The process of inquiry requires students to follow a somewhat linear process, which includes identifying a question, designing an investigation, developing a hypothesis, collecting data, answering and modifying the original question, and communicating their results. To complete each step successfully, however, students must possess specific abilities and prior knowledge. Unfortunately, not all students are created equal. Each student’s experiential profile, the sum of their past experiences, abilities, and knowledge, affects how much he or she will benefit from inquiry-based activities. To ensure that each student achieves success, teachers can tailor activities with students’ strengths and weaknesses in mind using the process of adaptive inquiry.

Adaptive inquiry is the product of the synergistic relationship between what a student brings to the classroom and the teacher’s ability to shape a lesson in response to the needs of the student. When designing investigations influenced by their own past experiences and abilities, this synergistic energy is not only evident between teacher and students, but also among classmates. The adaptive inquiry process requires some degree
Team members and job description
A minimum of four launches should be made allowing all team members to assume each role.
Flight engineer (Launches LSC rocket): _________________________
Data specialist (Records data): _________________________
Safety specialist (Prior to the activity, reviews safety checklist and obtains equipment):
_________________________
Communications specialist (Reports launch results to the class): _________________

Evaluation of rocket performance
1. Trial that produced the longest duration in flight: ___________ (in seconds)
   Describe rocket in terms of:
   Length: _______(m)   Material: ________   Number of fins: ________

2. Trial that produced the farthest distance from launch pad: ___________ (in meters)
   Describe rocket in terms of:
   Length: _______(m)   Material: ________   Number of fins: ________

Analysis of results
1. What recommendations would you make to produce the most effective rocket?
2. What other independent variables should be considered when building a rocket?
3. Compare your estimate, actual duration, and distance data. Identify trials with most and least accurate estimates.
of flexibility that must be balanced with the constraints of time, materials, and local curriculum. Beneficial results occur when the teacher has a basic concept plan—ready to be modified by students’ abilities.

By implementing a focus and review strategy, the teacher is able to assess students’ prior knowledge and understanding of the topic at hand. Further discourse is encouraged among students as they work in small groups to develop initial questions that may be suitable

**FIGURE 2** Graphing grid

- Dependent variable (DV)
- Independent variable (IV)

**Graph interpretation**
1. Is there a relationship between the DV and IV? If so, describe the relationship.
2. Based on the graph data, which IV (rocket length or number of fins) best predicts DV (duration or distance)?

**FIGURE 3** Student checklist

<table>
<thead>
<tr>
<th>Data documentation</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Data recorded in appropriate columns with units (when required)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation of rocket performance</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identified the trial that produced the longest duration in flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Included description of rocket in:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length: __________ (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material: __________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fins: __________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Identified the trial that produced the farthest distance from launch pad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Included description of rocket in:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length: __________ (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material: __________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fins: __________</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Graphing grid</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Graphed IV data along the x-axis and DV data along the y-axis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Labeled the IV and DV on the graph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Labeled axis using proportional units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Graph interpretation</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identified the relationship between IV and DV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Described the relationship between IV and DV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Identified IV that best predicts DV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analysis of results</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Made at least two recommendations to produce the most effective rocket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Identified at least two other independent variables to be considered when building a rocket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Identified trials with most and least accurate estimates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Constructing launch system compressor (LSC) and rockets

Materials
• one gallon zipper-lock plastic freezer bag
• 8 1/2 x 11” sheets of paper
• transparent tape
• duct tape
• scissors
• foam ear plug
• safety goggles

Procedure
1. Roll one sheet of paper lengthwise to create a long tube approximately 15 mm in diameter. Tape the seam with transparent tape to prevent the tube from unrolling.
2. Use the scissors to cut off one bottom corner of your freezer bag to create a hole that your tube will fit into snugly.
3. Insert one end of the tube into the bag and out through the hole in the bottom. Slide the tube through the hole until just a few millimeters remain inside. Tape the tube in place with duct tape.
4. Form a cone using a second sheet of paper that is approximately 33 cm long and 4 to 5 cm in diameter at its widest point. Secure seam with transparent tape.
5. Determine where the body of the cone is 2.5 cm in diameter and cut away the base of the cone at that point. This should leave you with a cone that is approximately 20 cm long.
6. To reduce eye injury during launches, tape a foam earplug to the tip of the cone to cover the point.
7. Cut out three identical fins from a third piece of paper and attach them to the base of the cone using transparent tape.
8. If necessary, inflate the bag with air by blowing into it and then resealing it.
9. Place the bag on a sturdy, flat surface, and then place the rocket snugly over the launch tube.
10. After you have checked to make sure the rocket isn’t pointed at anyone, squeeze the bag to initiate the rocket launch.
for later inquiry. Facilitated discussions, a key element of adaptive inquiry, are used to help students define problems, identify variables, collect data, graph results, recognize cause and effect relationships, and build and modify models. Through discourse and supplemental activities, students begin to internalize the use of inquiry in problem solving.

The following is an example of an adaptive inquiry activity that uses Launch System Compressor (LSC) Rockets (paper tubes launched by squeezing a plastic bag filled with air). Many divergent outcomes are possible with this activity, but each one can be used to reach the ultimate objective of this lesson—teaching Newton’s third law of motion.

**Focus and review**

Newton’s third law of motion states: For every action there is an equal and opposite reaction. After this activity, students should understand that forces come in pairs. In this activity, students demonstrate and observe equal and opposite reactions during a rocket launch. Students should be able to relate their observations of the rocket launch to Newton’s third law of motion.

**Simulation to generate thought**—Obtain a long thin balloon, a 5-cm piece of plastic straw, 4 meters of string or dental floss, and masking tape. Insert the 4 meters of string through the piece of straw. Tie each end of the string to the back of a chair or other stationary objects in the room. Be sure the string is taut. Tape the deflated balloon to the middle of the straw. Move the balloon to one end of the string. Inflate the balloon and hold the nozzle. Ask the students to describe what will happen when the nozzle is released. Release the nozzle and have students discuss what they observed. Students should note that they saw the balloon decrease in size, heard the sound of the escaping air, and saw the balloon move. Students may then note that the air escapes in one direction while the balloon moves in the opposite direction. Further questioning may reveal that the action is the escaping air and the reaction is the movement of the balloon.

**Goals and objectives**

1. Students will demonstrate Newton’s third law of motion—for every action, there is an equal and opposite reaction—as the basic principle of rocket propulsion.
2. Students will understand that the duration and direction of the flight of their rocket is caused by the change of direction of the flow of rocket engine exhaust, the launch direction, and moveable fins.
3. Students will become familiar with the parts of a rocket (as they construct LSC models) and its general design.

Facilitating adaptive inquiry

Based on the balloon rocket simulation in the focus and review, the teacher assesses student responses to questions to determine their levels of understanding. To conduct adaptive inquiry, a teacher must possess a pedagogical repertoire that ranges from direct instruction to open-ended inquiry. Direct instruction entails teacher-directed delivery of content in small amounts. It is designed to build a knowledge base. At the other end of the continuum is open-ended inquiry, which encourages pupils to use their prior knowledge to structure investigations.

Questioning and discussion at this juncture are rudimentary means of assessment that allow the teacher to establish vocabulary and a functional knowledge base to conduct the activity. This method of questioning may be employed at any point during the lesson when the teacher needs to determine instructional levels. A sample of questions, ranging from knowledge to evaluation, include:

- Knowledge—What are the variables in the balloon simulation?
- Comprehension—What was the purpose of the balloon simulation?
- Application—How does the movement of the balloon compare to that of the LSC rocket?
- Analysis—Describe the relationship between the volume of air in the balloon and the distance of the flight.
- Synthesis—Based on your own observations, what could you predict about the volume of air in the balloon and distance traveled?
- Evaluation—What criteria would you use to evaluate the results of the balloon simulation?

During the assessment, the teacher should also evaluate students’ skills. Some students will be stronger in some skills and weaker in others. Students who can identify independent and dependent variables, explain relationships between variables, and predict results require less direct instruction and are ready for open-ended inquiry. Other students may benefit from additional direction from the teacher. It is the goal of the teacher to adapt the levels of instruction to match the students’ needs.

Activities

In groups of four, students will:
1. Construct model LSC rockets (see Activity sheet on page 37).
2. Identify independent variables (IV) (e.g., rocket length, material, number of fins, size of freezer bag) that may affect dependent variables (DV), such as flight duration (seconds) and flight distance (meters) from launch pad of the LSC rockets (see Figure 1 for Flight Planner Data Collection Sheet).
3. Conduct a series of trial flights and record appropriate data regarding IV and DV.
4. Analyze data to evaluate rocket performance and recommend modifications.
5. Graph data to identify the relationship between IV and DV, and the best predictive model (see Figure 2 for Graphing Grid).

Evaluation

Students will be evaluated on their
- ability to follow directions to construct a workable LSC rocket,
- safe launching of the LSC rocket,
- written responses on the Flight Planner Data Collection Sheet and the Graphing Grid,
- completion of the Student Checklist (Figure 3), and
- adherence to Safety Countdown procedures (Figure 3).

References


National Standards

The following lesson highlights a portion of all the Teaching Standards; Assessment Standards A; 5–8 Content Standards A, B, and E; and Program Standards C and D (National Research Council 1996).