Engineering Design Components & Evaluation Process

What is an Engineering Design Challenge?

An engineering design challenge is a problem-based task that approaches design problems using the manner. The EDP encourages open-ended problem solving and learning from failure. Learners engage with integrated concepts from multiple disciplines and use design thinking as a mechanism to design a solution for an authentic problem.

There are numerous engineering design process models; however, the models all share the foundational practices:

- Identifying questions or defining problems
- Imagining and brainstorming a solution
- Planning
- Creating
- Testing
- Improving design

During this process, scientists and engineers identify the advantages and limitations of their designs and models. A cost-benefit analysis is used to balance the scope, expectations of quality, and managing a budget for the prototype, proof of concept, or process being designed.

When conducting an engineering design challenge, a clearly defined problem should be presented at the beginning of the challenge. Defining the challenge with criteria, constraints, a budget, and a design rubric is essential. A design rubric determines if the solution meets the parameters of the challenge. The students will use their rubric design score to improve their solution before testing it again. The evaluation criteria can provide a framework of knowledge, skills, and performance related to a design problem. Throughout the process, students are engaged in the STEM fluency skills of collaboration, communication, critical thinking, creativity, innovation, adaptability, resilience, and time/resource management.

Additional resources for developing an engineering design challenge can be found in the STEM Toolkit:

- The Engineering Design Process Facilitator Guide– STEM Implementation Tools: *STEM Instructional Planning Guide*
- *Sample Engineering Design Challenge and Design Rubric*

Engineering Design Evaluation Process

The following questions should be considered when evaluating an engineering design solution.

Were the criteria and constraints for the design challenge met?

- Students design their solution based on the criteria (desired outcomes) and consider constraints (limitations).

Did the design include ideas from all team members? Did the design solve the problem?

- Students must work in collaborative teams to contribute solution ideas and design a cohesive plan. Teamwork is a requirement of engineers in a work environment.

Did the design solve the problem?

- Students develop and implement testing processes, gather data, and engage in data analysis. Data results are analyzed to determine how the design solves the problem.

Was the project at or under budget?

- In an engineering design challenge, examples of a cost benefit analysis may include but are not limited to material costs, building and implementation, time investment or duration, environmental impact, safety considerations, and projected durability or longevity of the design solution. In the classroom, students conduct a cost-benefit analysis comparing projected or estimated costs and benefits (or opportunities) associated with project decisions. For kindergarten through grade 8 design challenges, it is age appropriate to provide a budget and allow students to plan, buy materials, and design their solution within their budget. Additional cost-benefit factors can be included for high school students.

Was the design team able to increase their rubric design score after making improvements?

- Students collaboratively design improvements or adaptations based on testing and analyzing their prototype, process, or proof of concept.

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Did the students communicate their solution clearly and address the needs of the client?

- When presenting design solutions to internal or external stakeholders, students communicate design aspects and how the solution addresses the client's needs.

Teacher Evaluation Rubric Example

A rubric is a tool that can be used to guide and assess student performance and skills related to the design challenge and associated thinking processes (engineering design process and computational thinking). This sample teacher-level rubric could be used as a formal evaluation of a design solution. Rubrics should be customized to align with the engineering design challenge and age of the students.

CRITERIA	3 Points	2 Points	1 Point	0 Points	SCORE
Defined Problem: Criteria & Constraints *Were the criteria (desired outcomes) and constraints (rules) for the design challenge met?*	All criteria were met **and** all constraints were considered in the design process	Most criteria were met **and** most constraints were considered in the design process	Some criteria were met **and** some constraints were considered in the design process	None of the criteria were met **and** constraints were not considered in the design process	**/3**
Collaborative Design Plan *Did the design include ideas from all team members?*	The design has elements contributed by all team members	The design has elements contributed by most team members	The design has elements contributed by some team members	The design has elements contributed by one team member	**/3**
Testing & Data Analysis *Did the design solve the problem?*	Reliable testing methods were used for testing the design **and** based on data gathered during testing procedures, the design solved the problem	Somewhat reliable testing methods were used for testing the design **and** based on data gathered during testing procedures, the design somewhat solved the problem	Somewhat reliable testing methods were used for testing the design **or** based on data gathered during testing procedures, the design somewhat solved the problem	Unreliable testing methods were used for testing the design **or** based on data gathered during testing procedures, the design did not solve the problem	**/3**
Budget *Was the design at or under budget?*	Based on the design, the prototype was at or under budget	Based on the design, the prototype was at budget	Based on the design, the prototype was slightly over budget	Based on the design, the prototype was extremely over budget	**/3**
Improvements *Was the design team able to improve their rubric design score after making improvements?*	The design team was able to greatly improve their design score after making improvements	The design team was able to somewhat improve their design score after making improvements	The design team maintained the same design score after making improvements	The design team lowered their design score after making improvements	**/3**
Communication *Did the students communicate their solution clearly and address the needs of the client?*	Students clearly communicated their solution **and** fully addressed the needs of the client	Students somewhat clearly communicated their solution **and** mostly addressed the needs of the client	Students vaguely communicated their solution **and** somewhat addressed the needs of the client	Students did not communicate their solution **and** did not address the needs of the client	**/3**
				TOTAL	**/18**