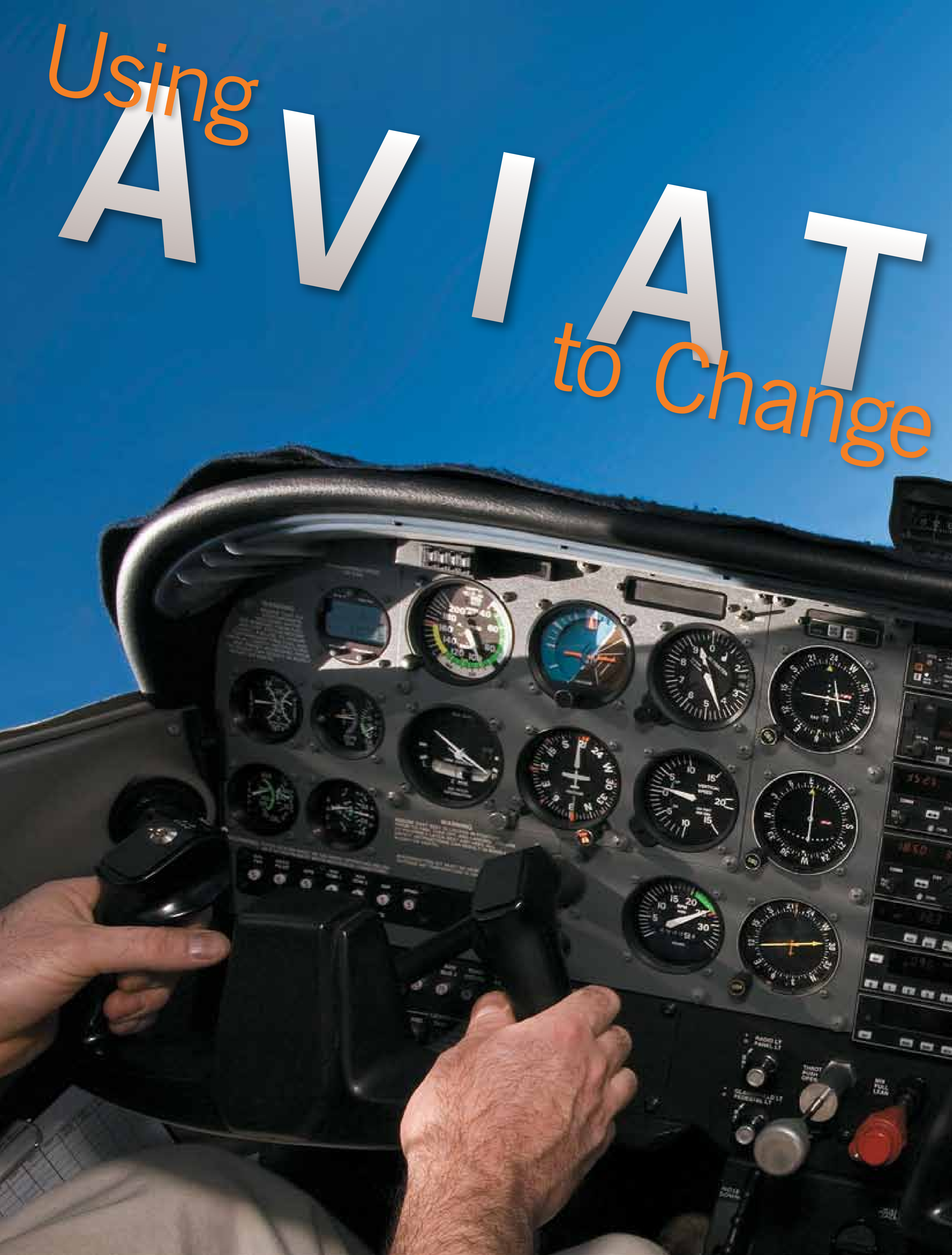
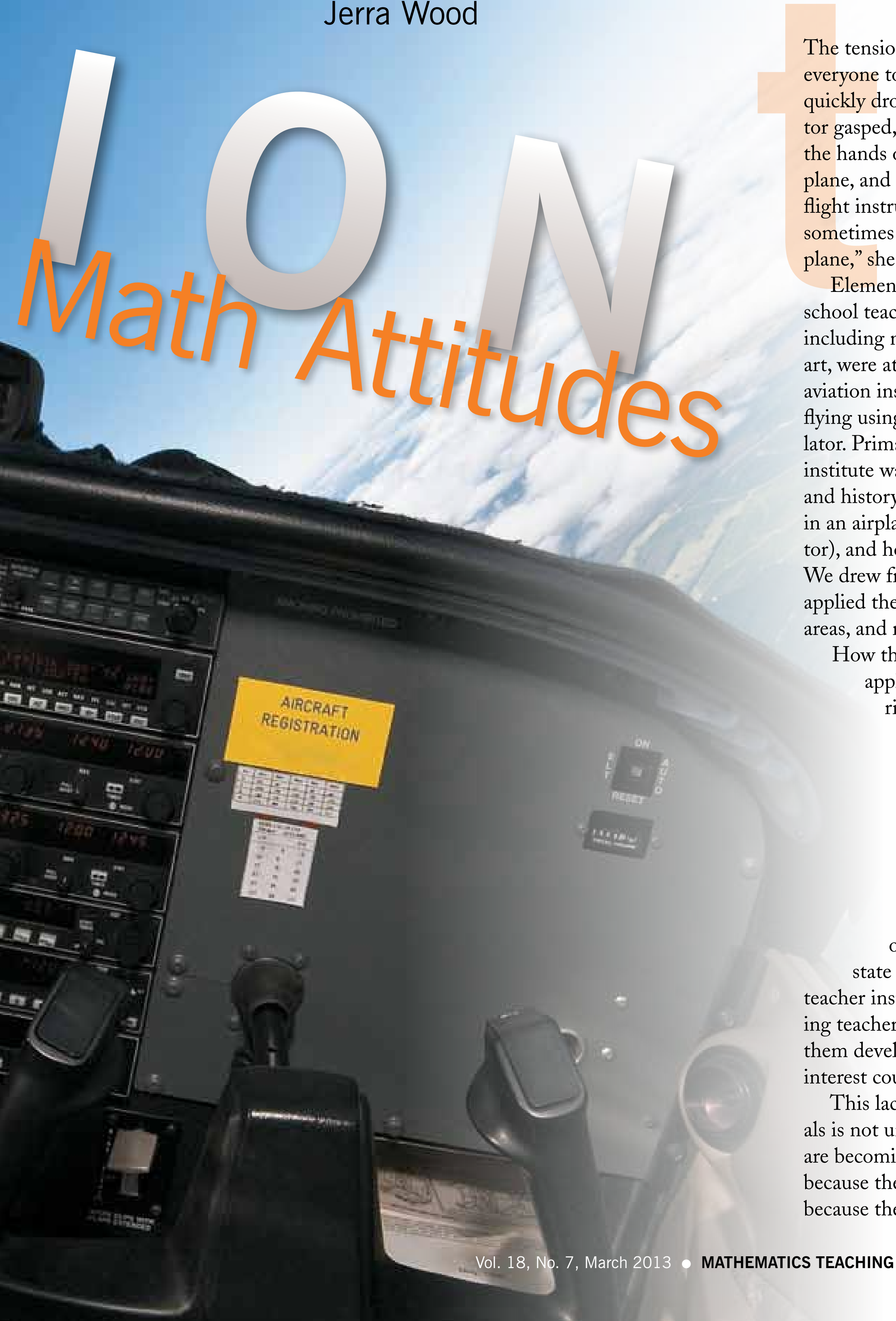
Using AVIAT to Change



A flight simulator presents a new STEM slant on students' knowledge of linear equations.

Jerra Wood

Math Attitudes



MIKULAS1/ISTOCKPHOTO

The tension was strong enough for everyone to feel. The altimeter was quickly dropping. The flight instructor gasped, pulled the controls from the hands of the student piloting the plane, and leveled the aircraft. The flight instructor sighed with relief. "I sometimes forget that it's not a real plane," she said, laughing at herself.

Elementary, middle, and high school teachers of various subjects, including mathematics, science, and art, were attending an educators' aviation institute and were practicing flying using Microsoft's Flight Simulator. Primarily what we learned at the institute was flying—the principles and history of flight, how to take off in an airplane (by way of the simulator), and how to approach a landing. We drew from the concepts learned, applied them to our individual subject areas, and related them to our content. How the study of aviation can be applied to such a range of curricula is amazing.

The Kentucky Aviation Teacher Institute (KATI) was an initiative of our state department of aviation. About six or seven years ago, Kentucky had unfilled jobs in aviation, in part because of a lack of qualified applicants. The state developed the aviation teacher institutes as a way of interesting teachers in aviation and helping them develop lessons so that this interest could be nurtured in students.

This lack of qualified individuals is not unique to my state. "These are becoming difficult jobs to fill, not because there is a labor shortage, but because there is a skills shortage. Our industry needs more innovative young scientists, technologists, engineers, and mathematicians . . ." (Aerospace Industries Association 2010).

CAREERS IN AEROSPACE

Piloting an airplane is the first job that comes to mind when thinking about aerospace careers, but many more options are available. Pilots would not have planes to fly without having had engineers design them and technicians build them. Aircraft mechanics keep the engines operational. Air traffic controllers provide direction for safe flights and landings. Architects design airports. Public safety officials ensure the security of passengers. Airports employ food service workers and baggage handlers. Astronauts, emergency personnel, lawyers, chemists, customs agents, flight trainers, fighter pilots, ticketing agents, computer programmers, and many others have roles in the aerospace industry (Aircraft Owners and Pilots Association 2003).

CLASSROOM APPLICATION

Mathematics teachers are constantly looking for real-world applications of mathematics. Aerospace education provides an incredible context for teaching and learning important STEM concepts, inspiring young people to pursue careers in science, technology, engineering, and mathematics (NSTA 2008). Teaching mathematics within the context of aerospace generates excitement and interest among students.

My favorite mathematics lesson from KATI, developed by Tim Smith of the Kentucky Institute of Aerospace Education, introduces linear equations using the Microsoft Flight Simulator X®. The Kentucky Institute of Aerospace Education works to improve learning in STEM topics and to provide direction to careers in aviation (Kentucky Institute of Aerospace Education 2010). This lesson combines rich mathematical content within the context of aerospace education.

INTRODUCING THE ACTIVITY

"Who has flown in an airplane?" To open the lesson on linear equations, I asked this question in Debra Allen's class of sixth-grade students at Turkey Foot Middle School in Edgewood, Kentucky. Just asking a simple question about aviation generated excitement in the room. As a follow-up, students were asked, "Who has actually assisted in flying an airplane?" Some middle school students may have had the opportunity to help pilot a plane. As long as they can reach the controls, students may begin to learn to fly at eleven or twelve years of age and may become licensed at age seventeen (SunState Aviation Flight School n.d.). Students were then told that some of them would have the opportunity to pilot an airplane during takeoff using a simulator.

Before introducing the students to the flight simulator, the class discussed associations they had with the word *linear*. Student answers included "slope," "straight," "line," "diagonal," "increasing," "graph," "it doesn't curve or turn," and "dots that connect in a straight line." One insightful student said that linear was used in flight to locate where you are going to go. The thinking shown by these answers included some ideas that were right on target and some that needed adjusting. I told the students that we were going to see how the ascent of an airplane during takeoff results in a linear equation.

READING FLIGHT INSTRUMENTS

Next, the students were introduced to Microsoft's Flight Simulator. Before class, I had opened the program and selected "Free Flight" and a Cessna 172 airplane. A local airport was chosen to maximize student interest. At this point, the simulated airplane's instrument panel was projected at the front of the room. The three instruments—the air speed indicator, the altimeter, and the attitude indicator—important for this exercise are shown in **figure 1**.

The altimeter's short hand indicates thousands of feet; its long hand shows hundreds of feet. The altimeter

Fig. 1 It took some effort to familiarize students with how to interpret the information on the instrument panel of an airplane, specifically, from left, the air speed indicator, the attitude indicator, and the altimeter.

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displayed on the screen showed its short hand slightly before the 1 and the long hand on the 9. Attempts to read the altitude included "0 feet," "500 feet," and "1900 feet." Pointing to an analog clock on the wall, which happened to have the long hand on the 9 and the short hand almost to the 1, I asked the students if the time was 12:45 or 1:45. They answered, "12:45." When asked why, one student explained that the short hand had not yet reached the one.

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Students built airplanes to simulate flight.

The students, when asked to read the altimeter again, correctly answered that the altitude was 900 feet. Students produced accurate readings once the connection was made between reading an altimeter and a clock. When next asked why the altitude was not 0, students answered that the altimeter measured the height above sea level, not the height above the ground. We recorded the first data point (0, 900) on a *t* chart. The *x*-column on the *t* chart is the time in minutes, and the *y*-column is the altitude in feet.

The air speed indicator has one hand and measures speed in knots. To take off, the student piloting the airplane opens the throttle by moving a knob on the joystick. The plane will start to taxi down the runway, gaining speed. Once the speed reaches 60 knots, the pilot pulls back gently on the joystick to lift off into the air.

Once in the air, the middle instrument, called the *attitude indicator*, helps the pilot determine the orientation of the airplane. This instrument contains a simple outline of an airplane, with blue above the plane and brown below. When the pilot pulls back on the joystick, more blue fills the dial. The pilot should keep a little brown visible in the dial upon ascent, as shown in the center circle of **figure 1**. When the dial is all blue, the ascent is too steep and the plane will stall. For this exercise, students should try to maintain a steady climb without banking or turning the plane.

DATA GATHERING AND PROCESSING

As the student piloting the airplane starts to pull back on the joystick, a student with a stopwatch starts timing. A third student watches the altimeter. When the time reaches one minute, a fourth student records the time and the altitude on a *t* chart. The altitude is recorded each minute into the flight. I chose to collect only four data points because of time constraints so that as many students as possible could have time on the flight simulator.

The next day, the students set up the graph and discussed independent and dependent variables. The decision was made to label the *x*-axis by intervals of 1 and the *y*-axis by 500s. Next, the students graphed the data and described the linear pattern of the points. The students then drew a line of best fit, which would most likely go through a few of the data points but not all. Real-world data can be messy, and pilots, especially inexperienced pilots, do not always maintain a constant ascent.

Next, we worked to write the equation of the fitted line using the slope-intercept form of a linear equation. First, students noticed that the graph crossed the *y*-axis at 900, so we replaced the *b*—the variable representing the *y*-intercept in $y = mx + b$—with 900. We next worked to find the slope of the line. Students should be able to explain that slope is a measure of the steepness of the line and is often described as "rise over run."

As a class, since we were working through an example together, the students picked one data point that was on the line of best fit. They were advised against choosing the first or second data point: The first data point, with an *x*-value of 0, would not enable them to solve for the slope; the second data point, with an *x*-value of 1, possibly could have set the students up for difficulty in solving other equations if they did not notice that the final step of solving the equation required both sides to be divided by 1.

Rich discussion could be produced by having students select different points on the fitted line to see that the slope remained the same, regardless of the points selected. Students could also be challenged to find the slope through another method, such as using the graph of the fitted line to calculate the rise over run. The students replaced the *x* and the *y* variables of $y = mx + 900$ with the values from the selected point. Then they solved the equation for "*m*," the slope. Help was offered to students who struggled to solve the equation.

A presentation by an aviation expert generated excitement in class.

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Teacher Resources

Teachers interested in incorporating aerospace into their lesson plans can easily access many available resources.

- The Aircraft Owners and Pilots Association (AOPA) offers free materials at http://www.aopa.org/path, such as an educational book for teachers called *PATH*, which connects mathematics and other subjects to general aviation.
- NASA (http://www.smartskies.nasa.gov) has two free online standards-based lessons for middle school students that connect aviation with math:

    1. "Line Up with Math" asks students to use proportional reasoning and solve rate-time-distance problems in an interactive air traffic control simulation; and
    2. "Fly by Math" allows students to solve five air traffic control problems that concern the safe separation of two airplanes. This lesson was featured in the August 2006 issue of *Mathematics Teaching in the Middle School*.

- The Federal Aviation Administration (FAA) site http://www.faa.gov contains information and activities. The FAA can also help teachers contact pilots to serve as guest speakers.
- The Civil Air Patrol (http://www.gocivilairpatrol.com) has lessons and activities that are available to their aerospace education members. Some of these lessons are hands on, ranging from making paper airplanes to constructing rockets to making a wind tunnel.

Once students had the values of b and m, they could go back to the slope-intercept form of the equation and substitute the values for b and m. They had an equation that described the ascent of the airplane. One class's data produced the equation $y = 867x + 900$. Students from that class should be able to explain the following:

- y represents the altitude;
- x is the flight time in minutes;
- 900 is the beginning altitude, or the altitude of the airport above sea level; and
- 867 represents the increase in altitude for each minute in flight that the airplane ascends.

This equation can be used to predict the altitude of the airplane for specific flight times, or given the flight time, predict the altitude of the airplane.

MANAGING THE SIMULATOR ACTIVITY

To randomly assign students to groups and jobs, each activity sheet had been labeled with a letter and a number. The letter indicated the group the student was in; the number indicated the role in the group. Each group in turn was to gather data to process from the flight simulator. As a group, they also completed an activity sheet, which would be used as an assessment.

The first group came to the simulator, and each student prepared to work. At the start of the simulation, the pilot taxied down the runway. Once in a while, the student pilot was too aggressive with the takeoff, stalled, and was unable to correct the issue after several attempts. In that case, another student became the pilot. The next pilot usually accomplished the takeoff easily. After completing the task, the students set up the computer for the next group. The first group stayed and helped the next group get started. This system worked well (even with eight students surrounding the computer) because it freed me to check on the work the others were doing.

About five minutes before class was over, the groups were called to order, and we reviewed the important points of the lesson, with special attention to problems 7 and 8 from the **activity sheet** (see p. 415). After being asked to describe the flight of the airplane in question 8, one response was that the plane was taking off in the wrong direction. To counter this misconception, I pointed out that our graph did not have direction on it, only time and altitude. The students' attention was directed to the numbers on the y-axis. "What is the altitude doing as the time increases?" At this prompt, the students could then see that this was a graph of an airplane descending.

REFLECTING ON THE LESSON

This lesson generated much excitement. The students loved using the flight simulator and were highly engaged in the mathematics. The real-world application invited the students into the mathematics. The first time I presented this activity, we began before the students were able to read the altimeter proficiently. I also did not have a stopwatch. Trying to use the clock on the simulator added another level of complexity to the activity. The first time, I made up data points for the students to use for the whole-class demonstration. Although I had to improvise at first, practice and a stopwatch made the following lessons proceed much more smoothly. Following up this lesson with a visit from a pilot, with an emphasis on how he or she uses mathematics, would also benefit students.

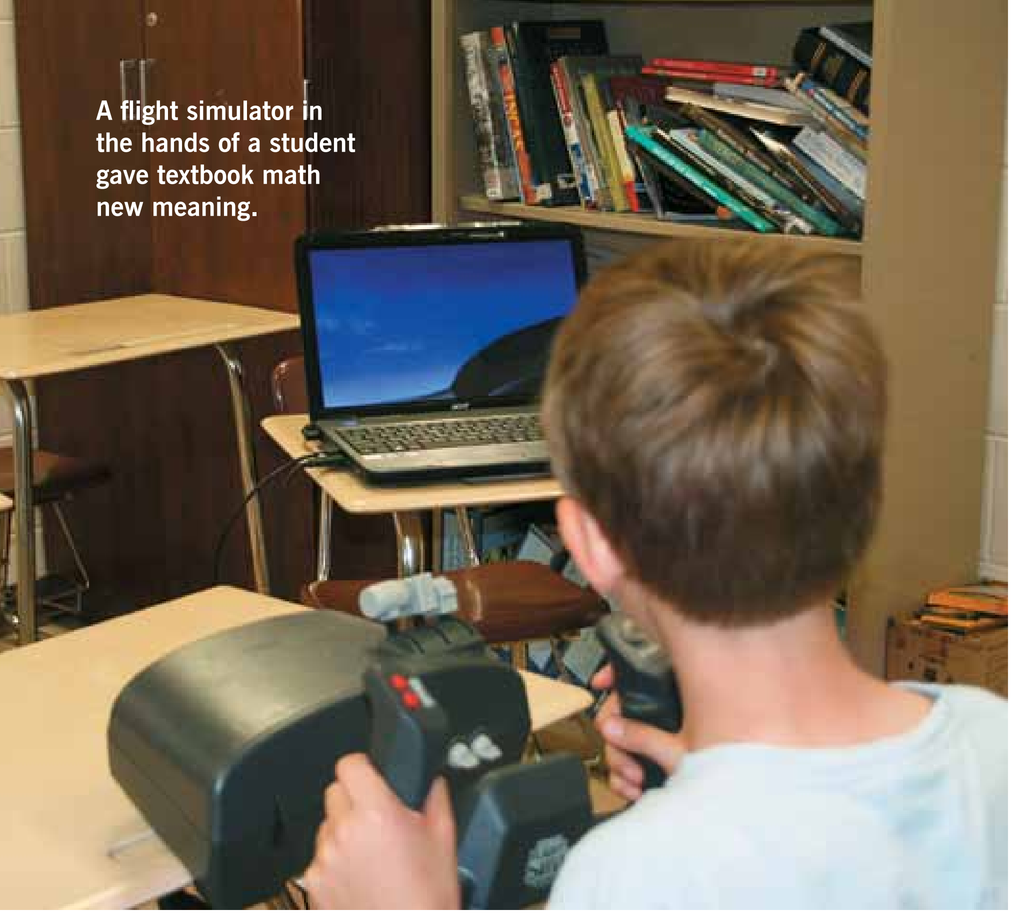
ACCESSING SIMULATION SOFTWARE

Technology is constantly changing, and Microsoft has published its next version of this program, called Flight, available as a free download at http://www.microsoft.com/games/flight/. The linear equation lesson can also be taught with this program or any other flight simulator. The setting of Microsoft Flight is Hawaii, and the plane is an Icon A5, an amphibious aircraft. Because it is a free program, choices are limited. Additional aircraft and locations are available for purchase. Two training missions must be flown before the full menu is accessible and free flight becomes an option. (The game rating is "E," but be warned: My reward for completing the second mission was a virtual coconut undergarment.) Although the tools on the instrument panel were functioning, they were much more difficult to read. However, the speed and the altitude readings were clearly shown at the top of the screen in an easy-to-read format. A joystick is not required, but it does make flying easier and adds to student interest.

CONNECTING STUDENTS TO AVIATION

Students who become excited about flying can start learning and applying their knowledge of aviation fairly quickly. The Young Eagles program, which gives young people between the ages of seven and seventeen the chance to fly in a general aviation aircraft, also can generate interest in aviation. This free program is made possible by the generosity of volunteer pilots (EAA Young Eagles 2011) and may create a significant draw for STEM disciplines. According to a study commissioned by Microsoft, close to 80 percent of STEM college students decide to pursue the study of STEM in high school or earlier, and 13 percent of students make this decision in middle school. (Microsoft News Center 2011.)

Aviation can be used in the mathematics classroom in many more ways than described in this lesson. Connections to aerospace education can be made throughout middle school mathematics core content, igniting



A flight simulator in the hands of a student gave textbook math new meaning.

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student interest. Since airplanes move through three-dimensional space, geometry connections are also possible. Geometry is also used in the design of both airplanes and airports. Aerospace can be connected to algebra through distance-rate-time problems, weight balance ratios, and an investigation of ticket prices.

In exploring the question, "Is a lost luggage rate of 1 percent an accomplishment that an airline should be proud of?" students study statistics and probability. Students could then investigate the actual rates of lost luggage for various airlines and find under what circumstances luggage is most likely to be lost. (Data can be found at http://airconsumer.ost.dot.gov/SA_Baggage_Report.cfm.) Measurement is involved in the physical dimensions of various airplanes, the amount of cargo space, and in how much fuel the airplane holds. Number and operations are used in calculating how much fuel is needed for various flight distances.

Just as the study of aviation can be applied across the curriculum, a career related to aerospace often piques the interest of students. Many of these fields require the study of mathematics. As stated in NCTM's *Principles and Standards for School Mathematics*, "those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures" (NCTM 2011).

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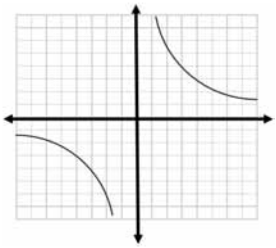
activity sheet

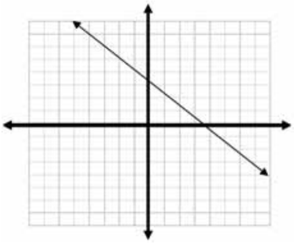
Name ______________________________

FLYING WITH LINEAR EQUATIONS

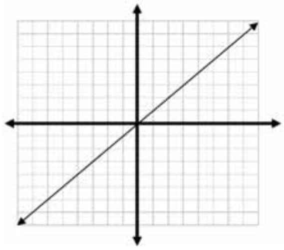
Identify the following graphs as linear or nonlinear.



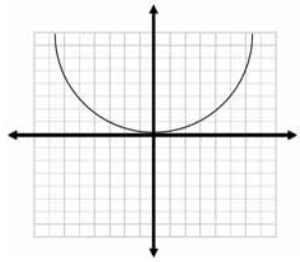
1. __________________



2. __________________



3. __________________



4. __________________

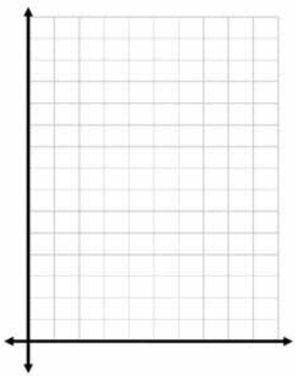
5. The equation $y = 2820x + 670$ describes the ascent of a Learjet 40 leaving Chicago O'Hare International Airport.

What is the altitude 10 minutes into the flight? ________ feet

How far into the flight does the plane reach an altitude of 10,000 feet? _________ minutes

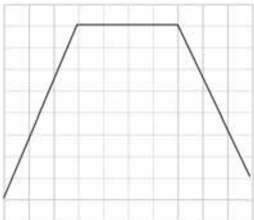
6. A Piper J-3 Cub takes off from Cincinnati Municipal Lunken Airport (elevation 500 ft.). It has a climb rate of 450 feet per minute. Make a *t* chart of the ascent, graph the data, and write an equation to describe the ascent.

Time	Altitude

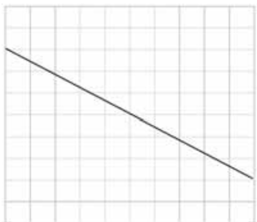


Equation: __________________

Each graph below is of an airplane in flight. Write a description of the flight of each airplane. Describe each graph as linear or nonlinear.



7.



8.

from the March 2013 issue of mathematics teaching in the MIDDLE SCHOOL