Grades K-2

General observable features of the practices by the end of 2nd grade:

Asking Questions and Defining Problems

I. Asking Questions
  1. Addressing Phenomena
     a. Students ask simple descriptive questions based on observations to find out more information about the natural and designed world.
  2. Identifying the Scientific Nature of the Question
     a. Students ask questions that can be investigated within the scope of the classroom.

II. Defining Problems
  1. Identifying the problem to be solved
     a. Students describe:
        i. 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.
        ii. Relevant scientific ideas for the problem and solution.
  2. Defining the features of the design
     a. With appropriate guidance, students describe the desirable features and limits for an acceptable solution to the problem.

Developing and Using Models

I. Using a Model: Using either a developed or given model to do the following:
  1. Components of the model
     a. Students identify and describe the relevant features or factors (components) for the concrete phenomenon, amounts, relationships, scales, proposed object, and/or patterns being represented.
     b. Students represent actual objects, processes, and/or events as models, and distinguish between the two (i.e., between the concrete event being modeled and the model itself).
  2. Relationships
     a. Students describe how components of the model relate and/or interact with each other.
  3. Connections
     a. Students describe how the components and relationships relate to the concrete phenomenon or problem being represented.
     b. Students distinguish between a model and the actual phenomenon, object, process, and/or event being modeled.

II. 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
     a. Students describe the phenomenon under investigation, question to be answered, or design solution to be tested.
  2. Identifying the evidence to answer this question
     a. Students collaboratively develop an investigation plan and describe the evidence to be collected.
     b. Students individually describe that the evidence will be relevant to the purpose of the investigation.
  3. Planning for the investigation
     a. Students collaboratively develop a grade-appropriate investigation plan that details how the

data will be indicated, collected, and/or measured, including number of trials.
   b. Students individually describe how the methods are relevant to the purpose of the investigation.
   c. When given an investigation plan, students individually identify how:
      i. The data/evidence will be collected
      ii. The methods are relevant to the purpose of the investigation
4. Collecting the data
   a. Students collaboratively perform the investigation, collecting and recording data systematically.

Analyzing and Interpreting Data

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

Using Mathematics and Computational Thinking

I. Using Given Mathematical or Computational Representations: Using either developed or given mathematical or computational representations to do the following:
   1. Representation
      a. Students decide when to use qualitative vs. quantitative representations.
      b. Students describe, count, and measure quantities.
      c. Students represent relevant quantities using simple graphs.
   2. Mathematical or Computational Modeling and Analysis
      a. Students use simple mathematical or computational representations to:
         i. Describe observable relationships and patterns.
         ii. Address scientific questions, phenomenon, and design solutions.
         iii. Compare solutions to a problem.

Constructing Explanations and Designing Solutions

I. Constructing Explanations
   1. Articulating the explanation for the phenomenon
      a. Students articulate a statement that relates the given phenomenon to a science idea.
      b. Students use grade-appropriate evidence and reasoning to construct evidence-based accounts of phenomena based on observations.
   2. Evidence
      a. Students make observations (first-hand and/or from media) to provide evidence for phenomena.
      b. Students distinguish between evidence and opinions in the explanations they construct.
   3. Reasoning
      a. Students use logical and grade-appropriate reasoning to connect the evidence to construct the explanation of phenomena.
II. Designing Solutions
   1. Using scientific knowledge to generate the design solution
      a. Given a problem to solve, students collaboratively design a solution(s) to the problem. In the design, students:

i. Identify the scientific information (e.g., observations, scientific knowledge, evidence) that is related to the problem.
ii. Describe a solution(s) to the problem.
iii. Specify how the design solution uses the scientific information to address the problem.

2. Describing expected features of the design
    a. Students describe the desired features and limits for the solution, based on the factors presented in the problem.
    b. Students design a solution that is intended to meet the expected features.
3. Evaluating potential solutions
    a. Students evaluate the design solution(s) by assessing whether the solution meets each feature described.
    b. When appropriate, students compare design solutions to each other based on how well they meet the described features.

Engaging in Argument from Evidence

I. Constructing Arguments about Natural Phenomena or Evaluating Design Solutions
  1. Identifying the claims or design solutions
      a. Students make claims about phenomena to be supported with argumentation.
      b. Students make claims about the effectiveness of design solutions.
      c. Students identify supported arguments.
  2. Identifying scientific evidence:
      a. Students describe given scientific evidence that are relevant to supporting claims about the particular phenomenon or design problem.
  3. Evaluating and critiquing evidence
      a. Students evaluate whether the evidence supports the claims.
      b. Students distinguish between opinions and evidence.
      c. Students describe whether additional evidence is needed.
  4. Reasoning and Synthesis
      a. Students use reasoning to connect the evidence and evaluation logically to construct arguments.

Obtaining, Evaluating, and Communicating Information

I. Obtaining information
  1. Students gather scientific and/or technical information from grade-appropriate books, texts, text features, and other reliable media.
  2. Students record observations, thoughts, and ideas about natural phenomena, problems, and design solutions
  3. Students obtain information to answer scientific questions, and to describe scientific and engineering ideas.

II. Evaluating information
  1. Students describe how specific sources of information describe ideas from science and engineering, including how those sources can support one another to help explain an idea, problem, or solution.

III. Communicating information
  1. Communication Style and Format
      a. Students critique and/or communicate information orally and in written formats, including models, drawing, writing, or numbers.
      b. Students use communication that is clear and effective.
  2. Connecting the Disciplinary Core Ideas (DCIs) and the Crosscutting Concepts (CCC)
      a. 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

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

Asking Questions and Defining Problems

I. Asking Questions
   1. Addressing Phenomena or Scientific Theories
      a. Students ask questions that clarify qualitative relationships between features or factors. Students ask questions that allow them to:
         i. Identify and clarify what happens when something changes within the system being examined.
         ii. Predict reasonable outcomes based on observable patterns (e.g., cause and effect).
   2. Identifying the Scientific Nature of the Question
      a. Students distinguish between scientific (testable) and non-scientific (non-testable) questions.
      b. Students ask questions that can be investigated within the scope of the classroom or outdoor environment.

II. Defining Problems
   1. Identifying the problem to be solved
      a. Students identify:
         i. A simple problem that could be solved through the development of a new or improved object, tool, process, or system.
         ii. Relevant scientific ideas for the problem and solution.
   2. Defining the boundaries of the system
      a. Students define the limits within which the problem will be addressed.
   3. Defining the criteria and constraints
      a. Students identify several criteria (desirable features) for an acceptable solution to the problem.
      b. Students identify the constraints (limits) for acceptable solutions to the problem, which may include:
         i. Time
         ii. Cost
         iii. Materials

Developing and Using Models

I. Using a Model: Using either a developed or given model to do the following:
   1. Components of the model
      a. Students identify and describe the relevant variables or factors (components) for the phenomenon being modeled.
      b. When appropriate, students identify the limitations of the model.
   2. Relationships
      a. Students describe how components of the model relate and/or interact with each other.
   3. Connections
      a. Students use reasoning to connect the components and relationships within the model to real-world phenomena or scientific theories.
      b. Students use the model to describe and/or make predictions about phenomena.

II. 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
    a. Students describe the phenomenon under investigation, question to be answered, or design solution to be tested.
2. Identifying the evidence to answer this question
    a. Students collaboratively develop an investigation plan and describe the evidence from qualitative and quantitative data to be collected.
    b. Students individually describe how the evidence will be relevant to the purpose of the investigation.
3. Planning for the investigation
    a. Students develop an investigation plan that details how the data will be indicated, collected, and/or measured, including number of trials.
    b. 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.
    c. Students individually evaluate and describe how the methods of the investigation are relevant to the purpose of the investigation.
    d. When given an investigation plan, students identify how:
        i. The data will be collected
        ii. The methods are relevant to the purpose of the investigation
4. Collecting the data
    a. Students collaboratively perform the investigation, collecting and recording data systematically.

Analyzing and Interpreting Data

1. Organizing Data
    a. Students use graphical or visual displays (e.g., tables, charts, graphs) to organize quantitative and qualitative data from multiple trials to indicate relationships.
2. Identifying Relationships
    a. 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.
3. Interpreting Data
    a. Students use logical reasoning to interpret patterns in the data to describe phenomena and refine or evaluate design solutions.

Using Mathematical and Computational Thinking

I. Using Given Mathematical or Computational Representations: Using either developed or given mathematical or computational representations to do the following:

1. Representation
    a. Students measure and estimate relevant quantities of physical properties (e.g., area, volume, weight, time).
    b. Students mathematically represent relevant quantities using standard and appropriate units.
    c. Students create and/or use appropriate graphs and charts to facilitate data interpretation and analysis.
2. Mathematical or Computational Modeling and Analysis
    a. Students use simple mathematical or computational representations to:
        i. Describe observable relationships and patterns.
        ii. Address scientific questions, phenomenon, and design solutions.

II. Developing Mathematical or Computational Representations: Students develop simple mathematical or computational representations with all of the attributes above.

Constructing Explanations and Designing Solutions

I. Constructing Explanations
   1. Articulating the Explanation for the Phenomenon
      a. Students articulate a statement that relates a phenomenon to a scientific idea, including a grade-appropriate level of the mechanism involved.
      b. When the explanation is given, students identify the explanation and any particular points that will be supported with evidence.
   2. Evidence to construct or support the explanation
      a. Students identify the relevant evidence to support the explanation. Students use evidence that specifies variables that describe and predict phenomena.
   3. Reasoning to connect the evidence to construct or support the explanation
      a. Students use reasoning to connect the evidence in order to construct the explanation of phenomena.
      b. When given the explanation and evidence, students use reasoning to describe which evidence specifically supports particular points within an explanation.

II. Designing Solutions
   1. Using scientific knowledge to generate the design solution
      a. Given a problem to solve, students collaboratively design a solution to the problem. In the design, students:
         i. Identify the scientific information (e.g., principles, theories, evidence) that is related to the problem.
         ii. Describe a solution to the problem.
         iii. Specify how the design solution uses the scientific information to address the problem.
   2. Describing criteria and constraints, including quantification when appropriate
      a. 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.
      b. Students design a solution that is intended to meet the criteria and constraints.
   3. Evaluating potential solutions
      a. Students evaluate the design solution(s) systematically by analyzing whether the solution meets each criterion and constraint described.
      b. When appropriate, students compare design solutions to each other based on how well they meet the criteria and constraints described.

Engaging in Argument from Evidence

I. Constructing Arguments about Natural Phenomena and Evaluating Design Solutions
   1. Identifying the claims or design solutions
      a. Students make claims about phenomena or solutions to problems that are supported by evidence.
      b. Students identify given claims, explanations, or design solutions to be evaluated, supported, or refuted with argumentation.
      c. Students make claims about the merits of design solutions.
   2. Identifying scientific evidence:
      a. Students identify and describe scientific evidence, models, and/or data that are relevant to supporting or evaluating claims about the particular phenomenon or design problem.
   3. Evaluating and critiquing evidence
      a. Students evaluate whether the evidence supports logical and reasonable arguments about the claims, explanations, or design solutions.
      b. Students evaluate whether other explanations or factors of the explanation could be supported by the evidence.
      c. Students distinguish among facts, reasoned arguments based on evidence, and speculation.
   4. Reasoning and Synthesis

a. Students use reasoning to connect the evidence and evaluation logically to construct arguments.
b. When appropriate, students compare and refine arguments based on the strengths and weaknesses of the evidence
c.

II. Evaluating given design solutions.
1. Identifying the given solutions and information about the problem.
a. Students clearly identify:
i. The given solutions, including their relevant features.
ii. The problem, including any specific relevant information.
2. Identifying any potential additional evidence that is relevant to the evaluation
a. 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.
3. Evaluating and critiquing
a. Students use a systematic method to identify the strengths and weakness of the solution(s).
b. Students evaluate the solution(s) against each criterion and constraint
c. Students use the evidence to assess the given features of the solution.
4. Reasoning/Synthesis
a. 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

I. 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, complex text, mathematical, verbal) to describe a phenomenon.

II. 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. Students determine the main idea of a scientific information source (e.g., text, images, combinations of media) and describe how it is supported by details within the source.

III. Communicating information
3. Communication Style and Format
a. Students communicate information orally (e.g., presentations, discussions) and in written formats, including various forms of media as well as tables, diagrams, models, and charts.
b. Students use multiple modes of communication together to support a cohesive communication of ideas.
c. Students use communication that is clear and effective.
4. Connecting the Disciplinary Core Ideas (DCIs) and the Crosscutting Concepts (CCC)
a. 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 6-8

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

Asking Questions and Defining Problems

I. Asking Questions
  1. Addressing Phenomena or Scientific Theories
     a. Students ask questions based on carefully observing models, phenomena, arguments, and evidence, including unexpected results. Students ask questions that:
        i. Identify and clarify claims and evidence of an explanation or argument.
        ii. Challenge the premise of arguments and the interpretation of data.
        iii. Clarify and refine models, explanations, and problems.
        iv. Determine relationships between:
           1. Independent and dependent variables
           2. Components of models
  2. Empirical testability
     a. Students ask questions that:
        a. Require empirical evidence to answer.
        b. Can be investigated within the scope of the classroom, outdoor environment, and other publicly accessible venues with available resources.
     b. Based on their questions, students frame hypotheses that can be addressed empirically.

II. Defining Problems
  2. Identifying the problem to be solved
     a. Students describe:
        i. A simple problem that could be solved through the development of an object, tool, process, or system.
        ii. The major consequences to people and/or the natural world if the identified problem remains unsolved
  3. Defining the process or system boundaries, and the components of the process or system
     a. 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:
        i. Which individuals or groups need the problem solved
        ii. The needs that must be met by the design solution
        iii. Scientific issues that are relevant to the problem
        iv. Potential societal and environmental impacts of solutions
        v. Relative importance of the various issues and components of the process or system.
  4. Defining the criteria and constraints
     a. Students specify the qualitative and quantitative criteria and constraints for acceptable solutions to the problem.

Developing and Using Models

I. Using a Model: Using either a developed or given model to do the following:
  1. Components of the model
     a. Students identify and describe all of the essential variables or factors (components) for the phenomenon being modeled.
     b. When appropriate, students describe the limitations of the model.
  2. Relationships
     a. Students describe how components of the model relate to and/or interact with each other within the system being modeled.
  3. Connections
     a. Students use reasoning to connect the components and relationships within the model to real-world phenomena or scientific theories.

b. Students use the model to describe and/or make predictions about phenomena.
c. Students use their understanding of the limitations of the model when describing or predicting phenomena.

II. 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
    a. Students describe the phenomenon under investigation, question to be answered, or design solution to be tested.
2. Identifying the evidence to answer this question
    a. Students describe:
        i. The evidence from data to be collected.
        ii. How the evidence will be relevant to the purpose of the investigation.
3. Planning for the investigation
    a. 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.
    b. Students indicate whether the investigation will be conducted individually or collaboratively
    c. When given an investigation plan, students identify how:
        i. The data will be collected
        ii. The methods are relevant to the purpose of the investigation
4. Collecting the data
    a. Students perform the investigation, collecting and recording data systematically.

Analyzing and Interpreting Data

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

Using Mathematical and Computational Thinking

I. Using Given Mathematical or Computational Representations: Using either developed or given mathematical or computational representations to do the following:

1. Representation
    a. Student identify the problem, explanation, argument, or conclusion that they are mathematically supporting or refuting, and use appropriate mathematical or computational tools.
    b. Students clearly define the system that is represented mathematically
    c. Students clearly define each object or quantity in the system that is represented mathematically, using appropriate units
2. Mathematical or Computational Relationships
    b. Students use mathematical or computational representations (e.g., equations, graphs, spreadsheets, computer simulations) to depict and describe the relationships between system components.

3. Analysis
    a. Students analyze the mathematical representations and use them to support claims, and connect them to or use them to predict phenomena.

II. Developing Mathematical or Computational Representations: Students develop mathematical or computational representations with all of the attributes above.

Constructing Explanations and Designing Solutions

I. Constructing Explanations
1. Explanation
    a. Students clearly explain a phenomenon, including a grade-appropriate level of the mechanism involved.
2. Evidence to construct or support the explanation
    a. 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.
3. Reasoning to connect the evidence to construct or support the explanation
    a. Students describe the reasoning that connects the evidence to phenomena, including scientific background knowledge, scientific theories, or models as appropriate.

II. Designing Solutions
1. Using scientific knowledge to generate the design solution
    a. Given a problem to solve, students design a solution to the problem. In the design, students:
        a. Identify the scientific information (e.g., principles, theories, evidence) that is related to the problem.
        b. Describe a solution(s) to the problem.
        c. Specify how the design solution(s) uses the scientific information to address the problem.
2. Describing criteria and constraints, including quantification when appropriate
    a. Students describe the criteria and constraints for the problem, based on the factors presented in the problem and any resource considerations.
    b. Students describe the rationale for which criteria should be given highest priority, if tradeoffs must be made.
3. Evaluating potential solutions
    a. Students evaluate the design solution(s) systematically by analyzing how the solution meets each criterion and constraint described.
4. Refining the design solution
    a. Students modify the solution(s) based on the results from the evaluation.

Engaging in Argument from Evidence

I. Constructing Arguments or Design Solutions
1. Identifying the claims or design solutions
    a. Students identify the claims or design solutions to be evaluated, supported, or refuted with argumentation.
2. Identifying scientific evidence:
    a. 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.
    a. Students assess the validity, reliability, strengths, and weaknesses of the chosen evidence.

b. Students evaluate whether the evidence supports logical and reasonable arguments about the claims, explanations, or design solutions.
c. Students critique explanations, models, arguments, and questions by citing relevant evidence.
d. 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.

4. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
   a. Students use reasoning to synthesize the evidence logically and make explicit connections to known scientific theories or models.
   b. Students develop an argument that explicitly supports or refutes the given claim, explanation, or design solution using the evidence and known scientific information.
   c. Students construct oral and written arguments in support of or refuting claims.

II. Evaluating given design solutions.
   1. Identifying the given solutions and information about the problem.
      a. Students clearly identify:
         i. The given solutions, including their relevant features.
         ii. The problem, including any specific relevant information.
   2. Identifying any potential additional evidence that is relevant to the evaluation
      a. 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.
   3. Evaluating and critiquing
      a. Students use a systematic method to identify the strengths and weakness of the solution(s).
      b. Students evaluate the solution(s) against each criterion and constraint
      c. Students use the evidence to assess the given features of the solution.
      d. Students evaluate the logic of the given reasoning.
   4. Reasoning/Synthesis: synthesizing the evidence logically and connecting to phenomena
      a. 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

I. 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.

II. 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.

III. Communicating information
   1. Communication Style and Format
      a. Students communicate information using at least two different formats (e.g., orally, graphically, textually, and mathematically).
      b. 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)
      a. Students' communication include clear connections between the targeted DCIs and the targeted CCCs in the context of a specific question, phenomenon, problem, or solution.