SOUTH CAROLINA DEPARTMENT OF EDUCATION

Vertical Articulation of Engineering, Technology, and Applications of Science for the *South Carolina College- and Career-Ready Science Standards 2021*

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Purpose and Use

The Engineering, Technology, and Applications of Science (ETS) disciplinary core ideas and instructional focus statements describe how students' understanding of engineering problems develops across grade bands. These progressions outline how concepts build over time, from early observational experiences to more formal, model-based explanations, and identify key conceptual shifts without prescribing instruction, pedagogy, or assessment.

Educators and leaders may use these progressions to support curriculum design, instructional planning, professional learning, and alignment across courses and grade levels. Classroom teachers can use this document to clarify the intended depth and breadth of content learning at their grade level. The instructional focus statements describe conceptual targets and are intended to help teachers confirm grade-level emphasis, identify content intentionally deferred to later grades, and avoid over-teaching beyond course expectations.

Instructional focus statements organized by full grades or courses can be found in Appendix A of the Performance Targets on the **Science Instructional Resources webpage**.

Reading this Resource

This resource uses a consistent structure for the progressions:

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
The grade, course, or content is represented here. This also hyperlinks to the Performance Target.	*The Disciplinary Core Idea statements from the Performance Expectation (PE) cards are replicated in this section. There are hyperlinks to the appropriate card to view the entire PE.*	*The Instructional Focus statements are presented in this section. They include statements appropriate for the grade, course, or content, not required activities. They also include "Knowledge Extended Beyond Course Expectations" as a guardrail for depth and breadth of the content. The extended knowledge statements represent a reasonable extension option for students in that grade, course, or content.*

Conceptual Vertical Articulation of Engineering, Technology, and Applications of Science Overview

Engineering, Technology, and Applications of Science	K	1	2	3	4	5	6	7	8	B1	B2	C	P	ESS
ETS1 – Engineering Design														
ETS1.A Defining and Delimiting an Engineering Problem	●				●		●						●	●
ETS1.B Developing Possible Solutions	●	●	●	●	●	●	●	●	●	●	●		●	●
ETS1.C Optimizing the Design Solution			●	●	●			●				●	●	
ETS2 – Links Among Engineering, Technology, Science, and Society														
ETS2.A Interdependence of Science, Engineering, and Technology	●	●		●	●	●	●	●	●			●	●	●
ETS2.B Influence of Engineering, Technology, and Science on Society		●	●	●	●	●	●	●	●	●	●	●	●	●

ETS1 – Defining and Delimiting an Engineering Problem

ETS1 focuses on how engineering design is used to define problems, develop possible solutions, and optimize those solutions based on evidence and constraints. Across the grade bands, students move from recognizing everyday situations as problems with multiple possible solutions to using systematic processes to design, test, and refine solutions. The ETS1 progression emphasizes using criteria and constraints to guide decision-making, comparing and improving designs through iteration, and applying disciplinary knowledge to evaluate tradeoffs and optimize solutions. Through this progression, students develop increasingly sophisticated ways to define problems clearly, communicate and test ideas, and justify design decisions as they work toward solutions that are effective, feasible, and responsive to real-world needs and impacts.

ETS1.A Defining and Delimiting an Engineering Problem

Students begin by recognizing that situations people want to change or create can be understood as problems to be solved and that such problems may have more than one acceptable solution. In upper elementary grades, students define engineering problems by identifying criteria for success and constraints such as materials, time, cost, and safety, and compare possible solutions based on how well they meet these requirements. In middle school, students specify criteria and constraints with greater precision, including measurable targets and limitations grounded in scientific principles, and analyze how these factors narrow the range of feasible solutions and introduce tradeoffs. In high school, students define problems in terms of competing priorities, including cost, safety, and environmental and social impacts, and apply disciplinary knowledge to explain how criteria, constraints, and tradeoffs shape and limit possible solutions in local and global contexts.

Progression of ETS1.A

Grade or Content	Disciplinary Core Idea Statement with the Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Kindergarten	• A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (**K-PS2-2**) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (**K-ESS3-2**)(**K-ESS3-3**)	• Recognize a classroom situation people want to change as an engineering problem with more than one acceptable solution. • Classify information from observations as "needs" or "wants" for the problem. • Explain, using age-appropriate academic language, what the solution should do, not how to build it. *Knowledge Extended Beyond Course Expectations* • Name a real-world problem that could be solved in more than one way. • Identify one way two different simple solutions meet the same need.
Fourth Grade	• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary) (**4-PS3-4**)	• Identify criteria as desired features and constraints as limits (materials, time, cost, safety) for a defined classroom problem. • Compare solution ideas by matching features to the stated criteria and identify any constraint that is not met. • Explain which solution best addresses the most important criterion qualitatively. *Knowledge Extended Beyond Course Expectations* • Recognize a trade-off and state which priority should guide the choice. • Identify one constraint that most strongly limits choices for this problem and explain why.

Grade or Content	Disciplinary Core Idea Statement with the Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Sixth Grade	• 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 is likely to limit possible solutions. (**6-PS3-3**)	• Specify precise criteria and constraints, including materials, time, cost, safety, and relevant scientific limits. • Classify success measures and constraints as qualitative or quantitative and set clear targets. • Explain how core ideas (for example energy transfer, material properties) inform the solution. • Analyze how the stated constraints narrow possible solutions. • Recognize typical trade-offs (for example insulation vs. mass vs. cost) and name which factor most limits the design. *Knowledge Extended Beyond Course Expectations* • Identify one success measure that should lead the decision and explain.
Physics	• Criteria may include satisfying cost, safety, reliability, aesthetics requirements and taking into account constraints regarding social, cultural, and environmental impacts. (**P-PS2-3**) (**P-PS3-3**)	• Specify criteria, including cost, safety, reliability, and aesthetics, and constraints, including social, cultural, and environmental impacts. • Compare competing priorities and state the trade-offs that must be accepted. • Recognize that improving one target (for example lower peak force) can reduce another (for example cost or mass) and state the priority used. • Explain how impulse–momentum or energy-conversion ideas inform which criteria and constraints matter most. *Knowledge Extended Beyond Course Expectations* • Identify a stakeholder constraint that most informs the solution and explain why.

Grade or Content	Disciplinary Core Idea Statement with the Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Earth and Space Science	• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (**E-ESS3-2**)	• Classify an Earth-resource challenge as community level or global. • Specify the criteria to be met and the constraints to honor (cost, time, safety; social, cultural, environmental effects). • Explain how relevant Earth-system understanding (resource availability, extraction or land-use impacts, renewable vs. non-renewable limits) informs the solution. • Analyze the trade-offs among options, including cost-benefit ratios. *Knowledge Extended Beyond Course Expectations* • None identified.

ETS1.B Developing Possible Solutions

Students begin by representing solution ideas using sketches, drawings, and physical models to communicate what a design will do. In upper elementary grades, students organize designs into parts, explain how each part contributes to the solution, and evaluate possible solutions by comparing how well they meet criteria and constraints and how they perform across a range of conditions. In middle school, students use systematic processes to test and compare solutions, analyze patterns in performance across conditions, and iteratively modify designs based on evidence, prioritizing features that perform consistently and making tradeoff-based decisions. In high school, students apply disciplinary knowledge and use physical and computational models to evaluate and refine designs, combining successful features from different solutions, justifying choices based on how well they optimize performance, and recognizing that multiple acceptable solutions may exist while accounting for constraints and social, environmental, and economic impacts.

Progression of ETS1.B

Grade, Content, or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Kindergarten	• Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (**K-PS3-2**)	• Represent a solution design with a simple sketch, drawing, or model. • Explain what the representation shows the solution will do. • Recognize a label or part that would help others understand the solution design. *Knowledge Extended Beyond Course Expectations* • Identify one feature in the representation that helps the solution meet the need. • Identify one small change to the representation that would make the solution more clear.

Grade, Content, or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
First Grade	• Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (**1-LS1-1**) To design something complicated, one may need to break the problem into parts and attend to each part separately, then bring the parts together to test the overall solution. (**1-PS4-4**)	• Decompose the problem into smaller parts. • Create a labeled representation that shows parts of the solutions and describes what each part does. • Explain how one part helps the solution work using words from the drawing or model. • Decide which part to improve first to better meet the stated need and give one reason. *Knowledge Extended Beyond Course Expectations* • Recognize when two parts could be combined to make the solution easier to use. • Identify a feature from a peer's design that would make your design clearer or more effective and state why.
Second Grade	• Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (**2-LS2-2**) (**2-ESS3-1**)	• Create a labeled representation that shows the parts of a possible solution and describe what each part does. • Compare two design ideas by matching visible features to the stated need. • Explain why one specific feature better fits the stated need. • Decide which single feature to adjust first to better meet the need without adding new parts and give one simple reason. *Knowledge Extended Beyond Course Expectations* • Recognize a simple trade-off between two features (for example bigger catches more seeds but weighs more) and name which priority should guide the choice. • Identify a feature from a peer's design that would make your design clearer or more effective and state why.

Grade, Content, or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Third Grade	• Testing a solution involves investigating how well it performs under a range of likely conditions. (**3-PS2-4**)	• Create a design solution that can be used to gather evidence about how well it solves a problem. • Describe the likely conditions the solution must handle (for example distance, orientation, material) in the magnet context. • Classify criteria and constraints and match them to the proposed designs. • Explain which design best fits the criteria across the listed conditions using qualitative observations. • Analyze how one changed feature affects performance patterns across conditions. *Knowledge Extended Beyond Course Expectations* • Identify a feature that works well across more conditions and state why it should be kept. • Recognize a basic test grid (for example near vs. far; aligned vs. misaligned) and name the configuration that works best across conditions.
Fourth Grade	• At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (secondary) (**4-PS3-4**) • Testing a solution involves investigating how well it performs under a range of likely conditions. Communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (**4-ESS3-2**)	• Create a design solution that can be used to gather evidence about how well it solves a problem. • Describe the likely conditions the device or solution must handle. • Compare proposed solutions by matching each to the stated criteria and constraints and noting any mismatch. • Explain which feature(s) most support better performance using grade-appropriate evidence. • Evaluate and communicate one targeted change that would strengthen the next version while staying within the same limits. *Knowledge Extended Beyond Course Expectations* • Recognize one peer suggestion that would improve clarity or performance and state why it should be incorporated in the next design. • Identify a simple trade-off (for example sturdier vs. heavier; brighter vs. battery life) and name which priority should lead the choice.

Grade, Content, or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Fifth Grade	• Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (**5-ESS3-1**)	• Create a design solution that can be used to gather evidence about how well it solves a problem. • Identify important information about the stated problem from provided sources and name the specific need the solution must address. • Compare proposed solutions by aligning how each meets the given criteria and constraints across the likely conditions. • Identify which criterion (effectiveness, cost, environmental impact) should take top priority for this problem and explain why. • Explain which solution best fits the high-priority criteria qualitatively. • Evaluate one targeted revision that would improve performance in more than one condition while staying within the constraints. *Knowledge Extended Beyond Course Expectations* • Recognize when two options could be combined and name the single feature from each that should be kept to better fit the criteria.
Sixth Grade	• A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (**6-PS3-3**)	• State the success target and limits for the thermal-transfer device. • Compare outcomes across conditions and classify which features align with better results. • Identify a feature that improves results across more than one condition and state why to keep it. • Explain qualitatively how a material or surface change connects to observed warming or cooling patterns. • Prioritize the best next change based on patterns in the data. *Knowledge Extended Beyond Course Expectations* • Recognize a trade-off among insulation, cost, and durability.

Grade, Content, or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Seventh Grade	• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (7-PS1-6) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary) (7-LS2-5)	• Identify the key conditions and success targets for the thermal-energy device. • Classify features of competing versions by how consistently they align with stronger outcomes across the listed conditions. • Identify which criterion (for example stability of temperature change vs. material cost) should lead the next choice and explain why. • Explain why one feature should be kept or removed using patterns from the data. • Analyze two feasible options and name the trade-off that drives the next revision choice. *Knowledge Extended Beyond Course Expectations* • Recognize when the "best" feature in one condition does not generalize and name a compromise feature that works across multiple conditions.
Eighth Grade	• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (secondary) (8-PS2-1)	• Describe the required conditions and targets for the design to reduce post-collision effects qualitatively. • Compare designs by matching features to the criteria and describe any constraint violations. • Identify one condition where the leading design is weak and state a simple change to broaden usefulness. • Explain which single feature most likely reduces post-collision effects based on pattern evidence in the results. • Analyze whether combining two features would improve outcomes across conditions and name the expected trade-off. *Knowledge Extended Beyond Course Expectations* • Recognize when a hybrid design outperforms individual versions and name the feature pair that drives the improvement.

Grade, Content, or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 1	• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary) (**B-LS2-7**)	• Identify criteria for reducing a biodiversity impact and list the constraints (for example, cost, safety, reliability, and aesthetics, and consider social, cultural, and environmental impacts, etc.). • Compare feasible options by classifying how each meets the prioritized criteria and respects constraints, including social, cultural, and environmental effects. • Identify the single most limiting constraint for this problem and explain how it should inform the next revision choice. • Explain which option best fits the criteria using evidence from biodiversity outcomes. • Analyze how one targeted refinement would improve outcomes and name the trade-off accepted to keep within constraints. *Knowledge Extended Beyond Course Expectations* • Recognize when combining one feature from each of two options would better balance benefits and impacts and name the feature pair to keep.
Biology 2	• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (secondary) (**B-LS4-6**)	• Identify criteria and constraints (for example, cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts, etc.) for the biodiversity problem in clear, measurable terms. • Classify proposed solutions by the features that align with prioritized criteria and by anticipated social, cultural, and environmental effects. • Explain how insight from a physical model or simple computer output supports keeping or dropping one design feature. • Analyze how a small refinement that improves fit to the criteria while acknowledging one trade-off (for example cost, reliability, access). *Knowledge Extended Beyond Course Expectations* • Recognize when a simulation result is sensitive to a single input and state a safe qualitative range for that input. • Identify a case where a physical model insight changes which simulation option should be favored and state the reason.

Grade, Content, or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Physics	• The aim of engineering is to design the best solution under clearly defined constraints and criteria, but there is often no one best solution. (**P-PS2-3**) (**P-PS3-3**) (**P-PS4-2**)	• State the criteria and constraints for the device or system (for example force reduction, efficiency, signal clarity; cost, safety, reliability, materials, environmental considerations). • Compare feasible designs and acknowledge that multiple acceptable designs may exist under the same constraints. • Explain how a specific feature aligns with the relevant physics idea for the stated goal (for example impulse to reduce peak force; loss pathways for efficiency; wave behavior for clarity). • Appraise the trade-offs among features and justify one modification that best aligns with prioritized criteria. • Identify one context where a different priority (for example reliability over peak performance) would change the preferred design and explain why. *Knowledge Extended Beyond Course Expectations* • Recognize when combining features from two designs improves the most important criterion and name the feature pair.
Earth and Space Science	• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Testing should lead to improvements in the design through an iterative procedure. (secondary) (**E-ESS3-2**) (**E-ESS3-4**)	• Identify criteria and constraints for the Earth-resource or impact-mitigation task, including cost, safety, reliability, aesthetics, social/cultural/environmental effects, and environmental stability. • Compare options by classifying benefits and limitations across economic, environmental, and social dimensions for the same need. • Explain which criterion should lead the decision and name one key trade-off that is accepted. • Evaluate a solution refinement that reduces an unintended impact. *Knowledge Extended Beyond Course Expectations* • Recognize when combining specific features from two options improves fit to the local context and name the pair to keep.

ETS1.C Optimizing the Design Solution

Students begin by recognizing that more than one solution can meet a need and that comparing designs can help identify ways to improve performance. In upper elementary grades, students compare how well designs meet criteria under the same conditions, make targeted changes to improve key features, and refine solutions to improve performance across multiple conditions while prioritizing the most important criteria. In middle school, students engage in iterative processes of testing and redesign, analyze patterns across results to identify features that perform well, and combine effective features from different designs to improve overall performance while balancing tradeoffs. In high school, students break down complex criteria into simpler components, compare alternatives using these sub-criteria, and evaluate tradeoffs to justify which solution is best overall, recognizing that optimal solutions depend on prioritized criteria, constraints, and context.

Progression of ETS1.C

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Second Grade	• Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (**2-ESS2-1**)	• Recognize that more than one design can meet the need to reduce changes to the shape of land. • Explain which design better fits the need under the same simple conditions. • Select the most important feature to change to improve land stability without adding new parts. *Knowledge Extended Beyond Course Expectations* • Name a basic trade-off (for example taller barrier resists better but uses more material). • Identify which feature matters most for a new but similar problem and explain why.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Third Grade	• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (**3-LS4-4**) (**3-ESS3-1**)	• Identify the criteria and constraints for the stated problem. • Compare designs by assessing how each meets the criteria across listed conditions. • Explain which design best fits the criteria using qualitative effects on the system. • Recommend one refinement that improves performance in more than one condition. *Knowledge Extended Beyond Course Expectations* • Recognize when a design works only in specific conditions and name a refinement to broaden usefulness. • Identify which criterion should lead the decision and state why.
Fourth Grade	• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (**4-PS4-3**)	• Identify the criteria and constraints for the stated problem. • Compare designs by assessing how each meets the criteria across listed conditions. • Explain which choice best meets the criteria under the same conditions using qualitative evidence. • Evaluate a specific change that improves accuracy without adding new requirements. *Knowledge Extended Beyond Course Expectations* • Name two features to combine and say why the pair improves signal clarity within the constraints. • Identify which single criterion should lead the decision and state why.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Seventh Grade	• 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 the characteristics may be incorporated into the new design. 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. (**7-PS1-6**)	• Describe which criteria matter most for the design task. • Sort strengths and weaknesses by identifying features linked with better outcomes across tests, qualitatively. • Explain why one feature should be carried forward into the next iteration based on evidence. • Analyze how combining two features would improve alignment with prioritized criteria and state the trade-off. *Knowledge Extended Beyond Course Expectations* • Recognize when a feature that excels in one test limits performance elsewhere and name a compromise feature. • Identify which criterion should be prioritized to select among equally performing designs and explain why.
Chemistry	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade- offs) may be needed. (secondary) (**C-PS1-6**) • Determining what constitutes “best,” however, requires value judgments, given that one person’s view of the optimal solution may differ from another’s. (secondary) (**C-PS2-6**)	• Break down broad criteria into simpler checks (for example yield, safety, cost, energy input) to enable clear comparison. • Compare alternatives using those checks and name one necessary trade-off for the choice. • Explain why a single change better aligns with the prioritized criteria under the given constraints. *Knowledge Extended Beyond Course Expectations* • Recognize that “best” depends on chosen priorities and name a context that would change the preferred option. • Identify one simple limitation (for example availability, hazard rating) that would change the selection and explain why.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Physics	• Criteria may need to be broken down into simpler ones that can be approached systematically. Trade-offs among the criteria will need to be analyzed, and certain criteria may need to be prioritized over others. (**P-PS2-3**) (**P-PS3-3**)	• Break down the stated criteria into simpler, checkable components for the same device or system. • Compare design options using those sub-criteria and classify where each option clearly meets, partially meets, or fails the checks. • Explain how one targeted modification (material, geometry, or energy-management feature) better aligns the design with the prioritized sub-criteria. • Evaluate the necessary trade-off among sub-criteria (for example small mass increase for longer impact time to lower peak force) and justify which option is best overall given the stated constraints. *Knowledge Extended Beyond Course Expectations* • Recognize when two partially effective features are complementary and name the pair to combine for a better overall score across the sub-criteria. • Identify the single sub-criterion that should lead the decision in this context (for example safety threshold) and state the reason for that priority.

ETS2 – Links Among Engineering, Technology, Science, and Society

ETS2 addresses the relationships among science, engineering, and technology and how each influences the others and society. Across the grade bands, students move from recognizing how tools and technologies support observations and meet needs to explaining how scientific knowledge, engineering design, and technological systems shape and respond to societal and environmental conditions. The ETS2 progression emphasizes how science, engineering, and technology interact through ongoing cycles of development and improvement, how technological systems influence people and the natural world, and how decisions about technology involve tradeoffs, values, and considerations of impacts across different contexts and over time.

ETS2.A Interdependence of Science, Engineering, and Technology

Students begin by using tools to support observations and measurements and recognizing that different tools provide different types of information for answering questions about the natural world. In upper elementary grades, students select and compare tools based on how well they reveal patterns or improve the clarity of observations and measurements. In middle school, students analyze how advances in technology expand the scope and types of evidence available, enabling new scientific discoveries and improving engineering decisions. In high school, students explain how science, engineering, and technology advance one another within a research and development cycle, using disciplinary knowledge and improved measurement systems to refine ideas, evaluate tradeoffs, and support the continuous improvement of technologies and explanations.

Progression of ETS2.A

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Kindergarten	• There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. (**K-PS3-2**) Observations and measurements are also used in engineering to help test and refine design ideas. (**K-PS2-2**) • People encounter questions about the natural world every day. (**K-ESS3-2**)	• Select a classroom tool that helps obtain/measure clearer information for the stated question. • Sort tools by what kind of information they give for the same question. • Connect how a selected tool makes the observation or measurement more clear than not using a tool. • Justify which tool is the better fit for the question and give one simple reason. *Knowledge Extended Beyond Course Expectations* • Recognize one non-classroom tool (for example smoke detector, thermal camera) and match it to the kind of question it helps answer in the real world. • Identify a real instrument used for sky watching (for example telescope, all-sky camera) and explain the pattern type it helps reveal (position, timing, brightness).
First Grade	• People encounter questions about the natural world every day. There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. Observations and measurements are also used in engineering to help test and refine design ideas. (**1-ESS1-1**)	• Determine which everyday questions about the sky are better addressed with tools than without them. • Classify simple instruments (for example, sundials for shadows, calendars for day and night patterns, and star charts for star patterns, etc.) by the sky pattern each supports observing. • Explain how the chosen instrument makes the sky pattern more clear. • Defend the best-fit instrument for the stated questions about the sky and explain why. *Knowledge Extended Beyond Course Expectations* • Identify a proposed feature that is clearly supported by a classroom generated science idea and contrast it with a feature that is not supported by that idea. • Select which of two everyday observational setups (for example window chart vs. binoculars from the playground) is better suited for the same sky pattern and explain why.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Third Grade	• Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (**3-PS2-4**) • Knowledge of relevant scientific concepts and research findings is important in engineering. (**3-LS4-4**)	• Identify the scientific idea that supports a design feature. • Explain how a design feature reflects or uses a scientific idea. • Compare design features to determine which aligns with a given scientific idea. *Knowledge Extended Beyond Course Expectations* • Recognize that the same scientific idea can support multiple design features.
Fourth Grade	• Knowledge of relevant scientific concepts and research findings is important in engineering. (**4-PS4-3**) (**4-ESS3-1**)	• Identify science concepts that should guide a classroom communication design. • Identify scientific concepts from trusted sources to provide evidence about natural resources. • Compare designs by matching features to scientific ideas. *Knowledge Extended Beyond Course Expectations* • Identify the single pattern feature (brightness, spacing, timing) that is most important for a new but similar classroom message and explain why qualitatively. • Recognize a trade-off between two pattern features (for example brighter vs. farther; tighter spacing vs. easy reading) and state which feature to prioritize.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Fifth Grade	• Tools and instruments (e.g., scales, thermometers, graduated cylinders) are used in scientific exploration to gather data and help answer questions about the natural world. (**5-PS1-2**) (**5-PS1-3**)	• Select the measurement instrument that matches the question about properties of matter (mass, volume, or temperature). • Organize measurements by property to contrast before-and-after changes in states of matter. • Evaluate how better precision or a better fit tool would strengthen the conclusion. *Knowledge Extended Beyond Course Expectations* • Identify a situation where using a more precise tool would likely change the answer and explain how the conclusion would be more confident. • Recognize one everyday constraint (time, cost, availability) that affects tool choice and note the likely impact on the quality of the data.
Sixth Grade	• Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (**6-LS1-1**) • Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (**6-ESS2-3**)	• Identify a technology that enables new evidence about cells or Earth systems. • Classify available tools by the information type each contributes. • Explain how a named tool expands accuracy or scope for the scientific concept. *Knowledge Extended Beyond Course Expectations* • Recognize one newer measurement or imaging tool and state the kind of evidence (image, signal, map) it adds that older tools did not. • Identify which of two tools gives broader coverage for the same topic and explain qualitatively why that is useful. • Recognize one limit of a commonly used classroom tool and name a real-world tool that reduces that limit.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Seventh Grade	• Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (**7-PS1-3**)	• Explain how advances in measurement technologies improve observations of phenomena such as particle motion and temperature. • Describe how different technologies provide different types or scales of information in scientific investigations. • Explain how improved measurements can refine scientific understanding. • Explain how scientific discoveries can lead to new or improved technologies. *Knowledge Extended Beyond Course Expectations* • Recognize that improvements in measurement can change how results are interpreted.
Eighth Grade	• Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (**8-LS4-5**) (**8-ESS1-3**)	• Recognize genetic or remote-sensing advances that opened new questions in life or Earth history. • Categorize technologies by the evidence type they add to the same claim. • Explain how a named technology raises confidence in a claim about relatedness or geologic time. • Analyze which technology better fits a local or global question and state why qualitatively. *Knowledge Extended Beyond Course Expectations* • Recognize when newer evidence makes a previously used technology less suitable and state the reason.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Chemistry	• Science and engineering complement each other in the cycle known as research and development (R&D). (secondary) (**C-PS4-5**)	• Recognize research-and-development as a cycle that links scientific understanding with engineered devices. • Differentiate technologies by classifying how electromagnetic ideas enable sensing, imaging, or communication. • Explain one chemistry-aligned technology (for example spectroscopy, imaging) and state the electromagnetic understanding it relies on. • Evaluate how improved measurements inform refinements to a scientific idea and the next device update. *Knowledge Extended Beyond Course Expectations* • Recognize a simple limitation in a device readout and explain how a complementary device could offset it.
Physics	• Engineers continuously modify these technological systems by applying scientific knowledge. (secondary) (**P-PS2-6**) (**P-PS3-3**) (**P-PS4-2**) (**P-PS4-5**)	• Compare feasible options by linking each to the physics understanding it uses to improve performance. • Explain how a selected feature reflects the relevant physics relationship for the stated goal. • Recognize a trade-off introduced by adopting a physics-informed feature and note why that trade-off is acceptable for this goal. *Knowledge Extended Beyond Course Expectations* • None identified.

Grade or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Earth and Space Science	• Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (secondary) (**E-ESS1-2**) (**E-ESS1-4**) (**E-ESS2-3**)	• Identify instruments and models that make key Earth- and space-science questions answerable. • Classify tools by the evidence they contribute to the same claim. • Explain how one instrument's data aligns with a key scientific model. • Identify which instrument data (spectrum, image, seismic trace) best supports the model and explain why. • Name one large R&D effort (for example space telescope, seismic array) and the evidence type it adds for a key claim. • Evaluate why a stated R&D collaboration strengthens both the tool and the scientific explanation. *Knowledge Extended Beyond Course Expectations* • Recognize one non-science role (for example software, materials) that strengthens the scientific result and describe the basic contribution.

ETS2.B Influence of Engineering, Technology, and Science on Society

Students begin by recognizing that human-designed products are made using knowledge of the natural world and materials derived from it. In upper elementary grades, students identify how devices meet specific needs and affect the natural world, compare options in terms of benefits and harms, and evaluate how technologies are improved over time to better meet changing needs. In middle school, students analyze how the development and use of technologies depend on societal values, available resources, environmental conditions, and scientific advances, and explain why different communities adopt different solutions and how these choices vary across regions and over time. In high school, students evaluate how large-scale technological systems influence people and the environment across different scales, using disciplinary knowledge to compare options, analyze costs, benefits, risks, and tradeoffs, and justify decisions about feasibility and sustainability as scientific understanding and societal priorities shape the development, use, and continuous refinement of technologies.

Progression of ETS2.B

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
First Grade	• Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. (**1-PS4-4**) (**1-LS1-1**)	• Select a familiar device and name the scientific idea or property it depends on. • Identify a device inspired by a plant or animal part and state the simple function copied. • Classify parts or materials in the device as coming from the natural world (wood, metal, glass, plastic origin) using age-appropriate academic language. • Evaluate which material choice better fits the device's purpose qualitatively (for example, stronger, clearer, safer). *Knowledge Extended Beyond Course Expectations* • Recognize one benefit of using a particular natural-based material (for example flexibility, strength) for the same device.

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Second Grade	• Developing and using technology has impacts on the natural world. (secondary) (**2-ESS2-1**) • Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. Thus, developing and using technology has impacts on the natural world. (**2-ESS3-1**)	• Identify a technology that changes a local natural place. • Sort solutions as increasing benefits or reducing harm for the same local need. • Explain how a stated technology affects natural materials or features qualitatively. *Knowledge Extended Beyond Course Expectations* • Appraise which option better fits the local goal while naming one trade-off. • Name which natural resource a technology uses most for this task and explain why that matters.
Third Grade	• Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones). (**3-ESS3-1**)	• Identify how a current technology helps people for a stated need (safety, communication, mobility). • Compare two options by assessing the benefits and risks for the same need. • Explain which option better addresses the need. • Evaluate one small improvement that would increase benefit or reduce risk. *Knowledge Extended Beyond Course Expectations* • Identify which benefit matters most for this situation and state why it takes priority. • Recognize a risk that remains after the improvement and note one simple way to reduce it further qualitatively.

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Fourth Grade	• Engineers improve existing technologies or develop new ones (4-PS3-4) to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2) • Over time, people's needs and wants change, as do their demands for new and improved technologies. (secondary) (4-ESS3-1)	• Select a familiar technology for the stated need and describe what it aims to improve. • Contrast two versions by matching features to benefit and risk categories. • Explain how a simple feature change could increase the benefit or lower a risk without adding new mechanisms. • Determine which version better meets the changing need and state one trade-off accepted. *Knowledge Extended Beyond Course Expectations* • Recognize how a change in a community need could shift which version is preferred and explain why. • Identify one environmental effect that decreases with the preferred version and state the simple reason.
Fifth Grade	• Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (5-ESS3-1)	• Identify the environmental problem and the need the technology should meet. • Compare two technologies by aligning expected effectiveness, cost, and environmental effects for the same problem. • Explain which option best fits the need qualitatively. • Appraise one revision to the preferred option that would improve fit while noting a simple trade-off. *Knowledge Extended Beyond Course Expectations* • Identify which criterion (effectiveness, cost, impact) should take top priority for this community and explain why.

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Sixth Grade	• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. (**6-ESS3-2**)	• Identify how local needs, values, and priorities shape which technologies are used in different places. • Classify examples of technology use by regional factors such as climate, available natural resources, and economic conditions. • Explain how a new scientific finding can shift which technology is adopted or adapted in a community. • Analyze how a limitation (cost, materials, environmental risk) changes whether a technology is practical in the stated context. *Knowledge Extended Beyond Course Expectations* • Identify two regions solving the same problem and name one local factor that leads them to different technology choices.
Seventh Grade	• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. (**7-PS1-3**) (**7-LS2-5**) • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. (**7-ESS3-1**) (**7-ESS3-3**) (**7-ESS3-4**) (**7-ESS3-5**)	• Describe how technology use and limits on use vary with community priorities and regional conditions over time. • Sort examples of human activity by their short- and long-term consequences, positive or negative, for people and for the natural environment. • Explain how scientific understanding of matter, energy, or environmental processes can change which technologies are adopted or phased out. • Evaluate how two mitigation technologies differ in effectiveness based on regional resources and societal priorities. *Knowledge Extended Beyond Course Expectations* • Identify which community value (for example safety, cost, environmental impact) should take priority for the stated case and explain why. • Recognize one unintended consequence that may remain after technology adoption and note a simple way to reduce it further.

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Eighth Grade	• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. (**8-PS2-1**) • Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (**8-PS4-3**)	• Identify how societal needs, values, scientific findings, climate, resources, and economics lead to regional differences in technology adoption. • Classify measurement or communication technologies by the capacity they add to study forces, motion, energy transfer, or waves. • Explain how adding a technology that extends measurement or modeling can improve a scientific conclusion in qualitative terms. • Appraise which of two technologies is a better fit for the regional context and state a trade-off accepted in that choice. *Knowledge Extended Beyond Course Expectations* • Recognize when resource limits make a previously used technology less suitable and state the reason.
Biology 1	• The understanding of evolutionary relationships has recently been greatly accelerated by using new molecular tools to study biology. (**B-LS4-1**)	• Identify a molecular technology used to determine relatedness among organisms and note the biological question it addresses. • Compare two molecular approaches by classifying the kind of information each provides for inferring evolutionary relationships using qualitative terms only. • Explain how using molecular evidence can clarify or reorganize groups compared with classifications based only on observable traits. • Evaluate one practical implication of adopting molecularly informed classifications for society or the natural world (for example conservation targeting, invasive-species recognition, disease tracking) and state a trade-off accepted in that choice. *Knowledge Extended Beyond Course Expectations* • Identify a situation where molecular grouping would likely change a real-world decision (for example which population to conserve first) and explain.

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 2	• The understanding of evolutionary relationships has recently been greatly accelerated by using new molecular tools to study biology. (**B-LS4-1**) (repeat) • Modern civilization depends on major technological systems, including those related to agriculture, health, water, energy, transportation (e.g., wildlife corridors), manufacturing, construction, and communications. (secondary) Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (secondary) (**B-LS4-6**)	• Explain how advances in technology have expanded the types of evidence available to support evolutionary explanations. • Explain how new technologies can lead to changes in scientific understanding of evolutionary relationships. • Explain how changes in available evidence can lead to revisions of scientific models of evolutionary history. • Describe how the interpretation and use of evolutionary evidence can influence decisions in areas such as conservation, medicine, or biotechnology. • Identify how interconnected technological systems (for example wildlife corridors, remediation, diagnostics, precision-agriculture) depend on biological knowledge to increase benefits and reduce risks. • Classify system features by their expected benefits, risks, and constraints for the stated population or ecosystem. • Explain which system design better aligns with goals for biodiversity and stability using qualitative reasoning. • Appraise a small system modification that would improve fit to community needs while noting a trade-off. • Recognize when a different priority would change the preferred system and state the reason. *Knowledge Extended Beyond Course Expectations* • None identified.

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Chemistry	• Modern civilization depends on major technological systems (secondary) (**C-PS4-5**)	• Identify a major technological system that depends on electromagnetic principles. • Explain how a principle of the electromagnetic spectrum supports the device's intended function. • Classify device features by how they increase societal benefits while recognizing environmental impacts. • Evaluate which design choice better balances benefit and impact for the same purpose. *Knowledge Extended Beyond Course Expectations* • Identify a simple limitation in a device readout and explain how a complementary device could offset it. • Recognize a context where a different benefit priority would change the preferred technology and explain why.
Physics	• Modern civilization depends on major technological systems which can have deep impacts on society and the environment. (secondary) (**P-PS2-6**) (**P-PS3-3**) (**P-PS4-2**) (**P-PS4-5**)	• Identify a large-scale system (transportation, energy, communication, imaging, sensing) grounded in forces, motion, energy, or wave interactions. • Compare two system designs by matching features to benefits and environmental or safety risks. • Explain how a physics concept supports a feature choice intended to improve performance. • Appraise which system version better serves the stated community priority and name the trade-of. *Knowledge Extended Beyond Course Expectations* • Identify one update that increased safety or efficiency and link it to the physics understanding behind the improvement. • Recognize a risk that remains and state an adjustment that would reduce it.

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Earth and Space Science	• Modern civilization depends on major technological systems (secondary) (**E-ESS3-1**) (**E-ESS3-3**) (**E-ESS3-7**) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (secondary) (**E-ESS2-2**) (**E-ESS3-3**) • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Analysis of costs and benefits is a critical aspect of decisions about technology. (secondary) (**E-ESS3-2**) (**E-ESS3-4**)	• Identify a societal need met by a large-scale Earth/space technology. • Classify options by costs, benefits, risks, and trade-offs, noting how these differ by region (climate, resources, economics). • Describe how engineers refine technological systems by applying scientific research (climate data, geoscience models, natural-resource analyses) to increase benefits while reducing risks to people and ecosystems. • Evaluate which option is most feasible or sustainable for the stated region. • Identify one regional factor that most shifts the preferred choice and explain why. *Knowledge Extended Beyond Course Expectations* • None identified.

References

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NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States (Appendix E: Disciplinary Core Idea Progression)*. Retrieved from https://www.nextgenscience.org/