How do you help promote 21st century skills while students engage in an engineering design process?

Communicate

Communication doesn't just happen during the communicate phase of EDP. It is crucial for youth to talk with, listen to and understand others throughout the design process!

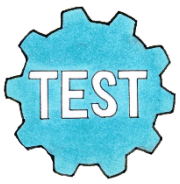
EDP Stage	Educators help youth:
	● Ask questions to clarify the problem to be solved o *What questions do you have about the problem?* o *What do you need to know before you can start to develop solutions to this problem?* ● Develop common vocabulary and language for discussing and understanding the problem o *What problem are you trying to solve?* o *Who can state the problem in their own words?* ● Craft a common problem statement. o *Can anyone add to this statement?* o *Does anyone disagree with the problem statement?* o *Is there anything we should change?* o *Is this the best word to use? Does anyone have any other ideas?* ● Record the group problem statement. Post it prominently. Refer to it often and clarify as needed.
	● Clarify language and develop common vocabulary for investigating and evaluating the properties of materials for a given task o *How would you describe this material?* o *What do you mean by "squishy"? Does anyone have another word to describe that property?* ● Develop visuals (graphs, charts, models) to communicate results of investigations o *What are different ways we can share the results of our investigation with others?* o *How might you organize that data so it is easy to see?* ● Choose appropriate visualizations to share findings/results o *Is a chart the best way to show your results?* o *What other ways might you present the data?* o Post examples of data visualizations from which youth might choose (charts, graphs, drawings) o Provide templates for recording data in different ways to supplement the Engineering Notebook
	● Explain their ideas to others with drawings, words, and models o *Have you added labels to explain your idea?* o *How can you make this idea more clear?* ● Listen and ask clarifying questions o *Can anyone summarize Martha's idea?* o *Why did Martha say she chose this material?* o *How does this part of the design move?*

	● Draw, label, and model the design o *Have you added labels to explain your idea?* o *How can you make this idea more clear?* ● Organize ideas before gathering materials o *How will you use the cotton balls? I don't see them in your design.* o *How will you attach this piece?* ● Clarify language and develop common vocabulary for success criteria o *Why do you think this design will be successful?* o *Which parts of this design do you predict will perform well?* o *Which parts of the design might not score as well based on our criteria?* ● Negotiate how they will conduct fair tests on designs to determine success or failure
	● Summarize performance of design and identify potential failure points o *Which parts of this design performed well?* o *Did the design perform as you predicted? What surprised you?* ● Provide constructive feedback to teammates and others o Encourage youth to focus on the elements of the design, and the evidence (data collected in the test) not the individuals who came up with the ideas. You can model this and talk about it prior to testing. o Provide a script for providing feedback (*based on this success criteria, this element of the design performed well, but this element did not perform as well).*
	● Develop ideas for changing the design for better performance o *Which elements of your design performed well?* o *Which elements of your design could be improved?* o *Is there any way you could change your design to get a better score?* ● Describe and model the new design ● Respond to constructive feedback and explain design decisions
	● Align media and message with audience ● Explain strengths and weaknesses of their solution ● Describe how they used the Engineering Design Process, including constraints ● Request constructive feedback on solutions

Think Critically

Throughout the EDP, youth will need to define problems, make sense of complicated information, and consider multiple sources of information in order to ultimately develop and share successful solutions.

EDP Stage	Educators help youth:
	● Clarify the problem they are trying to solve o *What problem are you trying to solve?* o *Who can state the problem in their own words?* o *Does anyone disagree with the problem statement?* ● Ask good questions and dig deep o *What questions do you have about the problem?* o *What do you need to know before you can start to develop solutions to this problem?*
	● Explore and evaluate different materials and their properties o *Which properties of that material might make it most useful in your solution?* o *Which properties of that material make it a bad choice for your solution?* o *Which material do you predict will work best?* ● Decide which data to collect o *What properties of this material might make it a good choice for our needs?* o *What properties of this material might make it a bad choice for our needs?* ● Determine how they will ensure fair tests are conducted o *How might you test these materials?* o *Is there anything one tester might do that another one might not do that could affect the results of the test?* o *How will you make sure everyone gets results they can compare?* ● Determine success criteria o *How will you judge the results of the test?* o *How will you determine if the test was a success or a failure?* ● Decide how they will analyze data o *How can you compare the data each group has gathered?* o *How will you compute the results? Do we need to use numbers or can we use another kind of scale?* ● Respectfully ask good questions o *Does anyone have questions for this group?* o *Does anyone disagree with that statement?* o *How do your results compare with other groups?* ● Provide reasoning, logic and evidence for ideas and prompt others to provide the same o *Why do you think that?* o *Can you say more about that?* o *What data do you have to support that claim?* o *Where did you get that information?*

	● Evaluate the pros and cons of each idea presented o *Can you explain the pros and cons (or tradeoffs) of each element in the design?* ● Provide reasoning, logic and evidence for ideas and prompt others to provide the same o *Why did you choose this material?* o *What properties of this material will make it work well for the solution?* o *What data do you have to support that claim?* ● Determine which ideas are the best to begin moving forward o *Which parts of all these ideas would be the best to incorporate into a first design?* o For each component: *How will this help you solve the problem?*
	●Determine how the design idea will work o *What properties of this material will make it work well for the solution?* ●Determine how they will test and evaluate the design in an equitable way o *How might you test these materials?* o *Is there anything one tester might do that another one might not do that could affect the results of the test?* o *How will you make sure everyone gets results they can compare?* ● Determine criteria for success o *How will you judge the results of the test?* o *How will you determine if the solution was a success or a failure?* ●Consider tradeoffs in the design o *Can you explain the pros and cons (or tradeoffs) of each element in the design?*
	●Evaluate different designs and components of designs to improve o *Which part of your design worked best?* o *Are there any parts of the design you wish would have worked better?*
	●Consider tradeoffs o *If you improve this part of the design, what might you have to compromise (e.g. if you make it taller, it might be less stable; if you make it stronger it might cost more, etc.)*
	● Logically explain the process of development, constraints, testing, design ● Explain how components of the design performed against the established criteria ● Explain how data informed design and improvement decisions and tradeoffs in the solution ● Evaluate their solution by describing strengths and weaknesses ● Explain what they learned and how they learned it o *Why did you engage in this engineering activity? What was your goal?*

	o *What were your initial ideas? How did they change?* o *How did you use what you learned from the early activities in the final design?* o *How did the constraints influence your design?* o *What parts of the design met the criteria? Where did it not meet the criteria?* o *How did you use the EDP throughout?* o *What tradeoffs did you have to consider in the improvements?*

Collaborate/Teamwork

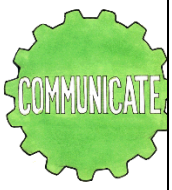
Being able to work well in teams is an important skill for any engineer. Throughout the EDP, youth have many opportunities to work with others toward the common goal of developing a solution to a problem.

EDP Stage	Educators help youth:
	●Agree on the problem statement ●Come to consensus/understanding of the problem they will solve ●Develop common vocabulary and language for discussing and understanding the problem ●Craft a common problem statement o *What is the problem you are trying to solve?* o *Can anyone add to this statement?* o *Does anyone disagree with the problem statement?* o *Is there anything we should change?* o *Is this the best word to use? Does anyone have any other ideas?*
	●Divide tasks/tests ●Compare and discuss results ●Come to consensus about results o *You may want to assign team roles to help youth that struggle with teamwork. Possible roles include: the data recorder, the materials acquisition specialist, and the presenter.*
	●Welcome multiple ideas from all team members ●Examine all ideas without judgment ●Listen and ask clarifying questions to better understand other's points of view o *Can anyone summarize Martha's idea?* o *Has everyone shared at least one idea?* o *Who can build on the idea that is on the table?*
	●Utilize a combination of ideas from all team members o *Which of pieces of this final plan did you contribute?* o *How does this plan build on ideas from the team?* o *You may want to assign team roles to help youth that struggle with teamwork. Possible roles include: the artist and quality assurance manager(s) (keeps track of constraints, calculates materials costs, notes tradeoff decisions made by the team)*

	●Divide tasks so each member contributes to success of the team o *You may want to assign team roles to help youth that struggle with teamwork. Possible roles include: the materials acquisition specialist, the builder, and quality assurance (keeps track of criteria and constraints)*
	●Divide tasks so each member contributes to success of the team o *You may want to assign team roles to help youth that struggle with teamwork. Possible roles include: the note taker, the materials gatherer, the tester, and the data recorder and the data analyzer (which parts of the design performed well and which failed?)*
	●Focus on the aspects of the design, not individual ideas ●Seek new creative ideas ●Provide constructive feedback ●Respond to constructive feedback o *What did you learn from others that might help you improve your design?* o *What did you learn that might help other teams improve their designs?*
	●Divide tasks – speaking, drawing, modeling o *You may want to assign team roles to help youth that struggle with teamwork. Possible roles include: the organizer, the artist, the script writer, the presenter of the problem (including constraints and criteria), the presenter of the activities and lessons learned, the presenter of the design and the presenter of the results.*

Creativity

Successful solutions depend on youth's abilities to develop new and innovative ideas.

EDP Stage	Educators help youth:
	● Generate multiple ideas that could work: o *Think of lots of ideas that could work, even if you think it sounds crazy. Don't stop at one or two (consider a challenge – how many ideas can you generate in 3 minutes?)* o *Great start! Can you come up with another idea?* o *Encourage youth to SCAMPER (Substitute a material for another; Combine two or more ideas; Adapt/Modify; Put something to another use; Eliminate something from the design; Reverse something)* o *Can anyone build on the ideas put forth so far?*
	● Focus on design failures and seek new ideas o *Which parts of the solution worked the best?* o *Which parts of the solution could work even better?* o *Which parts of the solution did not meet the criteria?* o *What are the pros and cons (or tradeoffs) of changing that part of your solution?* o *If you make that change, how will it help you solve the problem better than the current solution?*
	● Align media and message with audience o *Who is coming to the presentation?* o *What is the most important information to share with the guests?* o *What might be the best way to share this information?* o *What visuals might you need to help others understand what you did?*