Engineering Design Process Performance Assessment Rubric

This rubric is intended to assess students' understanding, knowledge, and skills related to the Engineering Design Process. The expectation is that it would be tailored to emphasize the essential goals for each individual project. We have avoided including numbers or grades on the rubric to emphasize its formative nature.

"Proficient" indicates successful achievement of the goals set out in the project assignment. "Advanced" signifies going demonstrably above and beyond the expressed assignment goals. "Developing" indicates significant progress toward the learning goal indicated in the domain. It should be emphasized that "beginning" and "developing" ratings are to be expected, and for early projects, should should be considered as opportunities for students to develop their skills more fully in future projects.

Related document:

- Engineering Design Process Inputs/Outputs

Phase 1: Problem Definition: What is the evidence that the student can identify and define a problem in a way that can be solved in an engineering design process? ***Disciplinary Core Idea: ETS1.A***	**Advanced**	**Proficient**	**Developing**	**Beginning**
Problem identification: I can identify the problem (or question or need) clearly, including the client, user, and other stakeholders *NGSS Practice 1* *CC Math Practice 1* *ELA Capacity 1, 7*	• Problem is relevant and important in context of the assignment, and considers issues of social, economic, or environmental equity • Problem is specific, challenging, and can be investigated given available resources. Root causes of problem have been identified and explored • Stakeholders and local context are clearly identified and actively involved in problem identification	• Problem is relevant and important in context of the assignment. • Problem is specific and can be thoroughly investigated given available resources • Stakeholders and local context are clearly identified and considered in problem identification	• Problem is relevant in context of the assignment. • Problem is specific enough to guide initial investigation • Stakeholders and local context are vaguely identified or superficially considered	• Problem's relevance or importance is unclear • Problem is too broad or narrow in scope to allow for adequate investigation • Stakeholders and local context are not identified or considered
Criteria prioritization: I can identify and prioritize constraints and criteria to reflect needs and preferences of clients, users, and other stakeholders. *NGSS Practice 1* *CC Math Practice 1, 5* *ELA Capacity 1, 4*	• Constraints are relevant, objective, testable, and expand scope of project. • Criteria are relevant and based on expressed and anticipated stakeholder preferences. • Protocols are used effectively to justify prioritization of criteria.	• Constraints are relevant, objective and testable. • Criteria are relevant and based on expressed stakeholder preferences. • Clearly justifies prioritization of criteria.	• Constraints are relevant but subjective in nature. • Criteria are relevant and weakly based on stakeholder preferences. • Weakly justifies prioritization of criteria.	• Constraints are vague and/or not relevant to the problem. • Criteria are vague and/or not relevant to the stakeholder preferences. • Does not prioritize or does not justify prioritization of criteria.

Phase 2: Design Exploration (Divergent): What is the evidence that the student can identify and thoroughly explore a variety of possible solutions and select an optimal design concept. *Disciplinary Core Idea: ETS1.B*	**Advanced**	**Proficient**	**Developing**	**Beginning**
Expansion: I can use brainstorming techniques to generate a broad range of possible design concepts *NGSS Practice 6* *CC Math Practice 1, 7* *ELA Capacity 6*	• Describes multiple viable design concepts based on initial testing data, reverse engineering, and/or new research prompted by one of the above.	• Describes multiple viable design concepts with scientific or engineering justification.	• Describes multiple viable design concepts without articulated scientific or engineering principles or a single solution based on articulated scientific or engineering principles.	• Describes only a single design concept based on partial or missing articulated scientific or engineering principles.
Exploration: I can explore promising solutions thoroughly through research, modeling, mock-ups, and experimentation to further inform design concepts *NGSS Practice 2, 3* *CC Math Practice 2, 4* *ELA Capacity 2, 6*	• Considers multiple metrics that align well with each criterion and constraint and justifies selection of the most valid metrics. • Documents preliminary testing data and/or research that is relevant to differentiating design concepts against multiple high-priority criteria.	• Establishes metrics that align well with the criteria and constraints. • Documents preliminary testing data and/or research that is relevant to differentiating design concepts against highest priority criterion.	• Establishes metrics that are weakly aligned with the criteria and constraints. • Documents preliminary testing data and/or research that is unlikely to differentiate design concepts against highest priority criterion.	• Establishes metrics that are poorly aligned with the criteria and constraints. • Documents minimal testing data and/or research, or is irrelevant to design concepts.
Design selection: I can compare a range of design concepts, and select a preliminary design that best meets the identified constraints and criteria *NGSS Practice 6, 7* *CC Math Practice 3, 5* *ELA capacity 2, 5*	• Deliberately and effectively uses initial testing, data and/or research to objectively support preliminary design selection • Defends preliminary design choice against other concepts in light of criteria and constraints (trade-offs) using an appropriate objective tool (e.g. decision matrix).	• Deliberately uses initial testing, data and/or research to subjectively support preliminary design selection. • Defends preliminary design choice against other concepts in light of criteria and constraints (trade-offs).	• Uses data unsystematically for preliminary design selection. • Selects preliminary design based on criteria that are poorly aligned with criteria or constraints.	• No data collected to support preliminary design selection. • Evidence for preliminary design choice not logical or unfounded (choices made without rationale, or based on "favorite" concepts)

Phase 3: Design Optimization (Convergent): What is the evidence that the student can methodically improve an identified design concept into an effective solution? ***Disciplinary Core Idea: ETS1.C***	**Advanced**	**Proficient**	**Developing**	**Beginning**
Design iteration: I can optimize a selected preliminary design using an iterative testing process. *NGSS Practice 3, 7* *CC Math Practice 3, 7* *ELA Capacity 4, 5*	• Uses deliberate and effective iterative modifications (e.g. component testing) to characterize performance. • Justifies detailed final design using objective performance data from iterative testing.	• Uses deliberate iterative modifications (e.g. component testing) to characterize performance. • Justifies detailed final design using objective performance data from iterative testing.	• Uses unsystematic iterative modifications (e.g. component testing) to characterize performance. • Testing data is not sufficient to support detailed final design.	• Makes no iterative modifications to characterize performance. • Uses no data from iterative testing to support detailed final design.
Prototype development: I can demonstrate form and functionality of the design by creating a working prototype (e.g. working model, component, computer simulation). *NGSS Practice 2, 6* *CC Math Practice 6, 8* *ELA Capacity 6*	• Prototype meets all constraints. • Prototype functionality exceeds expectations of detailed final design. • Prototype effectively communicates the form of the detailed final design with professional level quality.	• Prototype meets all constraints. • Prototype functionality aligns clearly with detailed final design. • Prototype effectively communicates the form of the detailed final design, and exhibits quality/craftsmanship.	• Prototype meets most but not all constraints. • Prototype functionality approaches expectations of detailed final design. • Prototype roughly communicates the form of the detailed final design.	• Prototype meets few constraints. • Prototype is insufficient to demonstrate basic functionality of detailed final design. • Prototype does not communicate the basic form of the detailed final design.

Phase 4: Design Communication: What is the evidence that the student can clearly communicate the detailed final design to an external audience?	**Advanced**	**Proficient**	**Developing**	**Beginning**
Communication: I can create a design documentation package that uses multiple representations to clearly explain the detailed final design. *NGSS Practice 8* *CC Math Practice 6, 8* *ELA Capacity 3, 6*	• Design documentation is appropriately detailed and structured for the intended purpose and audience; extraneous information has been removed. • Documentation includes tolerances for all necessary specifications. • Documentation is polished and professional.	• Design documentation is appropriately detailed and structured for the intended purpose and audience. • Documentation is neat and includes all necessary specifications for assembly and/or operation. • Documentation is well-organized, professional, and free of mechanical errors.	• Design documentation is detailed but may not be optimized for the designated purpose. • Documentation is neat and includes most of the key parameters for assembly and/or operation. • Documentation is organized, neat, and contains few mechanical errors.	• Design documentation is not appropriate for the designated audience. • Documentation lacks crucial information. • Documentation requires significant editing and/or formatting.

Justification: I can explain the benefits and weaknesses of the design, including opportunities, tradeoffs and ideas for further improvement *NGSS Practice 7, 8* *CC Math Practice 2, 3* *ELA Capacity 4, 5*	• Communicates the design's strengths and limitations relative to competitor benchmarks and other design options. • Evaluates design as well as opportunities and tradeoffs in light of criteria and constraints, and defends the validity of metrics used. • Recommends design improvements which are supported by objective evidence or data.	• Communicates the design's strengths and limitations relative to other design options. • Evaluates design as well as opportunities and tradeoffs in light of criteria and constraints. • Recommends design improvements which are supported by subjective evidence.	• Communicates the design's strengths relative to other design options. • Evaluates design based on criteria and constraints. • Recommends design improvements; no evidence is cited to support these recommendations.	• Does not consider other design options. • Does not cite the criteria and constraints in evaluation of design. • No suggestions for improvement are offered.

Reflection*:* What is the evidence that the student can deeply reflect on performance, growth as a learner and ability to apply this in the future? • Know: Explains goals, purpose, and academic skills/content of project • Do: Explains process, decisions, engineering practices and leadership skills used • Reflect: Describes the impact of project on self, future and growth as an engineer	**Advanced**	**Proficient**	**Developing**	**Emerging**
I can explain the purpose for doing this project, in terms of content understanding and academic skills	• Reflection clearly describes, in students' own words, key understandings and skills from the project, and connects far reaching or unanticipated content.	• Reflection clearly describes, in students' own words, key understandings and skills from the project.	• Reflection only partially identifies the key understandings and skills from the project or simply paraphrases teacher descriptions.	• Reflection misidentifies key understandings and skills from the project.
I can explain how I used the engineering design process effectively in this project, including engineering practices (leadership skills?)	• Reflection clearly connects project tasks to design process and engineering practices, and relates tasks and practices to divergent real-world examples.	• Reflection clearly connects project tasks to design process and references specific engineering practices.	• Reflection weakly connects project tasks with design process and engineering practices.	• Reflection does not explicitly connect project tasks with design process or engineering practices.
I can describe the impact of the project on my growth as a learner, as an engineer, and as a member of society	• Reflection describes specific skills and knowledge developed as a result of the project, and connects to personal interests/goals and societal needs/goals.	• Reflection describes specific skills and knowledge developed as a result of the project, and connects to personal interests and goals.	• Reflection describes specific skills and knowledge developed as a result of the project, weakly tied to personal growth.	• Reflection vaguely describes specific skills or knowledge without recognizing personal growth.

References:

NGSS Science and Engineering Practices	**CCSS Mathematics: Mathematical Practices**	**CCSS ELA: Capacities**
1. Asking questions (for science) and defining problems (for engineering) 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations (for science) and designing solutions (for engineering) 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information	1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 4. Model with mathematics. 5. Use appropriate tools strategically. 6. Attend to precision. 7. Look for and make use of structure. 8. Look for and express regularity in repeated reasoning.	1. They demonstrate independence 2. They build strong content knowledge 3. They respond to the varying demands of audience, task, purpose, and discipline 4. They comprehend as well as critique 5. They value evidence 6. They use technology and digital media strategically and capably 7. They come to understand other perspectives and cultures

Engineering Design: Disciplinary Core Ideas (NGSS)

- **ETS1.A: Defining and Delimiting Engineering Problems**
  - Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
  - 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. (HS-ETS1-1)

- **ETS1.B: Developing Possible Solutions**
  - 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. (HS-ETS1-3)
  - 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. (HS-ETS1-4)

- **ETS1.C: Optimizing the Design Solution**
  - 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. (HS-ETS1-2)

NGSS Performance Expectations for HS Engineering Design

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.