National Aeronautics and
Space Administration
Langley Research Center

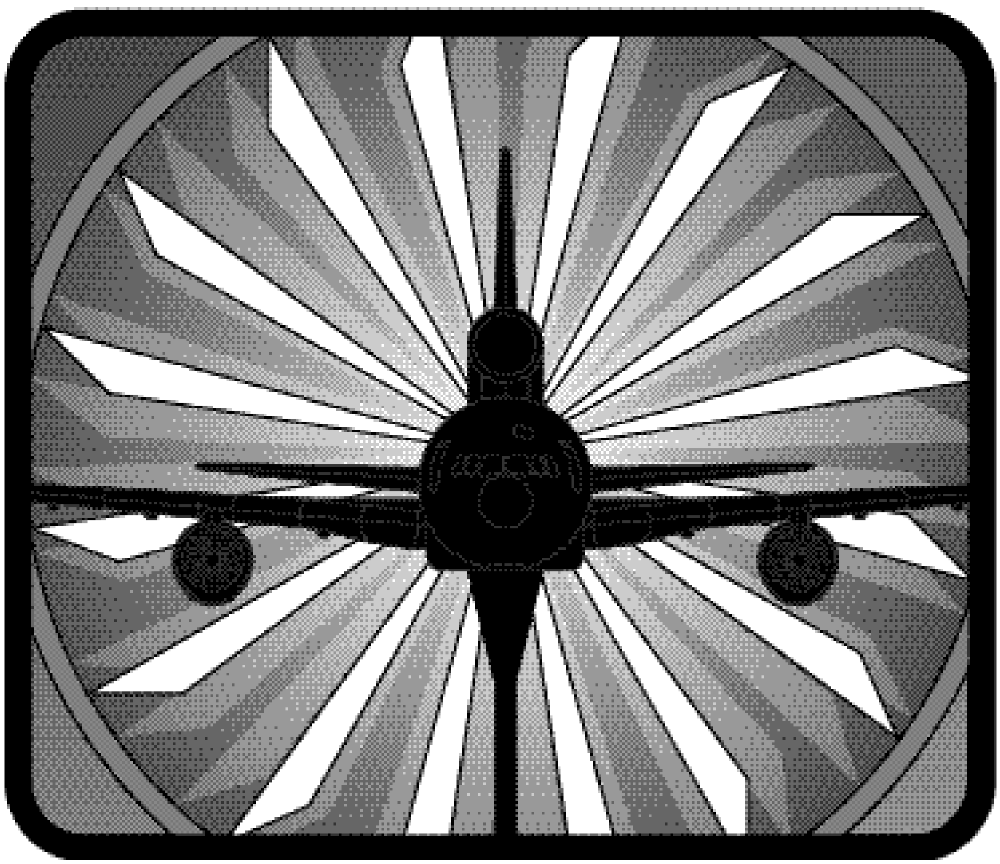
Educator's Guide	
Teachers & Students	Grades 4-8

A Series of Five Satellite (Television & Internet) Broadcasts

NASA con²ect

Program 2 in the 1998-1999 SERIES

THE SHAPES OF FLIGHT



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1998-1999 NASA CONNECT Program Overview

INTRODUCTION TO THE NASA CONNECT SERIES

NASA CONNECT is an award-winning instructional series produced by the NASA Langley Research Center's Office of Education (Hampton, VA). The series links the national mathematics and science standards to aeronautics and demonstrates the application of the standards through electronic visits by satellite and the Internet to the NASA workplace. Students engage in real or near real-time interactions with researchers and are exposed to innovative research, along with the tools and methods being used to conduct the research. The target audience is students in grades 4-8.

Each program in the NASA CONNECT series consists of a 30-minute instructional television broadcast accompanied by a web-based component designed to complement and extend the video and to facilitate the connection between the classroom and home. Inquiry into authentic questions is a central strategy used to "hook" the students into actively participating in the program and using the web components. Connections between mathematics and science concepts taught in the classroom and the workplace are emphasized.

Learning in a meaningful context is important for all students. Many television and web activities within the NASA CONNECT series are linked to form in-depth investigations that can be used in flexible ways. The investigations can be complete replacement units for parts of the present school curriculum or blended with other sources to give students explanations of ideas or practice with skills that are introduced or used in basal texts. Full integration of the series teaching protocol allows for active student participation in activities, group work, data gathering, student discourse, and journal writing. The activities and investigations in NASA CONNECT will prove useful in helping upper elementary and middle school students learn mathematics and science.

The 1998-99 NASA CONNECT program season uses aeronautics and space technology (AST) as its organizing theme. This theme will form the context to create interesting programs by featuring research questions that arise out of NASA's research. The theme addresses NASA's goals for AST that are grouped into three areas or "Three Pillars": *Global Civil Aviation*, *Revolutionary Technology Leaps*, and *Access to Space*. These goals reflect national priorities for the NASAAero-Space Technology Enterprise and require taking risks and performing the long-term research and development programs needed to keep the United States the global leader in aeronautics and space.

ABOUT THIS LESSON - THE SHAPES OF FLIGHT

The second program in the series is *The Shapes of Flight*, which involves students in the examination of the interaction between mathematics, science, and technology as they look at the process of airplane design. NASA researchers will show students the (engineering) process and tools to research, develop, test, and evaluate airplane designs. Students will see how the engineering process compares to the scientific method. Students will also calculate the glide ratio for a model paper airplane by using data collected by a featured classroom. Using the data, students will determine which method (shortest distance, longest distance, median or mean) of calculating the glide ratio is the "best" one. Students will be actively involved in organizing, comparing, and interpreting data.

The Shapes of Flight is a collaboration between NASAAmes Research Center, NASA Dryden Flight Research Center, NASA Headquarters, and NASA Langley Research Center. Additional program partners include the Smithsonian National Air and Space Museum, Dare County Airport, Kitty Hawk Kites, and Jockey's Ridge State Park.

PROGRAM FORMAT

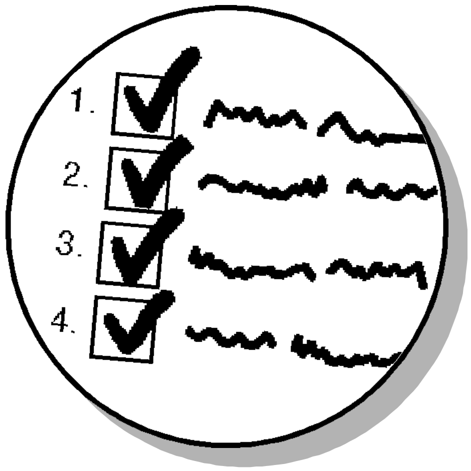
Each NASA CONNECT program includes the following:

- **NASAGuest** : The program features a program partner and a NASA engineer, scientist, or technician to illustrate the application of classroom lessons to the workplace.
- **Activities**: Students are involved in hands-on activities drawn from NASA educational products, including the National Council of Teachers of Mathematics (NCTM) math activity books, *Mission Mathematics*, developed in collaboration with NASA.
- **Students**: Middle school students who have conducted the program's experiment are highlighted. The results of their experiment are shared with viewers.
- **Challenge Point**: Most programs include a pause period in the flow of the program, in which students are presented with data and, working in pairs or small groups, are encouraged to perform analysis and data interpretation.
- **Call-In/E-mail**: Students can call-in following the Challenge Point portion of the program with questions related to the program topic, the activity, or the guest. Students can also E-mail questions one week prior to and two weeks following the live broadcast.
- **Print Materials**: Print materials are provided for registered educators. The materials include background on the program content and the featured activity, as well as a master copy of the Student Challenge Point Worksheets for copying and distribution to students. Also outlined is a teaching protocol for the implementation of the featured program activity and web investigation.
- **Web Site**: Throughout the program, the NASA CONNECT URL (http://edu.larc.nasa.gov/connect) will be displayed to indicate points where further details and/or interactive activities relating to the video presentation can be examined.

WEB FORMAT

The broadcast and the Internet are closely weaved in the NASA CONNECT series. The series uses the Internet in several ways to enhance the teaching and learning process.

- **Inquiry Instruction**: Students are provided with questions and investigations that require them to discover the generalities of the subject on the basis of practice examples. Feedback and elaboration are provided. Students gain new insight by making observations, developing inferences, making comparisons, and interpreting data.
- **Home Connection**: Parents are encouraged to be partners in the explorations and activities. The web site provides a means for the parent and child to share in the learning process. Educators are encouraged to make parents aware of the web site and to encourage this one-on-one discovery between the parent and child about the mathematics and science concepts.
- **Internet Simulcast**: Each NASA CONNECT program is simulcast in real time through the Internet. Educators are encouraged to check NASA's Learning Technologies Channel (http://quest.arc.nasa.gov/ltc/) schedule for further details on technology requirements and the broadcast schedule.
- **Registration and Feedback**: Educators can register on-line for NASA CONNECT, can obtain broadcast schedule information for their state, can download print materials, and can submit feedback about a program through the NASA CONNECT web site (http://edu.larc.nasa.gov/connect).



NCTM MATHEMATICS STANDARDS

- Problem Solving
- Number Sense and Numeration
- Patterns and Relationships
- Statistics
- Measurement
- Geometry

NCTM ASSESSMENT STANDARDS

- Talking and writing about predictions and interpretation of data help students confirm their learning
- Observing which students can use a data-collections form and which students need to learn how
- Engaging students in tasks that involve problem solving, reasoning, and communication

NSTA* SCIENCE STANDARDS

- Science as Inquiry
- Physical Science - Motion and Forces
- Science and Technology

* National Science Teacher's Association

NASA CONNECT MATRIX

The following matrix should help teachers organize the concepts from *The Shapes of Flight* program that complement each other (for better instruction). Teachers are encouraged to further extend and add to this matrix after viewing the program and reviewing their curriculum.

Math Standards	Science as Inquiry	Science & Technology
Geometry	Calculate the area for paper airplane model and wing area	NASA researchers demonstrate geometry modeling performed on the computer in the preliminary design configuration of blended wing model
Measurement	Measure the vertical distance to the nearest meter and use as the launch height (altitude) for the paper airplane Measure the horizontal distance to the nearest meter.	
Number Operations	Calculate the median Calculate the mean Calculate the glide ratio Calculate the ratio between total area and wing area of the airplane model	
Data Analysis	Collect data Keep records Graph results	NASA researchers discuss the necessary analysis performed on an unconventional configuration called a blended wing body.
Problem Solving	Determine which paper airplane design has the best glide ratio Engage in mathematical discourse to extend understanding of problem solving and capacity to reason and communicate mathematically	NASA researchers describe the technologies and engineering process used to research, design, develop, test, and evaluate futuristic airframe concepts Technologies provide tools for investigations, inquiry, and analysis

NASA CONNECT Teaching Protocol

There is a definite difference between "doing science" and doing science activities. Educators have few opportunities to work with scientists to develop an understanding of the nature of scientific inquiry. The model proposed to educators through the NASA CONNECT series is a shift from "activitymania" – a collection of hands-on activities that are often disconnected from each other – to inquiry, in order to introduce students to the process of searching for patterns and relationships and to better develop their higher order cognitive skills. Below is a six-step teaching protocol designed to prepare students for more active mental engagement to the video program so that they can make stronger connections between the NASA CONNECT program activities and appropriate mathematics and scientific concepts.

The six-step protocol includes reflective discussion, video engagement, dialogue notes, NASA CONNECT activity, journal writing, and NASA CONNECT web. This protocol is consistent with constructivist theory. A learning environment that promotes rich discourse among students is central to the approach. Student teams that engage in discovery, decision making, and problem solving give students opportunities to develop and present their findings to the entire class. The proposed format is flexible and is an effective way to teach students complex math and science concepts, to model science inquiry, and to emphasize connections.

STEP 1: REFLECTIVE DISCUSSION

Before viewing the NASA CONNECT program, list on the chalkboard the following questions to help students form their own theories and to give them a place to start constructing their knowledge about the show's topic. Have students share their thoughts or write their responses. Keep these questions on the board during the video. In addition to helping students prepare for the video, these questions can also serve as a pretest for assessment purposes.

1. What do you see as the relationship between science and technology?
2. What role do mathematics and mathematical tools have in scientific inquiry?
3. What value might collaborations and partnerships play in conducting research?
4. What forces help an airplane fly?
5. What effect does the size of an airplane's wing have on the performance of an airplane?
6. List the steps of the scientific method. How might the steps of the scientific method compare to the engineering problem-solving method?

STEP 2: VIDEO ENGAGEMENT

1. *Challenge Point.* Students work in cooperative groups to respond to the video's Challenge Point segment. During the Challenge Point, students are shown data from an experiment and are given a short time to respond to questions related to the data. The Student Challenge Point Worksheet appears on page 8, and teachers should copy and distribute the worksheet to students prior to the Challenge Point. One calculator per student group is also recommended.

2. *Call-In/E-Mail Opportunity.* Students can call and ask the NASA CONNECT guests questions during the call-in segment. E-mail questions can also be submitted for response one week before and two weeks following the live broadcast.

   Call in with questions (accepted during the live broadcast only) at
   Toll Free 1-888-835-0026 Local 864-3991

   E-mail questions (one week before and two weeks following the live broadcast date) to
   connect@edu.larc.nasa.gov

STEP 3: DIALOGUE NOTES

1. Immediately after the video, students should spend five to ten minutes reviewing the questions in the Step 1: Reflective Discussion section (page 5). Ask students to give examples from the video presentation that support their responses to each question.

2. Return to the Student Challenge Point Worksheet (page 8) and, if necessary, provide students with additional time to complete the mathematical calculations and the data analysis. Challenge students to come up with different kinds of investigations that can be created from the experiment.

STEP 4: NASA CONNECT ACTIVITY

Students learn from direct teaching, engaging in classroom discussion, conducting research, and taking notes. During the NASA CONNECT video an experiment is described. This activity (page 9) is provided for the educator to use as a math/science lab. When using the NASA CONNECT Activity, introduce students to the vocabulary, guide students toward connections, and explore misconceptions. Class data from the experiment can then be compared with the data collected by the students and highlighted in the video. Have students relate their lab experiment to the NASA research discussed in the video.

STEP 5: JOURNAL WRITING

Journal writing supports students' reflective thinking processes. Students should reflect on what they learned from the video and from their own experimentation. Educators can also ask students questions that relate to the real-life applications of the concepts in the video and their lab experiment. Educators might use journal questions to assess student understanding of the concepts at all levels of comprehension.

STEP 6: NASA CONNECT WEB

The web site uses the inquisitory instruction strategy to place students in a contextual environment to encourage them to discover the math and science concepts and skills behind the program's topic and to present multiple perspectives to specific questions raised in the video. An on-line experiment or series of activities is incorporated into the NASA CONNECT web site for each program to augment the video theme and to provide additional opportunities for students to perform multiple trials and share their data with others. Also, from the web site, students might submit E-mail questions to the on-air program guests up to two weeks following a live broadcast.

Educators might use this site to provide a connection between the classroom and home, such as sending home a notice about the NASA CONNECT program and its Internet URL and by encouraging parents to explore this site and complete the activities with their children.

From *The Shapes of Flight* web site, students can access the newly created NASA Langley Kids Corner page (http://kidscorner.larc.nasa.gov). An aeronautics poster hanging on the virtual wall of the Kids Corner will transport students to the on-line **Aeronautics Camp**. The six activities at the camp have been created to mirror the work that occurs at an aeronautical research lab and makes the students important members of an on-line research team. The activities culminate in an **Air Olympiad event**.

Many of the Aero Camp activities have been borrowed and modified from the NASA/NCTM product, *Mission Mathematics: Linking Aerospace and the NCTM Standards*. For more information on this product, check out the NCTM home page at http://www.nctm.org

Built within the program's design is a pause period (approximately four minutes long) in which students will be asked to look at generated data and, working in pairs or small groups, respond to questions, one at a time, as listed on the Challenge Point Worksheet. This pause period is important for providing students the opportunity to work with information presented up to this point and to actively examine and work with data in support of the NCTM standards.

During the Challenge Point Period

Teacher as Facilitator

1. Depending on the students, teachers may wish to have a large group or to divide students into pairs or smaller groups. This grouping should be done before the program.
2. The teacher is to act as a facilitator during this program time, supporting and guiding the students in discussion and in responding to the worksheet questions.

Student as Researcher

By working in pairs or small groups, students will better understand how NASA research teams work together to analyze and interpret findings and to communicate results in written, oral, and graph forms.

1. Observe the data shown on the television, as displayed on the Challenge Point Worksheet. The data were recorded by the featured school by using the Basic Square Paper Airplane Model.
2. Questions pertaining to the data will be presented one at a time on the videotape. Students will have a limited amount of time to discuss the question with their partner(s), calculate an answer, if necessary, and write down a response.
3. Feedback to the questions will be presented at the end of the Challenge Point period. Review the answers. Following the program, continue the discussions, if necessary.

Student Challenge Point Worksheet

Name of Airplane Model: The Basic Square Paper Airplane Model

Group Members: ______________________________

Trial	Distance Flown	Altitude	Glide Ratio
1	1.73 m	2.20 m	
2	4.00 m	2.20 m	
3	1.80 m	2.20 m	
4	1.50 m	2.20 m	
5	5.00 m	2.20 m	
Mean ($\bar{X}$)			
Median			

$$\text{Glide Ratio} = \frac{\text{Distance Flown}}{\text{Altitude}}$$

Challenge Point Questions

1. Calculate the glide ratios for the shortest and longest distance flown.
2. Calculate the mean and the median for the distance flown.
3. Predict how far the airplane would glide if launched from a height twice the experimental altitude shown in Trial 5.
4. Using the formula below, convert the distance flown in Trial 1 from meters to feet.

$$\text{Distance Flown (f)} = \frac{\text{Distance Flown (m)}}{0.3048}$$

NASA CONNECT Activity

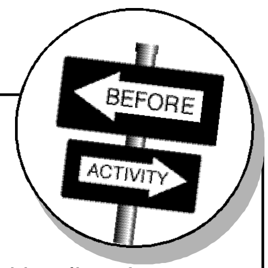
Students will investigate the glide ratio for a model airplane and determine which method (shortest distance, longest distance, median, or mean) of calculating the glide ratio is the "best" one in describing the plane's glide ratio.

EXPERIMENT MATERIAL (For each group of four students)

- airplane pattern (select from the four patterns on pages 14-19: Egret, Flex, Basic Square, and Condor)
- 1 piece 8-1/2" x 11" paper (typing paper)
- meter stick or metric tape measure

VOCABULARY TERMS

Glide ratio - the horizontal distance that the airplane will travel from a given altitude in the absence of power and wind; $\text{Glide Ratio} = \frac{\text{Horizontal Distance Flown}}{\text{Change in Altitude}}$



BEFORE THE ACTIVITY

1. Make copies of the airplane patterns.
2. Make copies of the data sheet and distribute to students.
3. Divide the class into small groups and have each group come up with a list of questions about the program topic. Have groups share their group questions.
   a. List each group's questions on the board and then select, as a class, 2 to 3 questions from the list.
   b. E-mail these questions to NASA CONNECT at connect@edu.larc.nasa.gov

STEP 1: CLASS REFLECTION/JOURNAL

In your journal, answer the following questions:

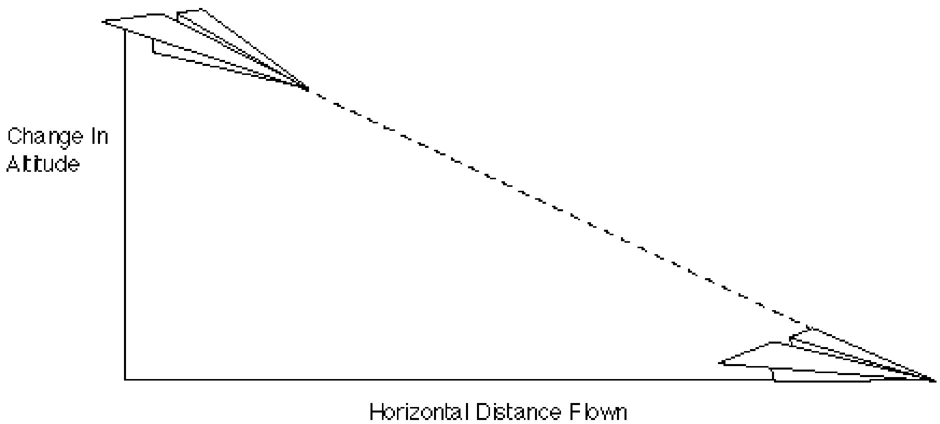
1. The four stages in the development of an aircraft are concept, design, modeling, and testing. List the stages in conducting a scientific experiment. Compare the two sets of stages. In what ways are the stages similar?
2. How are median, mean, and ratio similar? How are they different? When is the use of each particular value more appropriate?
3. What geometric shapes do you find in most airplanes?
4. What attributes of an airplane might affect the distance that the airplane flies?

STEP 2: THE ACTIVITY

Follow these directions to complete the activity.

1. Divide the class into at least four small groups (4-5 members per group). Distribute an airplane pattern to each group. Each group should use the pattern to construct a model airplane.
2. Set up an area to conduct test flights. You might use a length of cord, marked off in meters, anchored to a "starting line."

3. Have groups test-fly their airplanes. Be sure to instruct students about the importance of launching the model airplanes from a constant height and with a consistent amount of force for each trial in the experiment. Groups should conduct a minimum of five test flights.



Data from each flight should be collected and recorded onto the worksheet. Groups should measure the distance traveled by their model from the launch point to when the model first hit the ground (not necessarily the same as when the airplane came to a complete stop).

Each group should calculate the median and mean for its data. Then have each group compute the glide ratio for each of these distances: shortest, longest, median, and mean. Finally, have students analyze their data and glide ratios and answer the questions listed in Step 3.

$$\text{Glide Ratio} = \frac{\text{Distance Flown}}{\text{Altitude}}$$

STEP 3: DIALOGUE NOTES

Students should review their observations and data and then respond to these questions in their logs.

1. Which of the glide ratios that you have computed is the “best” one to use in describing your plane’s glide ratio? Why?
2. How far would you predict the plane would glide if it were launched from a height twice your experimental height?
3. Predict the height you would have to launch the plane in order to have it glide three times as far as the distance you used to determine the best glide ratio.

STEP 4: JOURNAL WRITING

1. How do the steps of the scientific method compare to the engineering problem-solving method you heard discussed in the program?
2. What do you think are the determining factors for assessing the optimal wingspan for an aircraft?
3. What steps would you take to build the world’s largest paper airplane and break the Guiness Book of World Record established in the 1980’s by high school students from the Hampton City Schools in Hampton, Virginia?

STEP 5: ELECTRONIC EXTENSION

1. Divide students into small groups. Have each group check out the *Shapes of Flight* web site (http://edu.larc.nasa.gov/connect/shapes.html) and complete the on-line investigation.

2. Inform parents about the *Shapes of Flight* web site and invite them to explore this site with their children.

STEP 6: ADDITIONAL CLASSROOM EXTENSION ACTIVITIES

1. Determine the ratio of the area of the wings to the total surface area. Begin this experiment by determining how much of your airplane's total material is devoted to its wings. We can use surface area to find the ratio of the material in the wings to the total material in the plane. Unfold your airplane. Determine the total area of the paper. Next, measure each of the smaller areas that help to form the wings of your plane. Calculate the ratio of the areas:

$$\frac{\text{Area of Wings}}{\text{Total Area of Paper}}$$

Hint: The students will need to consider how to measure the area of the wings. For the area of triangular wings, the following formula can be used: $A = 1/2bh$, where b is base and h is height. For wings that are irregular in shape, have the students brainstorm ideas for finding the area. A possible technique is to use graph paper to facilitate the counting squares inside the area covered by the shape of the wings. Let the students use their knowledge of fractions to estimate the area of each partial piece. These areas can be added by using paper-and-paper algorithms, a fraction calculator, or by estimating the area of partial squares as half, regardless of its size.

Next, have students use this ratio to test the idea: Does having larger or smaller wings help a plane stay in the air longer?

- Modify designs of model airplanes to INCREASE the size of the wings (by reducing the amount of paper used for the other surfaces of the airplane).
- Test fly new design to see if modifications have increased or decreased glide ratio.
- Conduct experiment 1 again using your new design.
- Plot the data for both planes to help analyze the effects of your redesign.
- Compare findings with other students' results.

2. Use the data already collected to make some predictions about flights begun from other altitudes. Test the idea that the glide ratio of the paper airplane will (or will not) change if it is launched from a different height.

- Do the mathematics. If the glide ratio of the paper airplane does not change, then the following proportion will hold true:

$$\frac{\text{Height 1}}{\text{Distance 1}} = \frac{\text{Height 2}}{\text{Distance 2}}$$

(Substitute for height 1 the height you used as a launch height in experiment 1. Substitute for distance 1 the distance that you used to determine the “best” glide ratio.)

- How far would you predict the plane would glide if it were launched from a height twice your experimental height?

- Predict the height from which you would have to launch the plane in order to have it glide three times as far as the distance you used to determine the “best” glide ratio.

- Verify the hypothesis. Determine a launch height that you can reach by standing on a stairway or another safe platform. You will need to determine the height and the glide distance, so plan this part of the experiment carefully.

- Conduct experiment 1 again from this new height. Find the glide ratio of the plane from this height. Compare your data with the original data you collected in experiment 1. Is the glide ratio the same?

  Use the Student Activity Worksheet on page 13 to record your findings.

Student Activity Worksheet

Name of Airplane Model: ______________________________

Group Members: ______________________________

Horizontal Distance Flown
1.
2.
3.
4.
5.

Mean ($\bar{x}$)	
Median	

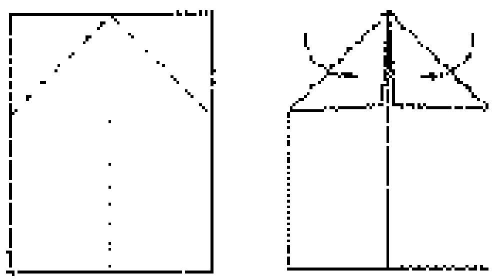
$$\text{Glide Ratio} = \frac{\text{Horizontal Distance Flown}}{\text{Change in Altitude}}$$

Altitude	Horizontal Distance Flown	Glide Ratio
	Shortest:	
	Longest:	
	Mean:	
	Median:	

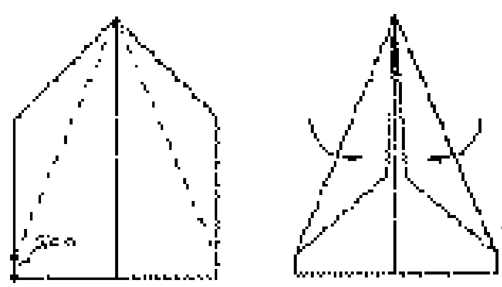
The Egret Paper Airplane

Directions for Constructing the Egret

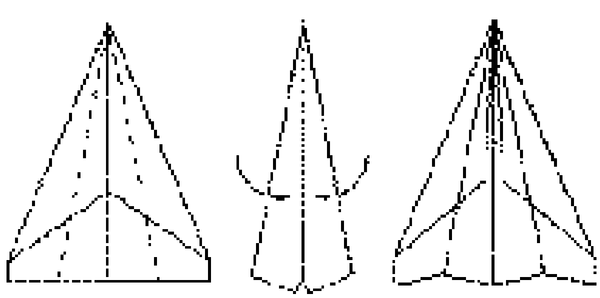
Step 1
Use a full sheet of typing paper. Using the mountain fold, fold the paper in half lengthwise. Unfold. Then valley-fold the upper corners to the center crease.



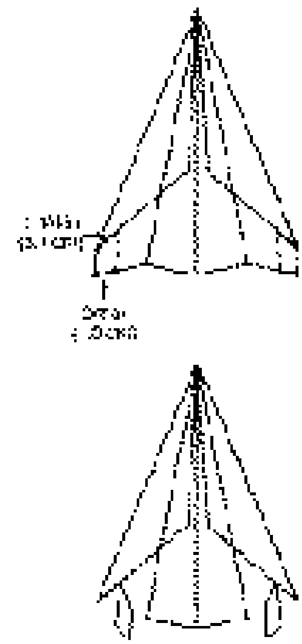
Step 2
Valley-fold along the dashed lines to form triangles that meet the center crease, as shown.



Step 3
Valley-fold the outer edges to meet the center crease as shown by the dashed lines. Unfold as shown.



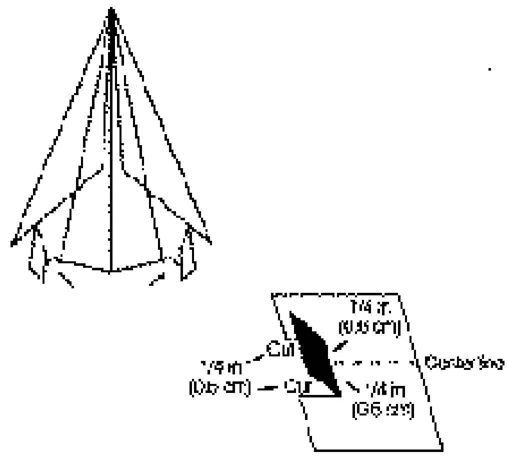
Step 4
On each side, measure along the diagonal edge of the paper, as shown by the heavy line, and cut. Along the bottom edge, measure 5/8 in. (1.6 cm) from each wingtip, and from this point, draw a line to the end of the cut. Valley-fold along this line to make vertical tails.



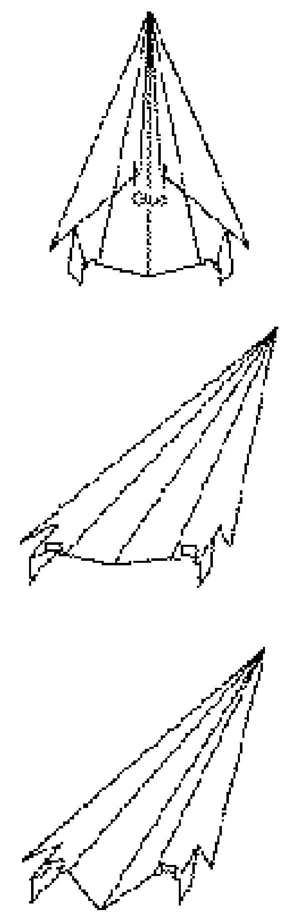
Making the Airplane
The Egret is constructed similarly to the common paper airplane that everyone makes, but because of this model's carefully measured shape, it can attain a very smooth and flat glide. Make sure that its shape is properly adjusted, with vertical tails straight up and down. Hold it between thumb and forefinger, launching it gently straight ahead.

The Egret Paper Airplane (Cont.)

Step 5
In the locations shown, find the centerline, measure, cut, and fold the elevators.



Step 6
Glue the folds only at the center of the fuselage. Flip the airplane over. Adjust the shape so that when viewed from the back, the airplane makes a shallow upside-down W, as shown.

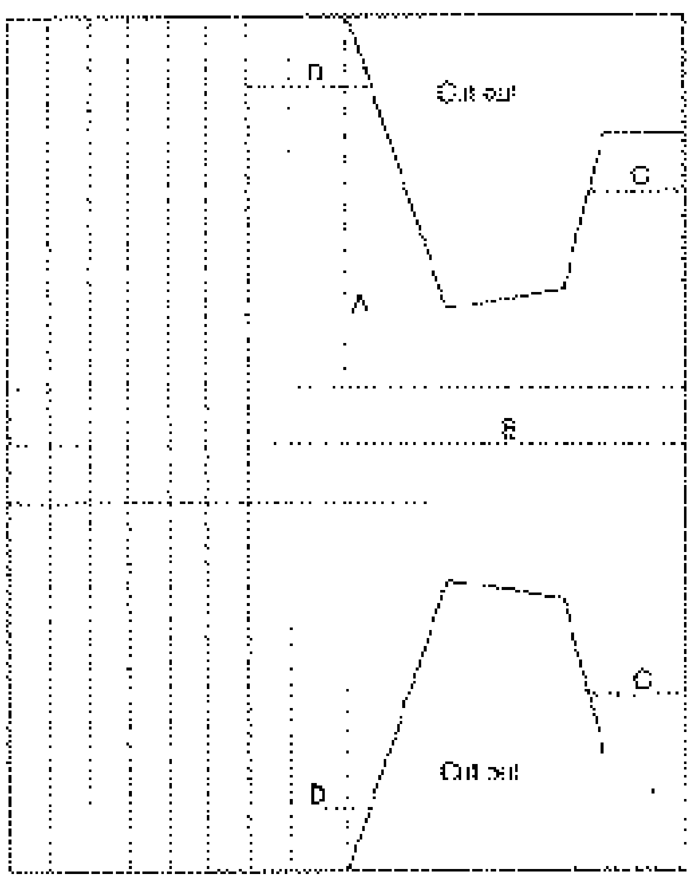


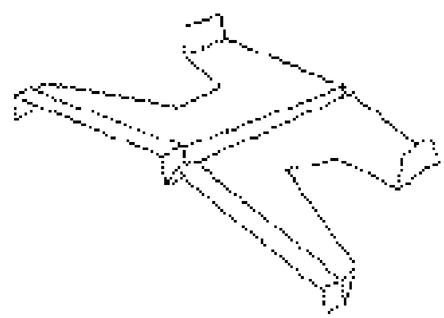
The Flex Paper Airplane

Directions for Constructing the Flex

1. Find centerline A of a sheet of typing paper. Valley-fold on that line and crease it. Then open the sheet.
2. Mark off seven lines, each 0.5 in. apart, parallel to the left leading edge. Valley-fold and crease along each line, "rolling" the paper flat toward the tail end.
3. Valley-fold on centerline A. Cut out the wings and tail sections of the plane as shown on the pattern.
4. Mountain-fold on both sides of line B about 0.5 in. from line B to form the body of the plane.
5. Valley-fold to form the tail flaps and mountain-fold to form the wing flaps as indicated by dashed lines C and D on the pattern.

By changing the positions of the wing and tail flaps, students can make this plane perform many different maneuvers.





The Basic Square Paper Airplane

Direction for Constructing the Basic Square

1. Use a full sheet of typing paper (see fig. 1).
2. Begin to make parallel valley folds, starting at the bottom of the sheet (see fig. 2).
3. Continue until the "wing" areas are almost square (see fig. 3).
4. Valley-fold along the centerline (see fig. 4).
5. Mountain-fold the two wings parallel to the centerline, leaving about 0.5 cm on either side of the line for the body of the plane (see figs. 5 and 6).
6. Be sure to crease the folds neatly at the front of the plane.

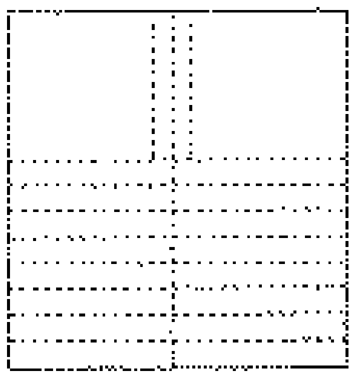


Figure 1

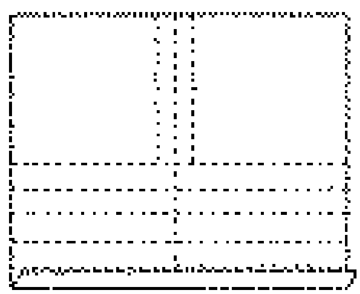


Figure 2

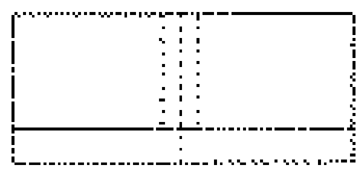


Figure 3

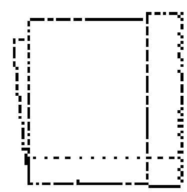


Figure 4

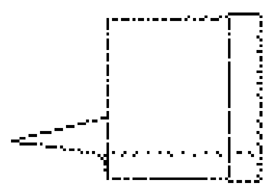


Figure 5

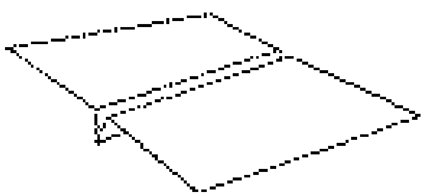


Figure 6

7. To fly well, your plane should have its wings higher than the body in a Y shape (see fig. 7).

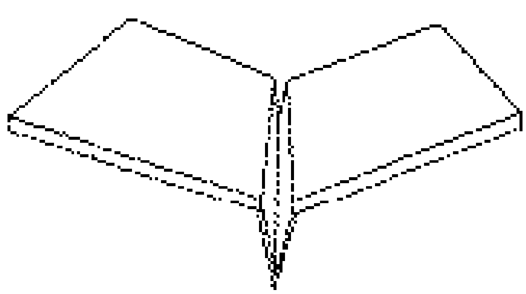


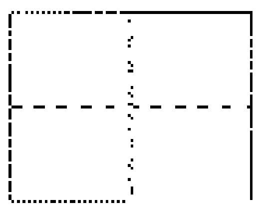
Figure 7

This plane is modeled after the "Basic Square," described by Ken Blackburn in *The World Record Paper Airplane Book* (1994). Ken is the world-record holder for keeping a paper airplane aloft (18.80 sec.).

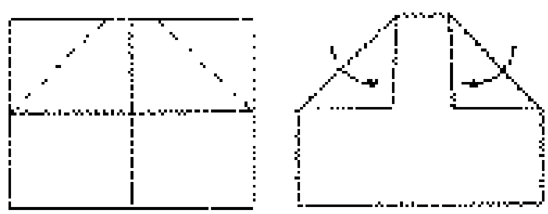
The Condor Paper Airplane

Directions for Constructing the Condor

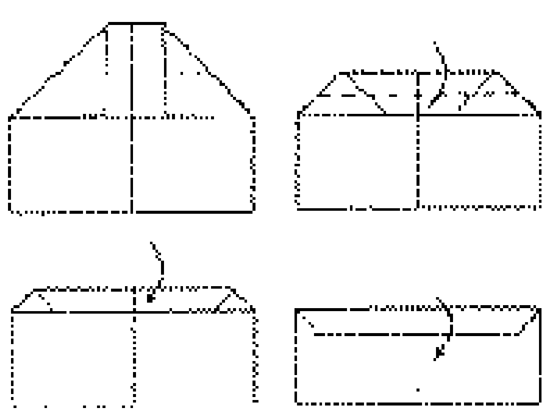
Step 1
Use a full sheet of typing paper. Mountain-fold the paper in half lengthwise. Unfold. Then valley-fold it in half perpendicular to the first fold. Unfold.



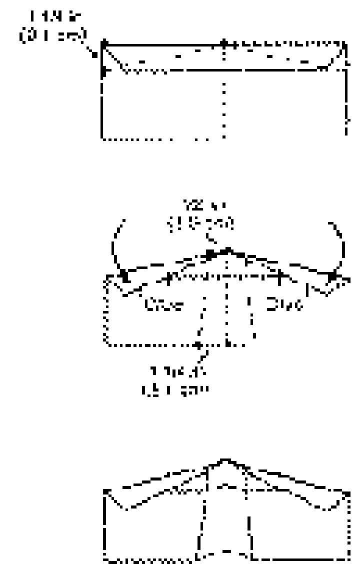
Step 2
On each side, valley-fold the top corners diagonally so that the outer edges meet the horizontal crease.



Step 3
Make a valley fold parallel to the step-1 lengthwise crease so that the top edge meets the crease. Make another valley fold so that the top edge meets the crease. Then refold the original lengthwise crease.



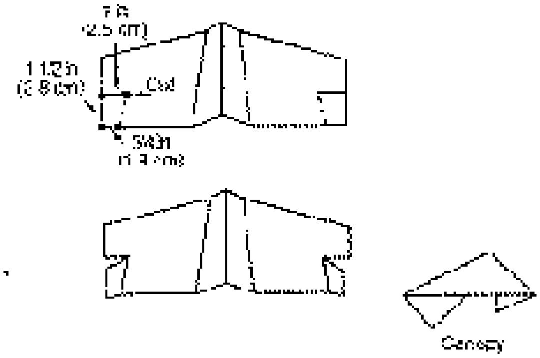
Step 4
On each side of the step-1 perpendicular crease, measure and draw diagonal lines as shown. Valley-fold the top outer edges along these lines. Glue the folded-over triangles to form the leading (front) edges of the wings. Then measure and draw lines as shown. Valley-fold along these lines to form the fuselage.



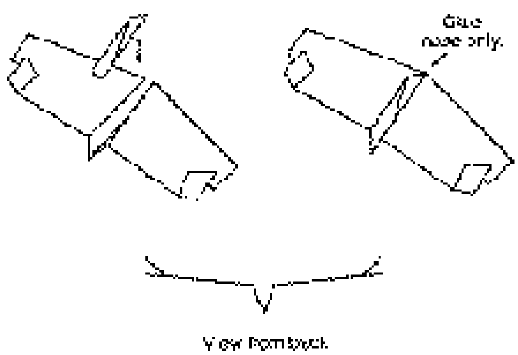
Making the Airplane
Condors have large feathers at their wingtips for control. Instead of feathers, this airplane has winglets. Because of its wide wing span, this paper airplane is fragile where the wings meet the fuselage. Adjust the winglets and bend the airplane to adjust the trim.

The Condor Paper Airplane (Cont.)

Step 5
Flip the plane over. On each side, measure and draw the lines for the winglets as shown. Cut on the heavy lines. Valley-fold as indicated to make the winglets. Make the canopy.

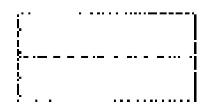


Step 6
Apply glue to the inside of the nose only and insert the canopy. Align it with the nose. Adjust the shape so that the wings have a slight dihedral angle (upward slant) and the winglets slant upward, as shown.

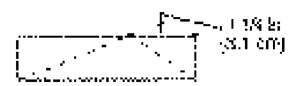


Making the Canopy

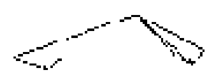
1. Measure and cut a 2in. X 3 in. (5 cm × 7.5 cm) rectangle from paper. Lay the paper flat. Use a mountain fold to fold it in half lengthwise.



2. Measure the top point as shown, and draw diagonal lines to the corners. Then, with the paper folded in half, as in step 1, sink-fold the corners. A sink fold changes part of a mountain fold into a valley fold.



3. Press the canopy flat to finish it.



NASA Aeronautics Educator Resources

The NASAAero-Space Technology (AST) Enterprise and the aviation and educational communities are partners in developing materials to stimulate student interest and enthusiasm for science and mathematics. By augmenting learning environments with ideas and experiences that use mathematics and science, we share with students and educators the excitement of how these tools can be used and how their power can change the world.

NASA ON-LINE AERONAUTICS PROJECTS

Follow these on-line links to more aeronautics-related projects that provide curriculum, interactive materials, activities, and more, as developed by NASA's AST Centers and Learning Technologies Project (LTP) Offices and by external partners through LTP-funded electronic projects!

Aeronautics and Aviation Science Careers and Opportunities (Massachusetts Corporation for Educational Telecommunications)	http://mcet.edu/nasa
Aeronautics Learning Laboratory for Science, Technology and Research (ALL STAR) (Florida International University)	http://allstar.fiu.edu/aero
IITA K-12 Wind Tunnel Program (NASA Lewis)	http://www.lerc.nasa.gov/WWW/K-12/WindTunnel/windlist.html
Internet-based Curriculum on Math and Aeronautics for Children with Physical Disabilities (InfoUse, Inc.)	http://planemath.com/
K-8 Aeronautics Internet Textbook (Cislunar Aerospace, Inc.)	http://wings.ucdavis.edu/
Kids Corner (NASA Langley)	http://kidscorner.larc.nasa.gov/
Lego Data Acquisition and Prototyping System (Tufts University)	http://ldaps.ivv.nasa.gov/
NASAAeronautics Enterprise Web Ground School (NASA Headquarters)	http://www.hq.nasa.gov/office/aero/edu/
Off to a Flying Start (NASA Langley)	http://k12unix.larc.nasa.gov/flyingstart/
Sharing NASA (NASAAmes)	http://quest.arc.nasa.gov
SRA On-line (NASA Dryden)	http://quest.arc.nasa.gov/sra

NASA ON-LINE RESOURCES FOR EDUCATORS

NASA Spacelink (http://spacelink.nasa.gov) is one of NASA's electronic resources specifically developed for use by the education community. This comprehensive electronic library offers teacher guides, wall sheets, and listings of videos, computer software, and other materials that have been developed to meet national education standards. Educators can search specific curriculum materials by grade level and subject matter. Current and historical information related to NASA's aeronautic and space research can be found from Spacelink. Links to other NASA resources, news releases, current state reports on agency projects and events, and television broadcast schedules for NASA Television are also given. Finally, a contact list of NASA Educator Resource Centers is located in most states, and the Central Operation of Resources for Educators (CORE) is available through NASA Spacelink.

Quest (http://quest.arc.nasa.gov) is the home of NASA's K-12 Internet Initiative. The electronic resource specializes in providing programs, materials, and opportunities for teachers and students to use NASA resources as learning tools to explore the Internet. One of its unique projects is "Sharing NASA," a series about on-line, interactive units where students can communicate with NASA scientists and researchers to experience the excitement of real science in real time. During the 1998-99 academic year, Aero Design Team On-line will be a featured project of "Sharing NASA."

Learning Technologies Channel (LTC) (http://quest.arc.nasa.gov/ltc/) is a NASA location on the Internet that allows you to participate in on-line courses and to remotely attend some NASA workshops and seminars. A primary focus of the LTC is to broaden the uses of the Internet to include in-service teacher training and to bring new Internet experiences into the classroom.

NASA CENTRAL OPERATION OF RESOURCES FOR EDUCATORS (CORE)

NASA's CORE is a worldwide distribution center for NASA's multimedia educational materials. Educational materials include videotape programs, slide sets, and computer software. For a minimal fee, NASA CORE will provide educators with materials through its mail order service. A free NASA CORE catalog is available.

NASA CORE
15181 State Route 58
Oberlin, OH 44074-9799
phone: (440) 775-1400
fax: (440) 775-1460
E-mail: nasaco@leeca.esu.k12.oh.us
URL: http://core.spacelink.nasa.gov

NASA EDUCATIONAL PROGRAMS AND MATERIALS

The widest possible distribution and use of NASA educational programs and materials is encouraged. Specifically, there is no claim of copyright by the U.S. Government concerning the NASA CONNECT series. Therefore, permission is not required to either tape each broadcast or to copy the associated print materials for classroom use and/or retention in your school's library.

NASA EDUCATOR RESOURCE CENTERS (ERC)

The NASA ERC Network is composed of Educator Resource Centers located at or near all NASA installations and ERCs located at planetariums, universities, museums, and other nonprofit organizations nationwide. These centers supply instructional activities, videotapes, slides, and computer software generated by NASA programs, technologies, and discoveries. These materials are designed for educators of all disciplines and are aligned to the national education standards.

For more information on NASA education programs and aeronautics-related materials, educators may contact the following NASA Centers' ERCs. The NASA installations that have the lead research programs in the NASAAero-Space Technology (AST) Enterprise are underlined:

AK, AZ, CA, HI, ID, MT, NV, OR, UT, WA, WY
NASA Ames Educator Resource Center
Mail Stop 253-2
Moffett Field, CA 94035-1000
(650) 604-3574

CA cities near the center
NASA Dryden Educator Resource Center
45108 North Third Street East
Lancaster, CA 93535
(805) 948-7347

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Goddard Educator Resource Center
Mail Code 130.3
Greenbelt, MD 20771-0001
(301) 286-8570

CO, KS, NE, NM, ND, OK, SD, TX
NASA Johnson Educator Resource Center
Mail Code AP2
2101 NASA Road One
Houston, TX 77058-3696
(281) 483-8696

NASA JPL Educator Resource Center
Mail Stop 601-107
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-8080 - fax

FL, GA, PR, VI
NASA Kennedy Educator Resource Center
Mail Code ERL
Kennedy Space Center, FL 32899-0001
(407) 867-4090

KY, NC, SC, VA, WV
NASA Langley Educator Resource Center
Virginia Air and Space Center
600 Settlers Landing Road
Hampton, VA 23669-4033
(757) 727-0900, ext. 757

IL, IN, MI, MN, OH, WI
NASA Lewis Educator Resource Center
Mail Stop 8-1
21000 Brookpark Road
Cleveland, OH 44135-3191

AL, AR, IA, LA, MO, TN
NASA Marshall Educator Resource Center
U.S. Space and Rocket Center
P.O. Box 070015
Huntsville, AL 35807-7015
(205) 544-5812

MS
NASA Stennis Educator Resource Center
Building 1200
Stennis Space Center, MS 39539-6000
(601) 688-3338

VA's and MD's Eastern Shore
NASA Wallops Educator Resource Center
Education Complex - Visitor Center
Building J-1
Wallops Island, VA 23337-5099
(757) 824-2297/2298

Return by Fax to: (757) 864-8835

1998-99 NASA CONNECT Series Program Evaluation

About the Program

		(please circle)	
1.	The program was used		
	a. to introduce a curriculum topic, objective, or skill.	Yes	No
	b. to reinforce a curriculum topic, objective, or skill.	Yes	No
	c. as a special interest topic.	Yes	No
	d. other (please specify)____		
2.	The program was viewed	Live	Videotaped
3.	Indicate the grade level(s) that viewed the program:	4 5 6 7 8	
	Other (please specify) ______________________________		

The Program's Value

Please circle the number that best reflects your opinion.

		Strongly Disagree				Strongly Agree	No Opinion
4.	The program met its stated objectives.	1	2	3	4	5	0
5.	The program's content was developmentally appropriate for grade level.	1	2	3	4	5	0
6.	The program's content was aligned with the National Math and Science Standards.	1	2	3	4	5	0
7.	The program's content was easily integrated into the curriculum.	1	2	3	4	5	0
8.	The program's content enhanced the teaching of math and science.	1	2	3	4	5	0
9.	The program raised student awareness of careers that require math and science knowledge.	1	2	3	4	5	0
10.	The program presented:						
	a. the application of math and science on the job.	1	2	3	4	5	0
	b. workplace science as a collaborative process.	1	2	3	4	5	0
	c. science as a process requiring creativity, critical thinking, and problem-solving skills.	1	2	3	4	5	0
11.	The technical aspects of the video production were professional.	1	2	3	4	5	0
12.	The program's web-based component enhanced student interest in learning math and science.	1	2	3	4	5	0

The Lesson Guide/Classroom Activity's Value

13.	The Lesson Guide was complete.	1	2	3	4	5	0
14.	The Lesson Guide was easily understood.	1	2	3	4	5	0
15.	The classroom activity (experiment) was developmentally appropriate for grade level.	1	2	3	4	5	0

Overall Evaluation

16.	The program was a valuable instructional opportunity.	1	2	3	4	5	0

Please record any comments or suggestions on an additional sheet of paper and fax with this form.

Evaluator's Characteristics (please circle)

17. Gender: Female Male

18. Ethnicity: African American Asian
Caucasian Hispanic Native American Pacific Islander
Other (please specify) ________________________

19. Highest Degree attained
Baccalaureate/BA or BS
Master's/Master's Equivalency
Doctorate

20. Total years' teaching experience _____