
   1. Students use simple mathematical or computational representations to:
      1. Describe observable relationships and patterns.
      2. Address scientific questions, phenomenon, and design solutions.
4. Developing Mathematical or Computational Representations: Students develop simple mathematical or computational representations with all of the attributes above.

**Constructing Explanations and Designing Solutions**

1. Constructing Explanations
2. Explanation
   1. Students clearly explain an observable phenomenon, including a grade-appropriate level of the mechanism involved.
   2. When the explanation is given, students identify the explanation and any particular points that will be supported with evidence.
3. Evidence to construct or support the explanation
   1. Students identify the relevant evidence to support the explanation. Students use evidence that specifies variables that describe and predict phenomena.
4. Reasoning to connect the evidence to construct or support the explanation
   1. Students use reasoning to connect the evidence in order to construct the explanation of phenomena.
   2. When given the explanation and evidence, students use reasoning to describe which evidence specifically supports particular points within an explanation.
5. Designing Solutions
6. Using scientific knowledge to generate the design solution
7. Given a problem to solve, students collaboratively design a solution to the problem. In the design, students:
   1. Identify the scientific information (e.g., principles, theories, evidence) that is related to the problem.
   2. Describe a solution to the problem.
   3. Specify how the design solution uses the scientific information to address the problem.
8. Describing criteria and constraints, including quantification when appropriate
9. Students describe the given criteria (desirable features) and constraints (limits) for the solution, based on the factors presented in the problem and any resource considerations.
10. Students design a solution that is intended to meet the criteria and constraints.
11. Evaluating potential solutions
12. Students evaluate the design solution(s) systematically by analyzing whether the solution meets each criterion and constraint described.
13. When appropriate, students compare design solutions to each other based on how well they meet the criteria and constraints described.
14. Refining the design solution
15. Students modify the solution(s) based on the results from the evaluation to improve the design solution.
16. When necessary, students make tradeoffs to optimize the solution based on the most important criteria.

**Engaging in Argument from Evidence**

1. Constructing Arguments about Natural Phenomena and Evaluating Design Solutions

1. Identifying the claims or design solutions

1. Students identify the claims, explanations, or design solutions to be evaluated, supported, or refuted with argumentation.
2. Students make claims about the merits of design solutions.
3. Identifying scientific evidence:
   1. Students identify and describe scientific evidence, models, and/or data that are relevant to supporting, refuting, or evaluating claims about the particular phenomenon or design problem.
4. Evaluating and critiquing evidence: identification of the strength of the evidence used to support an argument for or against a claim or a particular design solution
5. Students evaluate whether the evidence supports logical and reasonable arguments about the claims, explanations, or design solutions.
6. Students evaluate whether other explanations or factors of the explanation could be supported by the evidence.
7. Students distinguish among facts, reasoned arguments based on evidence, and speculation.
8. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
9. Students use reasoning to connect the evidence and evaluation logically to construct arguments.
10. Evaluating given design solutions.
11. Identifying the given solutions and information about the problem.
12. Students clearly identify:
13. The given solutions, including their relevant features.
14. The problem, including any specific relevant information.
15. Identifying any potential additional evidence that is relevant to the evaluation
16. Students identify and describe evidence from data, scientific theories, or models, including necessary information that students obtain from the given materials, prior knowledge, and through additional research, that is relevant to the evaluation.
17. Evaluating and critiquing
18. Students use a systematic method to identify the strengths and weakness of the solution(s).
19. Students evaluate the solution(s) against each criterion and constraint
20. Students use the evidence to assess the given features of the solution.
21. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
22. Students use reasoning to make a claim about the effectiveness (or relative effectiveness, when appropriate) of the solution(s) based on the strengths and weaknesses of the solution(s).

**Obtaining, Evaluating, and Communicating Information**

1. Obtaining information
   1. Students gather, read, and comprehend information from books and other reliable media (e.g., text, media, visual displays, data) appropriate to the grade level.
   2. Students compare and combine information presented in various modes (e.g., graphs, diagrams, photographs, text, mathematical, verbal) to describe a phenomenon.
2. Evaluating information
   1. Students assess the accuracy, and possible bias of each source of information at a grade appropriate level.
   2. Students combine information from multiple sources, and about various aspects of the phenomenon, to determine its meaning and relevance to phenomena.
3. Communicating information
4. Communication Style and Format
   1. Students communicate information orally and in written formats, including a various forms of media as well as tables, diagrams, and charts.
   2. Students use communication that is clear and effective.
5. Connecting the Disciplinary Core Ideas (DCIs) and the Crosscutting Concepts (CCC)
   1. Students’ communication includes clear connections between the targeted DCIs and the targeted CCCs in the context of a specific question, phenomenon, problem, or solution.

**Middle School *DRAFT***

*General observable features of the practices by the end of 8th grade.*

**Asking Questions and Defining Problems**

1. Asking Questions
2. Addressing Phenomena or Scientific Theories
   1. Students ask questions based on carefully observing models, phenomena, arguments, and evidence, including unexpected results. Students ask questions that:
      1. Identify and clarify claims and evidence of an explanation or argument.
      2. Challenge the premise of arguments and the interpretation of data.
      3. Clarify and refine models, explanations, and problems.
      4. Determine relationships between:
         1. Independent and dependent variables
         2. Components of models
3. Empirical testability
4. Students ask questions that:
   1. Require empirical evidence to answer.
   2. Can be investigated within the scope of the classroom, outdoor environment, and other publicly accessible venues with available resources.
5. Based on their questions, students frame hypotheses that can be addressed empirically.
6. Defining Problems
7. Identifying the problem to be solved
8. Students describe:
9. A simple problem that could be solved through the development of an object, tool, process, or system.
10. The major consequences to people and/or the natural world if the identified problem remains unsolved
11. Defining the process or system boundaries, and the components of the process or system
12. Students identify or define the system in which the problem is embedded to clarify what is and what is not part of the problem. In their definition of the system, students include:
    1. Which individuals or groups need the problem solved
    2. The needs that must be met by the design solution
    3. Scientific issues that are relevant to the problem
    4. Potential societal and environmental impacts of solutions
    5. Relative importance of the various issues and components of the process or system.
13. Defining the criteria and constraints
14. Students specify the qualitative and quantitative criteria and constraints for acceptable solutions to the problem.

**Developing and Using Models**

1. Using a Model: Using either a developed or given model to do the following:
2. Components of the model
   1. Students identify and describe all of the essential variables or factors (components) for the phenomenon being modeled.
   2. When appropriate, students describe the limitations of the model.
3. Relationships
   1. Students describe how components of the model relate to and/or interact with each other within the system being modeled.
4. Connections
   1. Students use reasoning to connect the components and relationships within the model to real-world phenomena or scientific theories.
   2. Students use the model to describe and/or make predictions about phenomena.
   3. Students use their understanding of the limitations of the model when describing or predicting phenomena.
5. Developing a Model: Students develop a model (e.g., conceptual, physical) for a phenomenon or scientific theory that includes of the attributes above.

**Planning and Carrying Out Investigations**

1. Identifying the phenomenon to be investigated
   1. Students describe the phenomenon under investigation, question to be answered, or design solution to be tested.
2. Identifying the evidence to answer this question
   1. Students describe:
      1. The evidence from data to be collected.
      2. How the evidence will be relevant to the purpose of the investigation.
3. Planning for the investigation
   1. Students develop an investigation plan that details how the data will be indicated, collected, and/or measured, including the variables to be tested or controlled.
   2. Students indicate whether the investigation will be conducted individually or collaboratively
   3. When given an investigation plan, students identify how:
      1. The data will be collected
      2. The methods are relevant to the purpose of the investigation
4. Collecting the data
   1. Students perform the investigation, collecting and recording data systematically.

**Analyzing and Interpreting Data**

1. Organizing Data
2. Students organize data to represent phenomena and to facilitate finding patterns and relationships.
3. Students clearly describe what each data set represents.
4. Identifying Relationships
5. Students analyze data using simple quantitative and statistical analyses, and describe observations that show patterns between variables in the data
6. Interpreting Data
7. Students interpret patterns in the data and use them to describe and/or predict phenomena.

**Using Mathematical and Computational Thinking**

1. Using Given Mathematical or Computational Representations: Using either developed or given mathematical or computational representations to do the following:
2. Representation
   1. Student identify the problem, explanation, argument, or conclusion that they are mathematically supporting or refuting, and use appropriate mathematical or computational tools.
   2. Students clearly define the system that is represented mathematically
   3. Students clearly define each object or quantity in the system that is represented mathematically, using appropriate units
3. Mathematical or Computational Relationships
   1. Students use mathematical or computational representations (e.g., equations, graphs, spreadsheets, computer simulations) to depict and describe the relationships between system components.
4. Analysis
   1. Students analyze the mathematical representations and use them to support claims, and connect them to or use them to predict phenomena.
5. Developing Mathematical or Computational Representations: Students develop mathematical or computational representations with all of the attributes above.

**Constructing Explanations and Designing Solutions**

1. Constructing Explanations
2. Explanation
   1. Students clearly explain a phenomenon, including a grade-appropriate level of the mechanism involved.
3. Evidence to construct or support the explanation
   1. Students cite evidence to support the explanation. The evidence can come from student-generated data or from other sources, such as observations, reading material, or archived data. The evidence needs to be both appropriate and sufficient to support the explanation.
4. Reasoning to connect the evidence to construct or support the explanation
   1. Students describe the reasoning that connects the evidence to phenomena, including scientific background knowledge, scientific theories, or models as appropriate.
5. Designing Solutions
   * + 1. Using scientific knowledge to generate the design solution
6. Given a problem to solve, students design a solution to the problem. In the design, students:
   1. Identify the scientific information (e.g., principles, theories, evidence) that is related to the problem.
   2. Describe a solution(s) to the problem.
   3. Specify how the design solution(s) uses the scientific information to address the problem.
      * 1. Describing criteria and constraints, including quantification when appropriate
7. Students describe the criteria and constraints for the problem, based on the factors presented in the problem and any resource considerations.
8. Students describe the rationale for which criteria should be given highest priority, if tradeoffs must be made.
   * + 1. Evaluating potential solutions
9. Students evaluate the design solution(s) systematically by analyzing how the solution meets each criterion and constraint described.
   * + 1. Refining the design solution
10. Students modify the solution(s) based on the results from the evaluation.

**Engaging in Argument from Evidence**

* + - 1. Constructing Arguments or Design Solutions

1. Identifying the claims or design solutions

1. Students identify the claims or design solutions to be evaluated, supported, or refuted with argumentation.
2. Identifying scientific evidence:
   1. Students identify and describe scientific evidence (e.g., from data, models, simulations, scientific literature) that is relevant to supporting, refuting, or evaluating claims about the particular phenomenon or engineering design problem.
3. Evaluating and critiquing evidence and alternative interpretations of the evidence: identification of the strength of the evidence used to support an argument for or against a claim or a particular design solution, including an analysis of why the evidence supports the claim rather than any alternative claims that may arise from considering parts or all of the evidence.
4. Students assess the validity, reliability, strengths, and weaknesses of the chosen evidence.
5. Students evaluate whether the evidence supports logical and reasonable arguments about the claims, explanations, or design solutions.
6. Students critique explanations, models, arguments, and questions by citing relevant evidence.
7. Students consider alternative interpretations of facts and evidence in context (e.g., different claims that are based on similar evidence or subsets of the given evidence), and describe why the evidence supports the current claim as opposed to other interpretations or claims.
   * + 1. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
   1. Students use reasoning to synthesize the evidence logically and make explicit connections to known scientific theories or models.
   2. Students develop an argument that explicitly supports or refutes the given claim, explanation, or design solution using the evidence and known scientific information.
   3. Students construct oral and written arguments in support of or refuting claims.
8. Evaluating given design solutions.
   * + 1. Identifying the given solutions and information about the problem.
9. Students clearly identify:
   1. The given solutions, including their relevant features.
   2. The problem, including any specific relevant information.
10. Identifying any potential additional evidence that is relevant to the evaluation
11. Students identify and describe evidence, scientific theories, or models, including necessary information that students obtain from the given materials, prior knowledge, and through additional research, that is relevant to the evaluation.
12. Evaluating and critiquing
13. Students use a systematic method to identify the strengths and weakness of the solution(s).
14. Students evaluate the solution(s) against each criterion and constraint
15. Students use the evidence to assess the given features of the solution.
16. Students evaluate the logic of the given reasoning.
17. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
18. Students use reasoning to make a claim about the effectiveness (or relative effectiveness, when appropriate) of the solution(s) based on the strengths and weaknesses of the solution(s).

**Obtaining, Evaluating, and Communicating Information**

1. Obtaining information
   1. Students gather information from published material appropriate to the grade level from at least two sources (e.g., text, media, visual displays, data)
   2. Students synthesize information presented in various modes (e.g., graphs, diagrams, photographs, text, mathematical, verbal) to describe a phenomenon.
2. Evaluating information
   1. Students assess the credibility, accuracy, and possible bias of each source of information, including publications and methods used to generate and collect the evidence.
   2. Students analyze the information to determine its meaning and relevance to phenomena.
3. Communicating information
4. Communication Style and Format
   1. Students communicate information using at least two different formats (e.g., orally, graphically, textually, and mathematically).
   2. Students use communication that is clear and effective with the intended audience(s).
5. Connecting the Disciplinary Core Ideas (DCIs) and the Crosscutting Concepts (CCC)
   1. Students’ communication include clear connections between the targeted DCIs and the targeted CCCs in the context of a specific question, phenomenon, problem, or solution.

**High School**

*General observable features of the practices by the end of 12th grade.*

**Asking Questions and Defining Problems**

1. Asking questions
   1. Addressing phenomena or scientific theories
      1. Students formulate specific questions based on examining models, phenomena, or theories.
      2. Students’ questions could generate answers that would clarify the relationships between components in a system.
   2. Empirical testability
      1. Students’ questions are empirically testable by scientists.
2. Evaluating questions
   1. Addressing phenomena or scientific theories
      1. Students evaluate questions in terms of whether or not answers to the questions would provide relevant information about the targeted phenomenon in a given context.
   2. Evaluating empirical testability
      1. Students’ evaluations of the questions include a description of whether or not answers to the questions would be empirically testable by scientists.
3. Defining problems
   1. Identifying the problem to be solved
      1. Students’ analyses include:
         1. A description of the challenge with a rationale for why it is a major global challenge;
         2. A qualitative and quantitative description of the extent and depth of the problem and its major consequences to society and/or the natural world on both global and local scales if it remains unsolved; and
         3. Documented background research on the problem from two or more sources, including research journals.
   2. Defining the process or system boundaries, and the components of the process or system
      1. Students’ analyses include identification of the physical system in which the problem is embedded, including the major elements and relationships in the system and boundaries so as to clarify what is and is not part of the problem.
      2. Students’ analyses include a description of societal needs and wants that are relative to the problem (e.g., for controlling CO2 emissions, societal needs include the need for cheap energy).
   3. Defining the criteria and constraints
      1. Students specify the qualitative and quantitative criteria and constraints for acceptable solutions to the problem.

**Developing and Using Models**

1. Using either a developed or given model to do the following:
   1. Components of the model
      1. Students define and clearly label all of the essential variables or factors (components) within the system being modeled.
      2. When appropriate, students describe the boundaries and limitations of the model.
   2. Relationships
      1. Students describe the relationships among the components of the model.
   3. Connections
      1. Students connect the model to causal phenomena or scientific theories that students then describe or predict, using logical reasoning.
2. Developing a Model: Students develop a model with all of the attributes above

**Planning and Carrying Out Investigations**

* 1. Identifying the phenomenon to be investigated
     1. Students describe the phenomenon under investigation, question to be answered, or design solution to be tested.
  2. Identifying the evidence to answer this question
     1. Students develop a plan for the investigation that includes a description of the evidence to be collected.
     2. Students describe how the evidence will be relevant to determining the answer.
  3. Planning for the investigation
     1. Students include in the investigation plan a means to indicate, collect, or measure the data, including the variables to be tested or controlled.
     2. Students indicate whether the investigation will be conducted individually or collaboratively.
  4. Collecting the data
     1. Students perform the investigation, collecting and recording data systematically.
  5. Refining the design
     1. Students evaluate the accuracy and precision of the data collected.
     2. Students evaluate the ability of the data to be used to answer the question.
     3. If necessary, students refine the investigation plan to produce more accurate and precise data.

**Analyzing and Interpreting Data**

1. Organizing data

* + 1. Students organize data to represent phenomena.
    2. Students clearly describe what each data set represents.

2. Identifying relationships

a. Students analyze data using appropriate tools, technologies, and/or models and describe observations that show a relationship between quantities in the data.

3. Interpreting data

* + 1. Students interpret patterns in the data and use them to describe and/or predict phenomena.
    2. Students include a statement regarding how variation or uncertainty in the data (e.g., limitations; accuracy; any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data.

**Using Mathematical and Computational Thinking**

1. Using Given Mathematical or Computational Representations: Using either developed or given mathematical or computational representations to do the following:
   1. Representation
      1. Students clearly define the system that is represented mathematically.
      2. Students clearly define each object or quantity in the system that is represented mathematically, using appropriate units.
      3. Students identify the mathematical claim.
   2. Mathematical or computational modeling
      1. Students use mathematical or computational representations (e.g., equations, graphs, spreadsheets, computer simulations) to depict and describe the relationships between system components.
   3. Analysis
      1. Students analyze the mathematical representations, use them to support claims, and connect them to phenomena or use them to predict phenomena.
2. Developing Mathematical or Computational Representations: Students develop mathematical or computational representations with all of the attributes above

**Constructing Explanations and Designing Solutions**

1. Constructing explanations
   1. Articulating the explanation of phenomena
      1. Students clearly articulate the explanation of a phenomenon, including a grade appropriate level of the mechanism involved.
   2. Evidence
      1. Students cite evidence to support the explanation. The evidence can come from observations, reading material, or archived data. The evidence needs to be both appropriate and sufficient to support the explanation.

* 1. Reasoning
     1. Students describe the reasoning that connects the evidence to phenomena, tying in scientific background knowledge, scientific theories, or models.
  2. Revising the explanation (as necessary)
     1. Given new evidence or context, students construct a revised or expanded explanation.

1. Designing solutions
   1. Using scientific knowledge to generate the design solution
      1. Students restate the original complex problem into a set of two or more subproblems.
      2. For at least one of the sub-problems, students propose two or more solutions.
      3. Students describe the scientific rationale for each solution, including choice of materials and structure of the device where appropriate.
      4. If the students propose solutions for more than one sub-problem, they describe how the solutions to the sub-problems are interconnected to solve all or part of the larger problem.
   2. Describing criteria and constraints, including quantification when appropriate
      1. Students describe criteria and constraints for the selected sub-problem(s).
      2. Students describe the rationale for which criteria should be given highest priority if tradeoffs must be made.
   3. Evaluating potential solutions
      1. Students evaluate the solution(s) to a complex real-world problem systematically, including:
         1. Analysis (quantitative where appropriate) of the strengths and weaknesses of the solution with respect to each criterion and constraint, as well as social and cultural acceptability, and environmental impacts;
         2. Consideration of possible barriers to implementing each solution, such as cultural, economic, or other sources of resistance to potential solutions; and
         3. An evidence-based decision of which solution is optimum, based on prioritized criteria, analysis of the strengths and weaknesses (costs and benefits) of each solution, and barriers to be overcome.
   4. Refining and/or optimizing the design solution
      1. Students refine or optimize the solution(s) based on the results from the evaluation.

**Engaging in Argument from Evidence**

1. Constructing arguments and evaluating given claims or design solutions
   1. Identifying the given claims or design solutions
      1. Students identify the given claims, explanations, or design solutions to be evaluated, supported, or refuted with argumentation.
   2. Identifying scientific evidence
      1. Students identify multiple lines of scientific evidence that is relevant to a particular scientific question or engineering design problem.
   3. Evaluating and critiquing evidence: identification of the strength of the evidence used to support an argument for or against a claim or a particular design solution
      1. Students assess the validity, reliability, strengths, and weaknesses of the chosen evidence along with its ability to support logical and reasonable arguments about the claims, explanations, or design solutions.
   4. Reasoning/synthesis: synthesizing the evidence logically and connecting to phenomena
      1. Students synthesize the evidence logically and make explicit connections to known scientific theories or models.
      2. Students develop an argument that explicitly supports or refutes the given claim, explanation, or design solution using the evidence and known scientific information.
2. Evaluating given evidence and/or reasoning
   1. Identifying the given claims and associated evidence and/or reasoning
      1. Students clearly identify the given claims or explanations.
      2. Students clearly identify the given evidence that supports or refutes the given claims or explanations.
      3. Student clearly identify the given reasoning that supports or refutes the given claims or explanations.
   2. Identifying any potential additional evidence that is relevant to the evaluation
      1. Students identify additional evidence, scientific theories, or models that were not given to the student.
   3. Evaluating and critiquing
      1. Students use the additional (not given) evidence to assess the validity and reliability of the given evidence along with the ability of the given evidence to support or refute the claims or explanations.
      2. Students evaluate the logic of the given reasoning.

**Obtaining, Evaluating, and Communicating Information** I. Obtaining information

* 1. Students obtain information from published material appropriate to the grade level.
  2. Students compare and coordinate information presented in various modes (e.g., graphs, diagrams, photographs, text, mathematical, verbal).

1. Evaluating information
   1. Students analyze the validity and reliability of each source of information, comparing and contrasting the information from various sources.
   2. Students analyze the information to determine its meaning and relevance to phenomena.
2. Communicating information
   1. Communication style and format
      1. Students communicate information using at least two different formats (e.g., oral, graphical, textual, mathematical).
      2. Students use communication that is clear and effective with the intended audience(s).
   2. Connecting the Disciplinary Core Ideas (DCIs) and the Crosscutting Concepts (CCC)
      1. Students’ communication includes clear connections between the targeted DCIs and the targeted CCCs in the context of a specific question, phenomenon, problem, or solution.