ASET Science & Engineering Practice (SEP) Tool: Designing Solutions

Name or ID:
Science Lesson/Unit Title:
Intended grade:

SEP 6	**Constructing Explanations and Designing Solutions:** The end-products of science are **explanations** of natural phenomena and the end-products of engineering are solutions to design problems. **a. Constructing Explanations:** The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power than previous theories. **b. Designing Solutions:** The goal of engineering design is to find a solution to problems that is based on scientific knowledge and models of the material world. During the design process models or prototypes are systematically tested, and iteratively revised based on performance. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.

SEP 6b. Designing Solutions

Components of SEP **In this lesson/unit plan, it is clear that *students* have a structured opportunity to:**	**Mark with "x" if present in lesson**	**What teacher actions were taken to facilitate this component for students?**	**What are the students doing?**	***How* is this component reflected in your research/laboratory experience?**
1) **Describe criteria** and **constraints** of a design problem, including quantification when appropriate				
2) **Apply scientific knowledge** to **generate** a design plan that includes consideration for the criteria and constraints				
3) Build, t**est,** and evaluate the design of an object, tool, process, or system				
4) **Refine and/or optimize** the design solution based on performance during testing and consideration of the criteria and constraints				

Notes on Context/Special Considerations (part of school year, differentiation, student developmental considerations, etc.):

 Project Next Gen ASET is supported by a grant to the California State University East Bay by the National Science Foundation Discovery Research K12, Award No. DRL-1418440. PI: michele.korb@csueastbay.edu or contact corinne.lardy@csus.edu, michelle.sinapuelas@csueastbay.edu

ASET Grade Band Criteria *(Grade Bands: 6-8, 9-12)*

Science & Engineering Practices		
SEP 6b: Designing Solutions: Designing solutions in 6-8 builds on K-5 experiences and progresses to include designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. In 9-12 they build on K-8 experiences and progress to designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.		
By the end of the grade band ***students*** *will have had a structured opportunity to develop an understanding of each of these. Individual lessons or units should include opportunities for* ***students*** *to practice one or more of the following components ……*		
	6-8 Grade Band	**9-12 Grade Band**
1) **Describe criteria** and **constraints** of a design problem, including quantification when appropriate	Students **identify and describe**: a. Criteria and constraints for specific sub-problems within a larger complex problem b. How all criteria and constraints will be taken into account when designing the solution c. The rationale for which criteria should be given highest priority if tradeoffs must be made	Students **identify and describe**: a. Criteria and constraints for specific sub-problems within a larger complex problem b. How all criteria and constraints will be taken into account when designing the solution c. The rationale for which criteria should be given highest priority if tradeoffs must be made
2) **Apply scientific knowledge** to **generate** a design plan that includes consideration for the criteria and constraints	Students apply scientific ideas or principles to design and/or construct a solution (object tool, process, or system) that solves a problem. As part of this solution, students: a. Break down a complex problem into a set of two or more sub-problems b. Propose two or more solutions for at least one of the sub-problems c. Describe/label the components of the solution d. Describe the scientific rationale for each solution (how it solves the problem), including choice of materials and structure of the device where appropriate e. Describe how solutions to sub-problems are interconnected to solve all or part of the larger problem	Students apply scientific ideas or principles to design and/or construct a solution (object tool, process, or system) that solves a complex real-world problem. As part of this solution, students: a. Break down a complex problem into a set of two or more sub-problems b. Propose two or more solutions for each of the sub-problems c. Describe/label the components of the solutions d. Describe the scientific rationale for each solution (how it solves the problem), including choice of materials and structure of the device where appropriate e. Describe how solutions to sub-problems are interconnected to solve all or part of the larger problem

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Last Updated 8/8/2019

3) Build, t**est,** and evaluate the design of an object, tool, process, or system	Students test a solution to determine how well it solves the defined problem. Students systematically evaluate the solution(s) to a complex real-world problem, including: a. Analysis (quantitative where appropriate) of the strengths and weaknesses of the solution with respect to each criterion and constraint b. An evidence-based decision of which solution is optimum, based on prioritized criteria, analyses of the strengths and weaknesses (costs and benefits) of each solution, and barriers to be overcome c. Critiquing **competing design solutions** based on set criteria and constraints Consideration of other factors to implementing each solution, such as cultural, economic, or other sources of resistance to potential solutions	Students test a solution to determine how well it solves the defined problem. Students systematically evaluate the solution(s) to a complex real-world problem, including: a. Analysis (quantitative where appropriate) of the strengths and weaknesses of the solution with respect to each criterion and constraint b. An evidence-based decision of which solution is optimum, based on prioritized criteria, analyses of the strengths and weaknesses (costs and benefits) of each solution, and barriers to be overcome c. Critiquing **competing design solutions** based on set criteria and constraints Consideration of other factors to implementing each solution, such as cultural, economic, or other sources of resistance to potential solutions
4) **Refine and/or optimize** the design solution based on performance during testing and consideration of the criteria and constraints	a. Refine a solution based on the results from testing and evaluation b. Improve the design relative to criteria and constraints c. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting	a. Refine a solution based on the results from testing and evaluation b. Improve the design relative to criteria and constraints c. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting

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