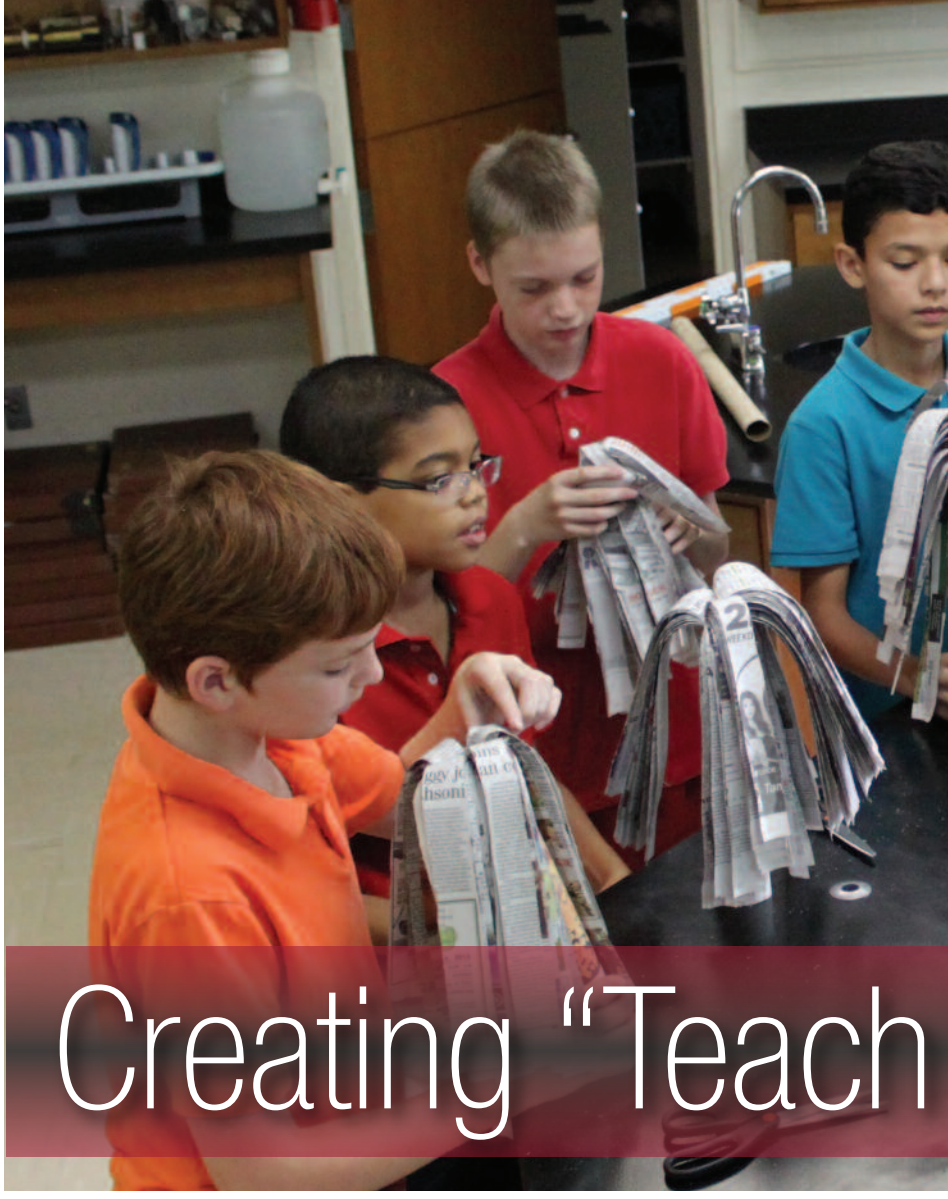


Creating "Teach

Is anything more rewarding in a teacher's day than the "teachable moment" when all the students are listening and connected? It's the "aha" moment when students connect what they are learning with prior knowledge in significant and lasting ways. Students and teachers alike treasure these teachable moments, which help to validate the instructor's preparation and presentation. They change a routine assignment into an adventure in discovery.

Incorporating discrepant events into a lesson is a proven method to help create more of these teachable moments. In science classes, a *discrepant* event is a demonstration with an outcome that can surprise students and cause them to rethink their understanding of scientific concepts. Piaget,[1] Lawson,[2] and other researchers have recommended the use of surprise outcomes to stimulate assimilation and accommodation in student learning. The contrast between what students think will happen and what occurs in the teacher's demonstration creates a state of disequilibrium. This motivates students to learn the reasons for what they just observed.[3]

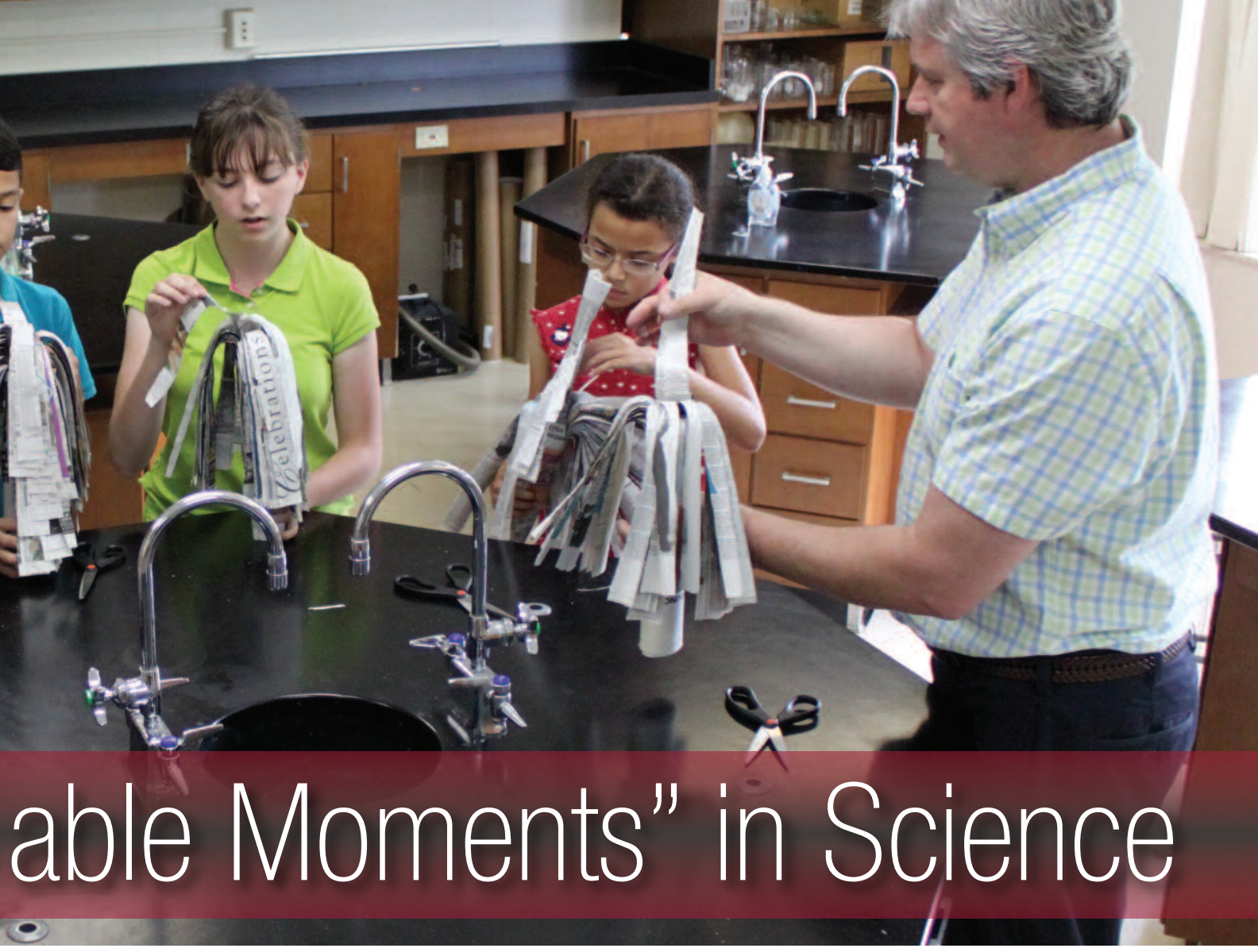
A discrepant event helps to focus students' attention and enhances concept retention. A growing body of research verifies the positive effect of non-static learning environments on students with learning differences such as ADD.[4] These students often struggle with lessons that are text-intensive or worksheet-driven. Discrepant events enable these students to use their hands to follow the procedures and their minds to answer the questions raised by the demonstration.[5] Because discrepant events lend themselves to face-to-face interaction, students learn by helping, sharing, and encouraging their peers' efforts to learn.[6]

The new North American Division Adventist science textbook series, *ByDesign: A Journey to Excellence Through Science* (grades 1-8), incorporates the concept of the discrepant event in the first two steps of its instructional model: "Engage" and "Discover." The text uses these steps to "Capture students' attention with a question that relates to the concepts being introduced in the lesson" and have "Students participate in one or more inquiry-based activities to explore the lesson concepts."[7] Steps 4 and 5, "Extend" and "Access/Reflect," help teachers expand the lesson concept into other subject areas, evaluate students' understanding of the concepts, and make spiritual applications.

Our Seventh-day Adventist schools afford us the opportunity and the responsibility to move our students beyond an understanding of the physical world. We have the privilege of using teachable moments to lead our students to see the connection between the observable creation and the Creator God in whom "is wisdom and strength."[8]

The following three discrepant events, which include materials, procedures, and explanations, facilitate teachable moments in a science classroom. The NAD *ByDesign* Standards and Next Generation Science Standards (NGSS), from the National Science Teachers Association (NSTA), are documented in each activity. The Cross-Curricular Extensions provide teachers with activities that make connections with other subject areas, while the Spiritual Applications connect the discrepant event with spiritual truths. Although these activities are targeted for middle-grade students (grades 5-8), they are easily

BY GARY F. BRADLEY



able Moments" in Science

Note to Teachers

Journaling is a powerful way to increase long-term retention of concepts.[9] These three discrepant events along with the accompanying spiritual applications and cross-curricular extensions are enhanced by journaling. Teachers can refer to the journals to assess their students' participation and concept mastery.

adapted to meet the needs of elementary and high school-level physical science and biology students.

Discrepant Event No. 1: Bernoulli's Table Tennis Ball

Objective: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object (NAD *ByDesign* Physical Science Standards).[10] The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change (NGSS).[11]

Materials: Table tennis ball, hair dryer, and safety goggles.

Safety: Care should be taken when working with an electric appliance. Check to make sure the lab table and floor are dry. Remind students to always point the hair dryer away from faces. Use the cool setting on the hair dryer. This will not change the flight of the table tennis ball and will eliminate any potential discomfort caused by too-hot air.

Procedure: Place the table tennis ball on the table.

Ask your students to write in their journals or discuss what they think will happen when the hair dryer is turned on and pointed at the ball. Students will likely say that the air from the hair dryer will blow the ball across the table.

Turn on the hair dryer to the cool setting; point it at the table tennis ball. The ball will be blown quickly across the table.

Turn off the hair dryer, and ask the

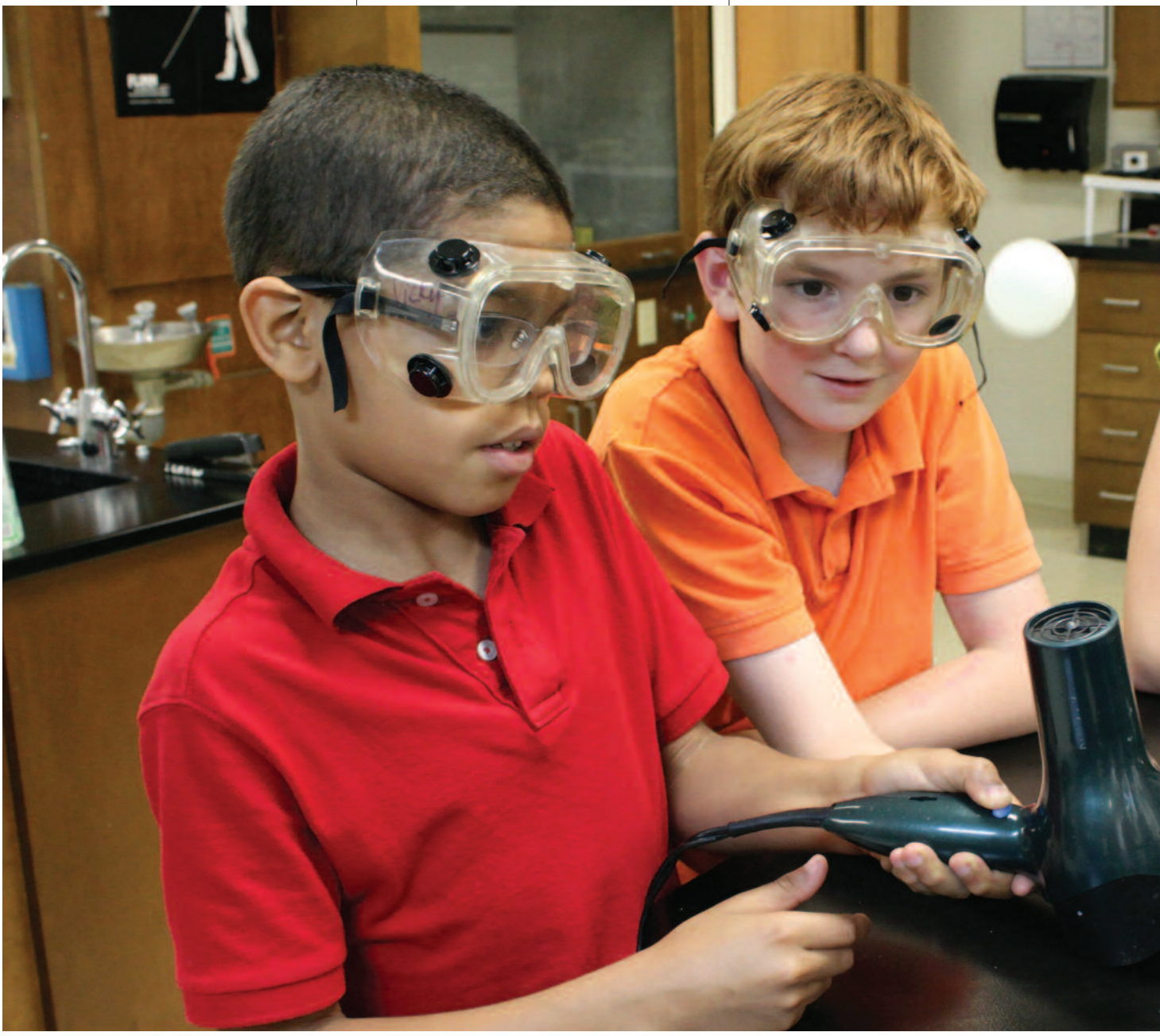
students to discuss or write in their journals what will happen to the table tennis ball if it is placed above the hair dryer while it is pointed straight up. Students may say that the hair dryer will blow the ball away just as in the previous demonstration. This is a good time to have your students write what they have observed thus far in the experiment, and predict what they think will happen next.

Turn the hair dryer to the cool setting and then place the table tennis ball in the hair dryer's air stream while it is pointed straight up. The table tennis ball will hover above the hair dryer, bobbing in its air stream.

Try gently moving the hair dryer left to right. The table tennis ball will move with the hair dryer. Next, twist the hair dryer gently clockwise and then counterclockwise. The table tennis ball will move left and right of the hair dryer. Finally, try putting two table tennis balls in the air stream. Have your students write their observations in their journals.

Student Response: Students will be surprised to see the table tennis ball float in mid-air and seem to follow wherever the hair dryer is pointing. They will want to know why the ball reacts this way. This is the "teachable moment."

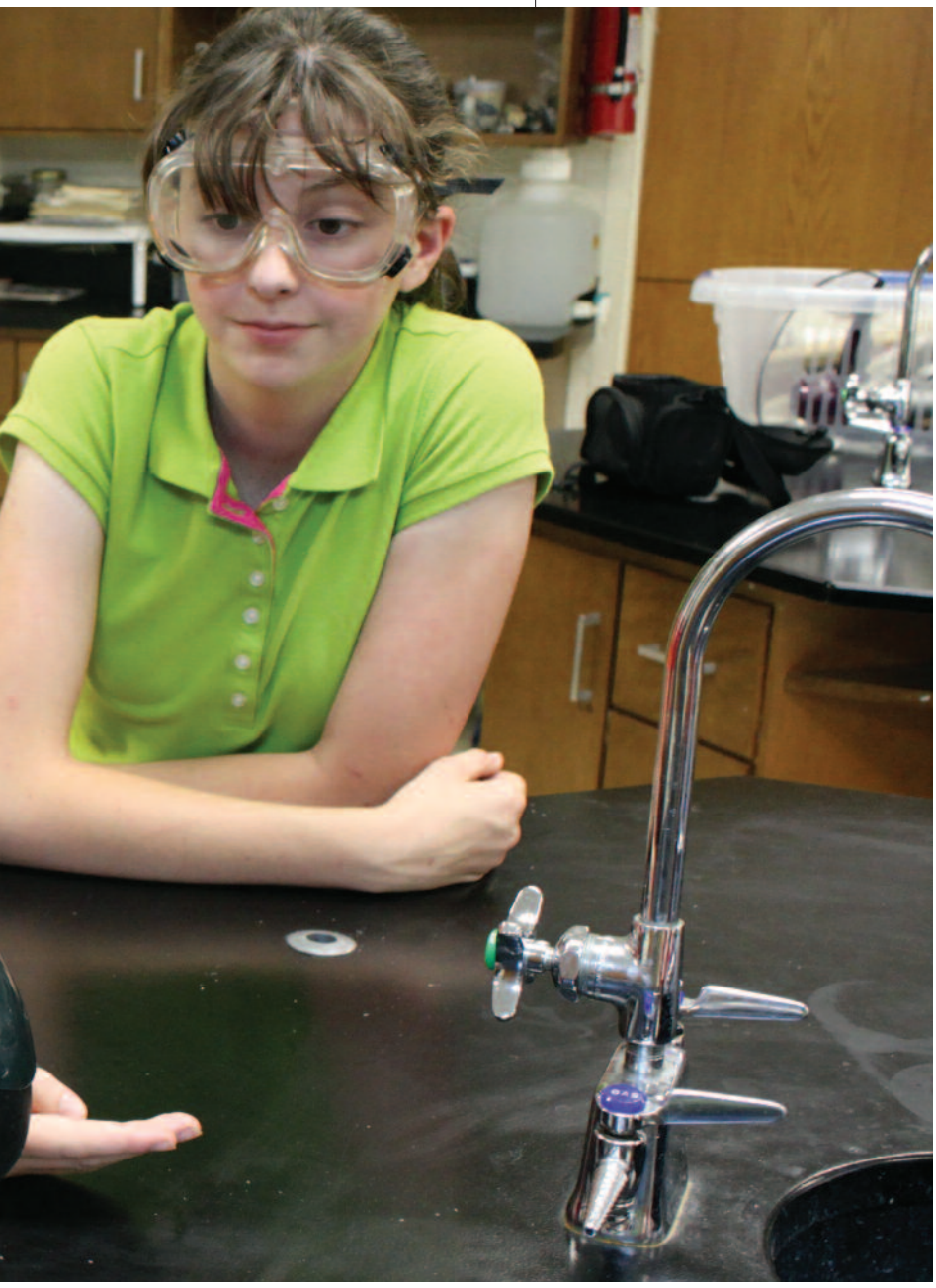
Explanation: Why does the table tennis ball float in the air? The upward pressure from the hair dryer balances the downward force of gravity, keeping the ball "levitating." The Bernoulli principle explains why the table tennis ball seeks to stay in the airstream of the hair dryer.



Teachable moments occur when students experience the surprise of a discrepant event.

This principle states that fast-moving fluids (air is considered a fluid) are at a lower pressure than slow-moving fluids. The airstream from the hair dryer is at a lower pressure than the air surrounding it, so the table tennis ball tends to stay in the moving air of the hair dryer.

Spiritual Application: Teachers can use this teachable moment as a spiritual lesson. For example, just as gravity pulls the table tennis ball down, things of this world will drag people down. A television program, video game, movie, substance, or something we couldn't watch or enjoy with Jesus should be avoided. God gives us power to rise above the pull of temptation just as the hair dryer gave the table tennis ball freedom to float above the ground. As the ball stayed in the air stream of the hair dryer, we stay connected to God by allowing Him to speak to us through reading the Bible, prayer, and following the Holy Spirit's prompting. We can follow God's leading in our lives just as the table tennis ball followed the movements of the hair dryer. King David knew about God's leading when he wrote, "Thy word is a lamp unto my feet, and a light unto my path."[12] Ask your students to write in their journals or discuss a time when they felt God leading in their life.



Cross-curricular Social Studies Extension: The Bernoulli principle is what the Wright brothers used in planning their first successful flights in 1903. Ask your students to try to imagine life without airplanes. How long would it take to get packages from across the country? How would people travel between continents? These questions can lead to a meaningful discussion or journaling activity on how air travel has dramatically changed our society.

Discrepant Event No. 2: The Super Tennis Ball

Objective: Ask questions and predict outcomes about the changes in energy that occur when objects collide (NAD *ByDesign* Physical Sciences Standards).[13] When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object (NGSS).[14]

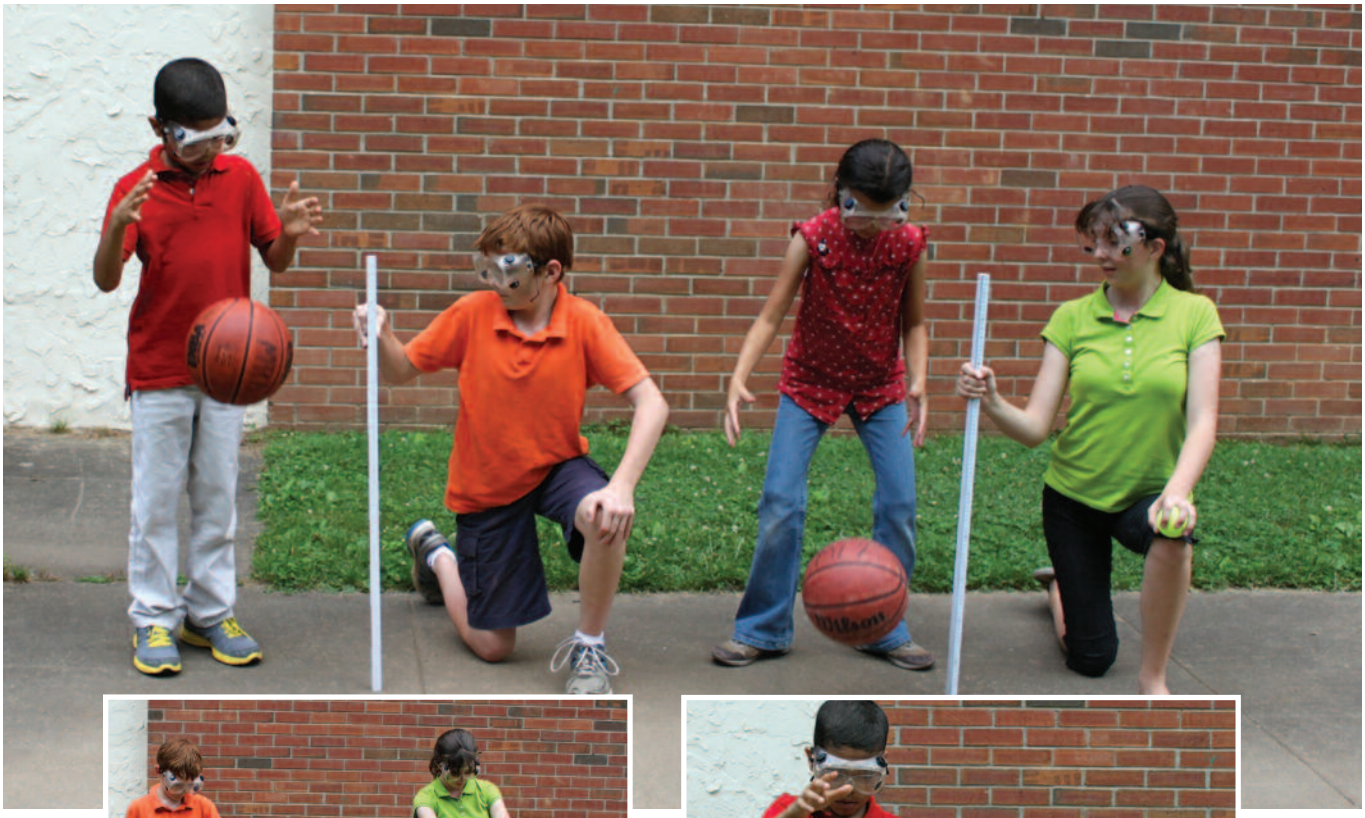
Materials: Basketball, tennis ball, meter stick (100 cm/39 inches), and safety goggles for all students participating in the experiment.

Safety: CAUTION! The tennis ball will bounce energetically off the basketball. Consider going outdoors or using a room with a high ceiling for this discrepant event. Strongly emphasize to the students that they must only drop and never throw the basketball or the tennis ball.

Procedure: Have one student hold a meter stick vertically and a second student hold the bottom of the basketball at the top of the meter stick.

Ask the class to write in their journals how high they think the basketball will bounce (rounding off to the nearest centimeter) when dropped in free-fall. Answers will vary, but most students will be aware that no ball will bounce higher than its starting point.

Ask the first student holding the meter stick to measure how high the bottom of the basketball reaches on the first bounce.



Top and left: The students measure the rebound height of the basketball and the tennis ball.

Right: A student drops the basketball and tennis ball together in freefall.

Have the second student drop the ball in freefall.

Ask the first student (the one holding the meter stick) to tell the class how high the ball rebounded, to the nearest centimeter. Repeat dropping the ball in freefall and measuring the rebound height several times while the students record the rebound height in their journals. A properly inflated basketball will rebound to about half the original height.

Repeat this procedure (Steps 1-5), but this time use a tennis ball. Remind the second student to let the tennis ball freefall. Ask your class to journal or discuss their predictions about the rebound height of the tennis ball and record the height in several trials.

Ask the students to predict in their journals how high the tennis ball will bounce when it is placed on top of the basketball. Students will likely predict that the tennis ball will rebound a meter or less.

Have the second student place the tennis ball directly on top of the basketball, and then drop the two balls in freefall.

CAUTION! The tennis ball will bounce several meters high.

Ask students to write their observations in their journals.

Student Response: Students will be amazed to see the tennis ball bounce many times higher when dropped in

Students will be amazed to see that the tennis ball will fly several meters into the air, while the basketball doesn't bounce nearly as high.

freefall with the basketball than it did by itself. This is the teachable moment—students want to know why this occurred.

Explanation: Why does the tennis ball bounce so high? Repeat the tennis-ball-on-top-of-the-basketball drop, but this time, have students watch the basketball. They will observe that the basketball reaches only a small fraction of the height that it bounced when dropped by itself. The basketball transferred some of its kinetic energy to the tennis ball, causing it to bounce much higher than it would have alone. This is a demonstration of the law of conservation of energy. The tennis ball got an extra upward "push" from the basketball, which gave up some of its kinetic energy.

Spiritual Application: Teachers may use this teachable moment to focus on cooperation. They can ask their students to respond by writing in their journal or by discussing the question, "When have you helped someone accomplish something that he or she probably wouldn't have been able to do alone? Did you give something to this person—time, money, knowledge? Who has given you a boost? Parents, grandparents, friends?" Of course, Jesus gives us the ultimate opportunity. Because of His sacrificial gift, we can enjoy life more fully here on planet Earth and know that God has invited us to live with Him forever in heaven. An important prompt is, "What did Jesus do that gave us the opportunity to receive eternal life?" Teachers can have students read John 3:16 and then ask, "How can we work together with Jesus to help others learn about the wonderful gift that Jesus has given us?"

Cross-curricular Math Extension: The data students record during this discrepant event can be used as an application of the measures of central tendency: mean, median, and mode. Five or more data points work well for this activity. Using calculators will decrease response time. Ask students to recopy the data, arranging the numbers from lowest to highest in their journal. This will help them find the median (the value of the middle data point) and the mode (the data point that appears most often). Check whether your students understand that the mean is the average of the sum of all of the numbers divided by the number of data points.

Discrepant Event No. 3: The Newspaper Tree

Objective: Develop models to show that organisms have unique and diverse life cycles, but all share birth, growth, reproduction, and death in common (NAD *ByDesign* Life Sciences Standards).[15] Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors (NGSS).[16]

Materials: Newspaper, scissors, tape, safety goggles for each student.

Safety: Care should be taken when working with scissors. Remind students about safety procedures such as how to pass lab materials to a lab partner.

Procedure: Tell your students that they are going to design their own "growing plant." Just as real plants do, they are going to use a simple repeated process to create a "growing" structure.

Tape two newspaper pages together (at the short edges) using three small pieces of tape: one each at the top, middle, and bottom. (See the illustration on page 20.) Repeat this process to tape five pages of newspaper together, making one long row of pages.

Using the outside of a cardboard tube (such as a wrapping paper tube), roll up the newspaper.

Tape the end edge of the newspaper roll to the body of the newspaper in the middle.

Remove the cardboard tube from the center of the newly created newspaper tube.

Starting at the top end of the newspaper tube, cut straight down to the middle of the tube. Turn the tube a quarter turn, and make another cut from the top down to the middle. Do this two more times so there are four equal strips of newspaper that come halfway down the newspaper tube.

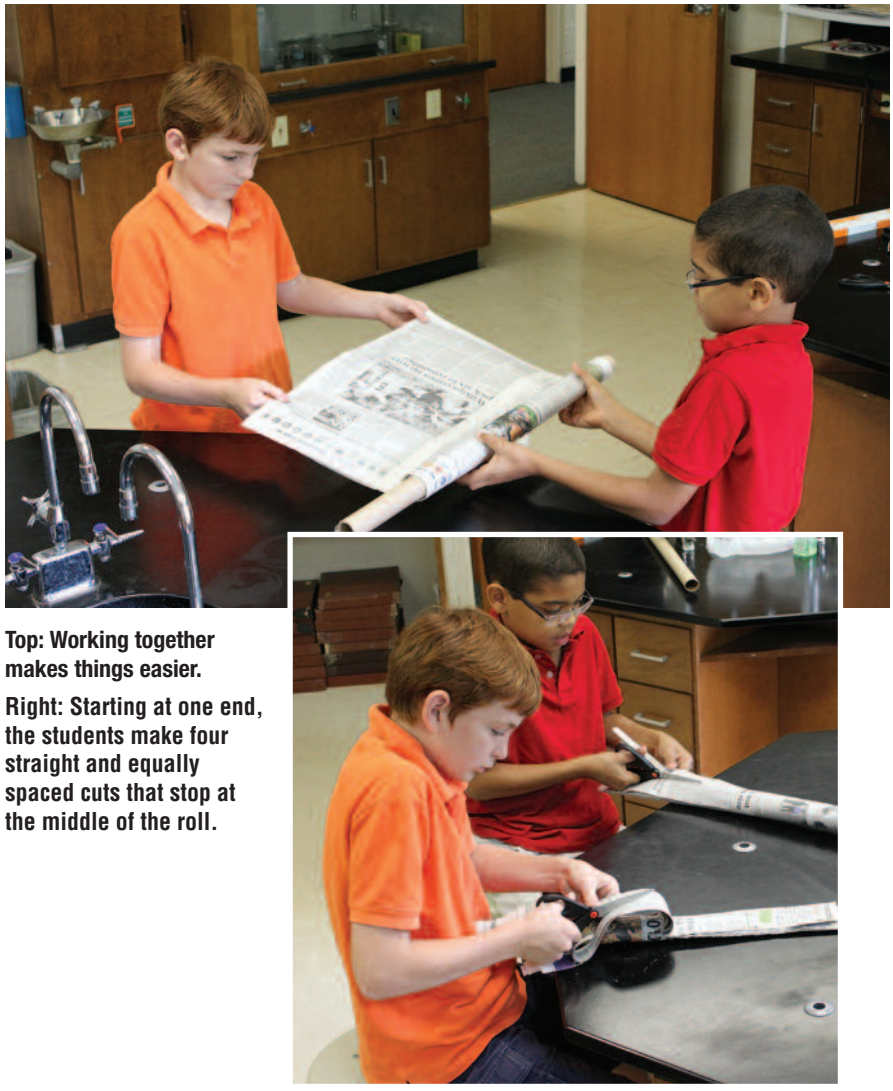
Gently lay the four pieces away from the opening of the newspaper tube.

Ask your students what they think the structure might look like. Students will probably not have an accurate idea of the new shape of their newspaper tube.

Hold onto the base of the tube with one hand while reaching into the center of the newspaper roll with the other hand. Using a gentle upward motion, pull on the newspaper strip closest to the opening to start the newspaper "tree" growing. Keep pulling to make the newspaper "tree" grow taller and taller.

Explanation: The newspaper tree is an example of how a simple object like a newspaper roll can be made into a beautiful and symmetrical object resembling a tree. This type of growing pattern is seen in the palmetto tree, Romanesco broccoli, and the chambered nautilus shell. The cells of plants and animals grow in spiral patterns, producing a self-similar pattern or one that is replicated. Ask your students to share other plants or animals that they have seen that have a comparable repeating growth pattern.

Spiritual Application: God made plants, animals, and people to grow in beautiful symmetry. Ellen White wrote: "Let the children learn to see in nature an expression of the love and the wisdom of God; let the thought of Him be linked with bird and flower and tree."[17] Ask students what spiritual lessons they can gather from this discrepant event. Compare the steady growth of plants with the importance of daily spiritual growth. Follow-up questions could include asking students how much time they spend studying their Sabbath school lesson, memorizing Scripture, or having devotions. Do they make regular prayer time (beyond just a food blessing) a part of their day? Students need to know that God is deeply interested in our lives and wants to spend time with us to help us grow to our full spiritual potential.



Top: Working together makes things easier.

Right: Starting at one end, the students make four straight and equally spaced cuts that stop at the middle of the roll.

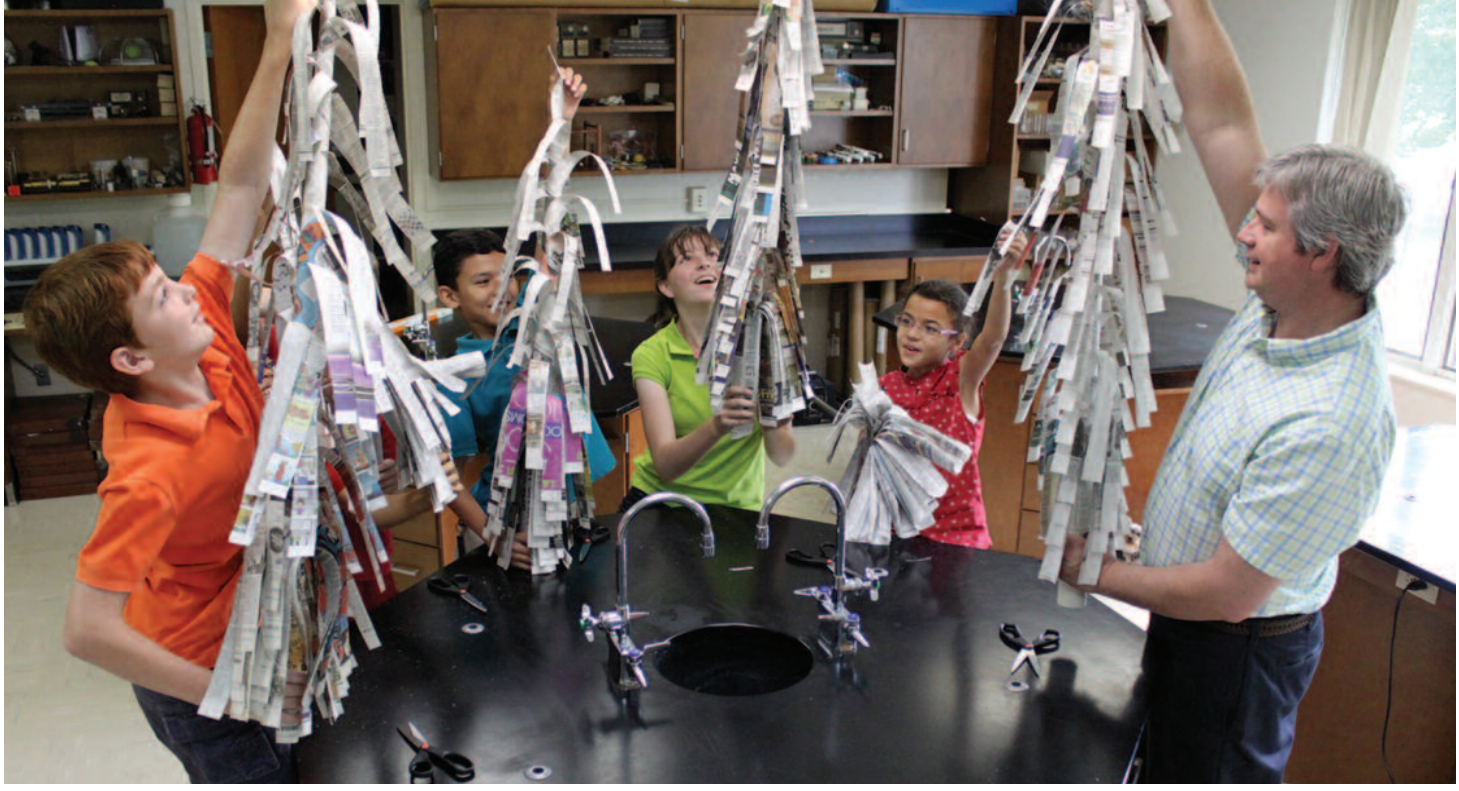
Cross-curricular Health Extension: Ask your students to discuss or write in their journal ways that they have seen themselves grow physically. What are they able to do now that they couldn't do just a few years ago? Ask what they can do to help themselves grow physically. Share with your students the well-researched connection between healthful living and Adventist health principles. You may also want to introduce students to the eight natural remedies: nutrition, exercise, water, sunlight, temperance, air, rest, and trust in God (NEWSTART).[18]

My 110 Favorite Discrepant Events

A discrepant event can be found for most of the topics in the new *ByDesign* curriculum. "Discrepant Events for Science Teachers"[19] is a Web page with 110 discrepant events specifically created for science teachers. This site includes materials, procedures, and explanations. The discrepant events that I compiled and formatted have been evaluated for "wow" factor, safety, cost, and setup/cleanup. Feel free to use these discrepant events in your classroom!

Creating a Teachable Moment Environment

Teachable moments cannot be forced. But teachers can create an atmosphere in which they can occur. Discrepant events help to create teachable moments by causing students to ques-



Students love to make their newspaper tree grow. The newspaper "leaves" resemble spiraling self-similar growth patterns found in live plants and trees.

tion their understanding about science. Students want to find out for themselves why they were surprised by what they just saw happen.

We, as Seventh-day Adventist teachers, have the privilege and responsibility of taking these teachable moments beyond just a scientific explanation. We can connect science with social, moral, and spiritual lessons. Plan, present, and participate in the joy of creating a teachable moment in your next science class.

This article has been peer reviewed.

Gary F. Bradley, Ph.D., *is Assistant Professor of Education at the University of South Carolina Upstate in Spartanburg, South Carolina, whose area of specialization is teaching education and science methods. He previously taught science for 20 years to grades 6-12 in Adventist schools. Dr. Bradley enjoys presenting discrepant events at conferences, camp meetings, and in classrooms.*

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