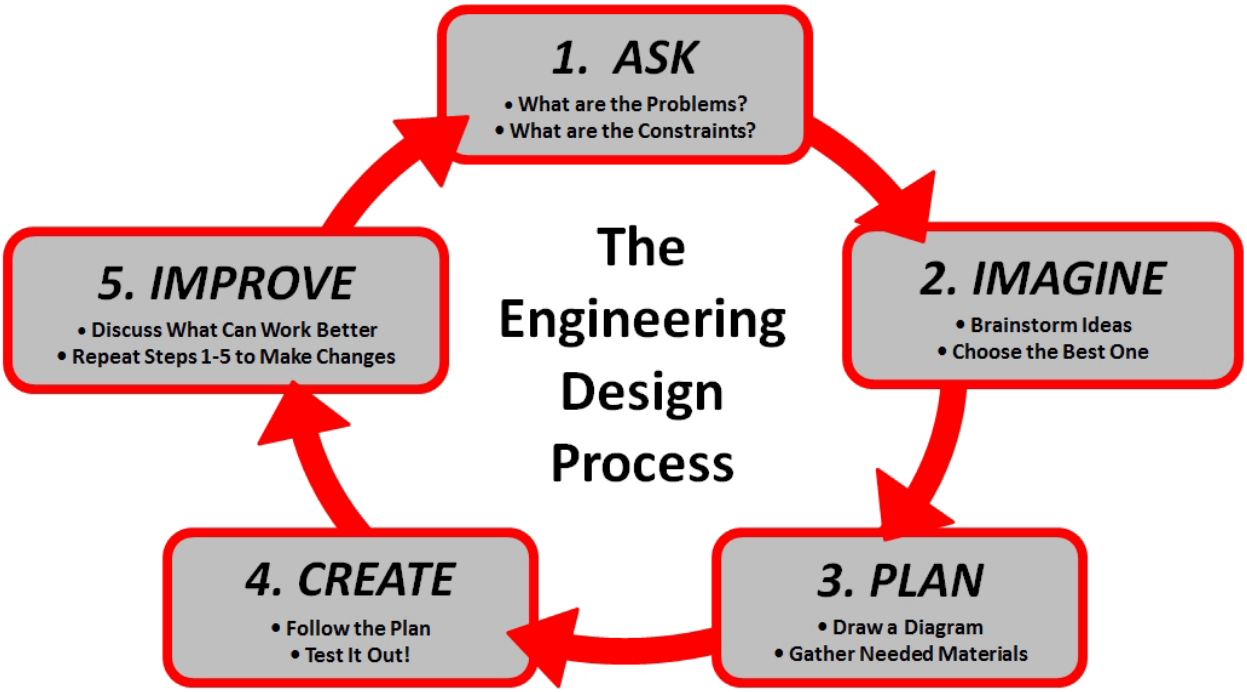
Building a Whirligig using the Engineering and Design Process



In this lesson we are going to use the Engineering and Design process (above) to create whirligigs. For inspiration we will be looking at the work of Vollis Simpson and the sculptures he has created. Go to http://learn.ncartmuseum.org/artwork/wind-machine/ to see an example of his work.

As you develop your whirligig your team will be breaking the task down into subsystems and using the engineering and design process on each subsystem. One group will focus on support structure, one group will work on blade design, and the third group will work on drivetrain and end effectors. All three pieces must work together to make a free standing kinetic sculpture that moves when the wind blows. Your prototype will be 1:4 scale.

As you research your designs you should look up and take note of simple machines, gear trains, and crankshafts for the mechanical parts. Look up tower designs for the structural supports and how wind turbines work for both efficient blade design and drivetrain.

Materials will be provided to you to construct your design. Any additional materials you wish to bring from home must be approved by your teacher before it is incorporated into your design and brought to school.

Be sure to thoroughly document your progress on the provided document and in your engineering and design journal. Refer to the rubric regularly to ensure you are moving in the right direction and meeting the requirements. Make sure each subsystem works flawlessly with the others by looking for clearance between moving and stationary parts, balance and symmetry in the design, and remember alignment is critical in anything with moving parts.

Support Structure

1. **Ask** – In this section identify the criteria and constraints of the design problem. Write out the design problem with details (i.e. shape, scale, material requirements) to clearly define the problem and expectations.

2. **Imagine** – For this section brainstorm as many ideas as possible. Identify and research existing solutions to the design problem, if one exists. Once a list of ideas has been generated use a decision matrix to evaluate your ideas before moving to the next step. Attach your completed decision matrix to this paper.

List your sources here.

3. **Plan –** In this section draw your product with as much detail as you can. Include dimensions. Identify what materials you are going to use to create your product.

Top View	**Front View**
Side View	**Isometric (3D)**

4. **Create** – Gather the materials you need and follow the plan you have created. Take notes of anything you change as you move forward with your plan and indicate why it changed.

Test conducted	Results

5. **Improve –** Evaluate your structure against the criteria in the ask phase. Go back to the design problem and identify what features support the requirements and what does not. List what does not completely meet requirements and what changes can be made to ensure all the requirements have been met and document how tradeoffs made were necessary.

Drivetrain

1. **Ask** – In this section identify the criteria and constraints of the design problem. Write out the design problem with details (i.e. shape, scale, material requirements) to clearly define the problem and expectations.

2. **Imagine** – For this section brainstorm as many ideas as possible. Identify and research existing solutions to the design problem, if one exists. Once a list of ideas has been generated use a decision matrix to evaluate your ideas before moving to the next step. Attach your completed decision matrix to this paper.

List your sources here.

3. **Plan –** In this section draw your product with as much detail as you can. Include dimensions. Identify what materials you are going to use to create your product.

Top View	**Front View**
Side View	**Isometric (3D)**

4. **Create** – Gather the materials you need and follow the plan you have created. Take notes of anything you change as you move forward with your plan and indicate why it changed.

Test conducted	Results

5. **Improve –** Evaluate your structure against the criteria in the ask phase. Go back to the design problem and identify what features support the requirements and what does not. List what does not completely meet requirements and what changes can be made to ensure all the requirements have been met and document how tradeoffs made were necessary.

Blade Design

1. **Ask** – In this section identify the criteria and constraints of the design problem. Write out the design problem with details (i.e. shape, scale, material requirements) to clearly define the problem and expectations.

2. **Imagine** – For this section brainstorm as many ideas as possible. Identify and research existing solutions to the design problem, if one exists. Once a list of ideas has been generated use a decision matrix to evaluate your ideas before moving to the next step. Attach your completed decision matrix to this paper.

List your sources here.

3. **Plan –** In this section draw your product with as much detail as you can. Include dimensions. Identify what materials you are going to use to create your product.

Top View	**Front View**
Side View	**Isometric (3D)**

4. **Create** – Gather the materials you need and follow the plan you have created. Take notes of anything you change as you move forward with your plan and indicate why it changed.

Test conducted	Results

5. **Improve –** Evaluate your structure against the criteria in the ask phase. Go back to the design problem and identify what features support the requirements and what does not. List what does not completely meet requirements and what changes can be made to ensure all the requirements have been met and document how tradeoffs made were necessary.

This rubric will be used to evaluate your engineering and design process:

Category	Below Average	Average	Excellent
Defining a Problem	Rephrases the problem with limited clarity.	Rephrases the problem clearly.	Rephrases the problem clearly and precisely.
Brainstorming	Contributes few or implausible ideas.	Contributes a plausible idea.	Contributes multiple plausible ideas.
Researching and Generating ideas	Contributes ideas, but without documented research. Produces incomplete sketches. Does not present a concept.	Contributes one plausible idea based on documented research. Produces marginally accurate pictorial and orthographic sketches of design concepts.	Contributes multiple plausible ideas based on documented research. Produces accurate pictorial and orthographic sketches of design concepts.
Identifying Criteria and Specifying Constraints	Does not restate the criteria clearly and fails to identify constraints.	Restates the criteria clearly and identifies several constraints.	Restates the criteria clearly and precisely and identifies many constraints.
Exploring Possibilities	Inadequately analyzes the pluses and minuses of a variety of possible solutions.	Satisfactorily analyzes the pluses and minuses of a variety of possible solutions.	Thoroughly analyzes the pluses and minuses of a variety of possible solutions.
Selecting an Approach	Selection of solution is not based on consideration of criteria and constraints.	Selects a promising solution based on criteria and constraints.	Selects a promising solution based on a thorough analysis criteria and constraints.
Developing a Design Proposal	Design proposal is inadequate and lacking pertinent information.	Design proposal is adequate, containing all pertinent elements.	Design proposal is accurate and comprehensive.
Making a Model or Prototype	Prototype meets the task criteria to a limited extent.	Prototype meets the task criteria.	Prototype meets the task criteria in insightful ways.
Testing and Evaluating the Design using Specifications	Testing and evaluation processes are inadequate.	Testing and evaluation processes are adequate for refining the problem solution.	Testing processes are innovative.
Refining the Design	Refinement based on testing and evaluation is not evident.	Refinements made based on testing and evaluation results.	Significant improvement in the design is made based on prototype testing and evaluation.

Creating or Making it	Finished solution (product) fails to meet specifications.	Finished solution (product) meets specifications.	Finished solution (product) exceeds specifications.
Communicating Processes and Results	Solution presented with limited accuracy. Limited supporting evidence on how the solution meets the task criteria.	Solution presented accurately. Some supporting evidence on how the solution meets the task criteria.	Solution presented concisely with clarity and accuracy. Extensive supporting evidence on how the solution meets the task criteria.
Scale of 1:4	The student presents a model that is much larger or much smaller than a 1:4 scale	The student presents a model that is built to an approximate scale of 1:4	The student presents a model that is built to an exact scale of 1:4
Material Selection	The student recommends a material for the part and does not include any justification.	The student recommends a material for the part and justifies his/her material selection by specific reference to the criteria and constraints of the design problem.	The student recommends a material for the part and justifies his/her material selection using data and specific reference to the criteria and constraints of the design problem.
Individual Participation	Does little work on the project and copies from others. (50%)	Student fully engages in the group and works well with others. (90%)	Student fully engages in the group, works well with others, and assists other team members as needed. (100%)