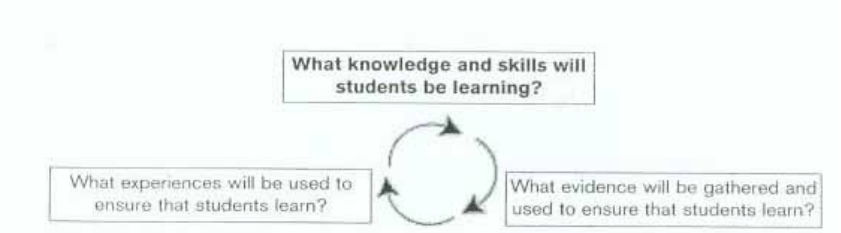
ALIGNMENT WITH ILLINOIS CONTENT STANDARDS



(Figure source: "Keeping the Focus on Learning", B. B. Gaddy, C. B. Dean, & J. S. Kendall. McREL, 2002.)

This activity can be linked to Illinois science standard 11.B. The alignment is defined by student learning objectives for the appropriate grade levels, as follows:

EARLY ELEMENTARY: 11.B.1b. Design a device that will be useful in solving the problem.
1. After completing this exercise, students will design and construct a flying device meeting specific constraints.

LATE ELEMENTARY: 11.B.2b. Develop a plan, design and procedure to address the problem identifying constraints (e.g., time, materials, technology).
1. After completing this exercise, students will design and construct a flying device meeting specific constraints.
2. After completing this exercise, students will discuss the engineering design process by describing the basic steps in engineering design for this device.

MIDDLE/JUNIOR HIGH SCHOOL: 11.B.3b. Sketch, propose and compare design solutions to the problem considering available materials, tools, cost effectiveness and safety.
1. After completing this exercise, students will design and construct a flying device meeting specific constraints.
2. After completing this exercise, students will discuss the engineering design process by describing the basic steps in engineering design for this device.

EARLY HIGH SCHOOL: 11.B.4b. Propose and compare different solution designs to the design problem based upon given constraints including available tools, materials and time.
1. After completing this exercise, students will design and construct a flying device meeting specific constraints.
2. After completing this exercise, students will discuss the engineering design process by describing the basic steps in engineering design for this device.
3. After completing this exercise, students will describe how he/she/they evaluated design trade-offs in the creation of the device.

LATE HIGH SCHOOL: 11.B.5b. Select criteria for a successful design solution to the identified problem.
1. After completing this exercise, students will design and construct a flying device meeting specific constraints.
2. After completing this exercise, students will discuss the engineering design process by describing the basic steps in engineering design for this device.
3. After completing this exercise, students will describe how he/she/they evaluated design trade-offs in the creation of the device.

STUDENT PERFORMANCE DESCRIPTORS

Statements of Assessment that show whether the students have achieved the skills and knowledge defined by the Learning Objectives and the grade appropriate Standard(s).

Learning Objective
1. After completing this exercise, students will design and construct a flying device meeting specific constraints.

Assessment Statements
Students will sketch the flying device, meeting the specified constraints.

Students will construct their flying device from the sketch and make modifications to achieve the requirements that it stays in the air as long as possible and lands as close to a given target as possible.

Learning Objective
2. After completing this exercise, students will discuss the engineering design process by describing the basic steps in engineering design for this device.

Assessment Statement
Students will write a report (and/or make an oral presentation) describing the steps of the engineering design process that were followed in the construction of the flying device.

Learning Objective
3. After completing this exercise, students will describe how he/she/they evaluated design trade-offs in the creation of the device.

Assessment Statements
Students will report on the modifications made in the design of their flying device to assure achievement that it stays in the air as long as possible and lands as close to a given target as possible. They will also write on their design the reasons for the modification and the result of the modification.

ENGINEERING DESIGN USING INQUIRY
PAPER DROP COMPETITION

Statement of the Problem:

Design a "flying" device that stays in the air as long as possible and lands as close to a given target as possible. Seventy percent of the score for the device will be determined by how long it stays in the air, and thirty percent of the score will be determined by how close it lands to a given target. Each group will receive three sheets of 8½" x 11" paper, adhesive tape, one 3" x 5" index card, four paper clips, and a pair of scissors. The scissors may not be used in the actual falling device. Be sure to sketch out your possible solutions before building the model of your optimum design. Make a unique identifiable marking on your flying device to distinguish it from other devices during the testing stage.

Communication of the Process:

When designing your group's flying device, explain what scientific principles were taken into account in the selected solution to your problem.

Sample Inquiry Questions

Planning Stage:

- What are the criteria for your device to be successful during the trial runs?
- How are you going to document your trials?
- What is necessary to make your device successful?
- What are you going to be looking for?
- What are the parameters?
- What are the variables you need to take into account?

Solutions Stage:

Sketch/design several possible solutions. Then pick one solution to try after optimizing a solution.

- How/Why do you think your design is going to be successful?
- What problems are you going to meet?
- What are your worries/concerns?
- What are the weaknesses/flaws?

Model Construction Stage:

- Describe what you are doing.
- What are the problems/limitations you are having with the design?
- What is working? What is not working?
- How are you going to change the design?
- How are you going to document the trials?
- What are the criteria to be used for the trials?
- What problems (if any) do you anticipate with the trials?
- How many trials do you plan for the design?

Testing the Model – Trials:

- How is it going?
- How is your design working?
- What do you think is making it work?
- Why do you think it is not working?

Evaluating the Trials:

- What changes would you make to the design of the device based on your trials?
- What happened in your trials that would make you want to make those changes?

Be the Engineer – Paper Drop Design

In this exercise, you will play the role of the engineer. You are given a goal and must design a solution to achieve that goal.

Learning Objectives

After completing this exercise, students will:

- Design and construct a flying device meeting specific constraints.
- Discuss the engineering design process by describing the basic steps in engineering design.
- Describe how they evaluated design trade-offs in the creation of the device.

Design Specification

Each team is required to design and construct a "flying" device. There are two design criteria for this device.

1. The device must stay in the air as long as possible.
2. The device must land as close as possible to a given target.

Each team must construct their device using any or all of the following materials.

- Three sheets of 8½" x 11" paper
- Adhesive tape
- One 3" x 5" index card
- Four paper clips
- A pair of scissors

Scoring

The competition can be held anywhere that a paper can be dropped from at least several feet in height. This could be an alcove with an opening to a lower floor or simply someone standing on a chair in a classroom. One member of each team will go to the takeoff point and launches the device toward a target on the floor. The time will be recorded from when the device is launched until it hits the ground. Then the distance will be measured from the device to the target. Each team will perform three drop runs; the times and distances will be totaled for each team.

The scoring for this competition emphasizes flight time over accuracy. The length of time before reaching the ground comprises 70% of the overall score, and the

distance from the target accounts for the other 30% of the score. The scores are scaled by the slowest and fastest times or closest and farthest distances. The formula for calculating the time portion of the score, a maximum of 70 points, is as follows.

$$\text{Time score} = \frac{(\text{Your team's time} - \text{Shortest team's time})}{(\text{Longest team's time} - \text{Shortest team's time})} \times 70$$

To illustrate how this works, consider three teams with total times of 4, 8, and 11 seconds. The formula becomes

$$\text{Time score} = \frac{(\text{Your team's time} - 4\,\text{seconds})}{(11\,\text{seconds} - 4\,\text{seconds})} \times 70$$

For the three teams, this is

$$\text{Time score} = \frac{(4\,\text{seconds} - 4\,\text{seconds})}{(11\,\text{seconds} - 4\,\text{seconds})} \times 70 = 0\,\text{points}$$

$$\text{Time score} = \frac{(8\,\text{seconds} - 4\,\text{seconds})}{(11\,\text{seconds} - 4\,\text{seconds})} \times 70 = 40\,\text{points}$$

$$\text{Time score} = \frac{(11\,\text{seconds} - 4\,\text{seconds})}{(11\,\text{seconds} - 4\,\text{seconds})} \times 70 = 70\,\text{points}$$

The longest time always earns 70 points and the shortest time receives no points. Other times earn varying numbers of points; the closer they are to the maximum time, the greater the number of points they earn.

The distance scores are calculated in a similar manner using the following formula.

$$\text{Distance score} = \frac{(\text{Longest team's distance} - \text{Your team's distance})}{(\text{Longest team's distance} - \text{Shortest team's distance})} \times 30$$

Acknowledgments

Thanks to Stephen Tricamo, Professor of Industrial and Manufacturing Engineering at NJIT, for allowing us to adapt this experiment from one he developed for his FED 101 class.