

Differentiated Instruction for Science

Instructions and activities for the diverse classroom

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Introduction

To meet the needs of all students and design programs that are responsive to the intellectual strengths and personal interests of students, we must explore alternatives to traditional science instruction. We need to examine not only what is taught but how it is taught and how students learn.

Carol Ann Tomlinson in *The Differentiated Classroom: Responding to the Needs of All Learners* encourages educators to look at teaching and learning in a new way. Using the phrase “One size doesn’t fit all,” she presents, not a recipe for teaching, but a philosophy of educational beliefs:

- Students must be seen as individuals. While students are assigned grade levels by age, they differ in their readiness to learn, their interests, and their style of learning.
- These differences are significant enough to require teachers to make accommodations and differentiate by content, process, and student products. Curriculum tells us what to teach; differentiation gives us strategies to make teaching more successful.
- Students learn best when connections are made between the curriculum, student interests, and the students’ previous learning experiences.
- Students should be given the opportunity to work in flexible groups. Different lessons point toward grouping students in different ways: individually, heterogeneously, homogeneously, in a whole group, by student interests, and so forth.
- There should be ongoing assessment—assessment can be used to help plan effective instruction.

To address the diverse ways that students learn and their learning styles, we can look to Howard Gardner’s eight intelligences to provide a framework. Gardner’s theory of multiple intelligences encourages us to scrutinize our attitudes toward science learning so that each student can learn in a more relaxed environment.

Let's explore what multiple intelligences look like in the science classroom.



Visual/Spatial

Perceives the visual world with accuracy; can transform and visualize three dimensions in a two-dimensional space. Encourage this intelligence by using graphs and making sketches, exploring spatial visualization problems, relating patterns in science to visual and color patterns, using mapping activities, and using manipulatives to connect concrete with abstract.



Verbal/Linguistic

Appreciates and understands the structure, meaning, and function of language. These students can communicate effectively in both written and verbal form. Encourage this intelligence by using class to discuss scientific ideas, using journals to explore scientific ideas using words, making written and oral presentations, and doing research projects.



Logical/Mathematical

Ability to recognize logical or numerical patterns and observe patterns in symbolic form. Enjoys problems requiring the use of deductive or inductive reasoning and is able to follow a chain of reasoning. Activities related to this intelligence include organizing and analyzing data, designing and working with spreadsheets, working on critical-thinking and estimation problems, and making predictions based upon the analysis of numerical data.



Musical/Rhythmic

The ability to produce and/or appreciate rhythm and music. Students may enjoy listening to music, playing an instrument, writing music or lyrics, or moving to the rhythms associated with music. Activities related to this intelligence include using songs to illustrate science skills and/or concepts and connecting rational numbers to musical symbols, frequencies, and other real-world applications.



Bodily/Kinesthetic

The ability to handle one's body with skill and control, such as dancers, sports stars, and craftspeople. Students who excel in this intelligence are often hands-on learners. Activities related to this intelligence include the use of manipulatives, involvement with labs and hands-on activities (weighing, measuring, building), and permitting students to participate in activities that require movement or relate physical movements to scientific concepts.



Interpersonal

The ability to pick up on the feelings of others. Students who excel in this intelligence like to communicate, empathize, and socialize. Activities related to this intelligence include using cooperative-learning groups; brainstorming ideas; employing a creative use of grouping (including heterogeneous, homogeneous, self-directed, and so forth); and using long-range group projects.



Intrapersonal

Understanding and being in touch with one's feelings is at the center of this intelligence. Activities related to this intelligence include encouraging students to be self-reflective and explain their reasoning, using journal questions to support metacognition, and giving students quiet time to work independently.



Naturalist

Naturalist intelligence deals with sensing patterns in and making connections to elements in nature. These students often like to collect, classify, or read about things from nature—rocks, fossils, butterflies, feathers, shells, and the like. Activities related to this intelligence include classifying objects based upon their commonalities, searching for patterns, and using Venn diagrams to help organize data.

The Format of the Book

Primarily this book is arranged based on science subjects being taught throughout the nation. This includes the traditional, separated science subject areas such as life science or biology (including environmental science), physical science (or chemistry and physics), and earth science. This book may also be utilized by teachers teaching integrated science curricula. The arrangement within this book will allow teachers to easily choose activities and labs that not only fit with their standards, but also exemplify differentiated science instruction. Embedded throughout the book are strands based on the National Science Education Standards (NSES) developed by the National Research Council (1995) including Inquiry, Science and Technology; Science in Personal and Social Perspectives; and History and Nature of Science.

Using the Teacher's Pages

Each activity is preceded by a “Teacher’s Page” that has valuable information for managing the lesson. In addition, if the teacher changes the lesson or connects it to other lessons, these changes may be noted on the Teacher’s Page to be used in future lesson planning. Science journals for both laboratory observations in addition to thinking processes are strongly encouraged.

- **Science Topics:** Most science experiments address more than one science skill or topic. In the real world, science is often an integrated experience, and skills and concepts interrelate and blend. When using these experiments, teachers can use this section to connect the lesson to skills and concepts that are part of their science curriculum.
- **Educational Goals:** A brief listing of the lesson concepts based on standards will be listed.
- **Multiple Intelligences:** Teachers and students alike are encouraged to explore a variety of multiple intelligences. While each experiment does not focus on each of the eight intelligences, activities are open-ended and allow students to use a variety of strategies and intelligences to solve the problems.
- **Materials:** A comprehensive list of materials and supplies needed are listed to aid the teacher in laboratory preparation time and organization.
- **Procedure:** These are not intended to be a scripted, step-by-step plan but rather suggestions to help facilitate students and act as motivation for the experiences. Some lessons suggest specific questions to be asked while others offer suggestions to develop student understanding. These are merely suggestions and should be used only if appropriate to the needs of the class.
- **Differentiation:** Some of the activities may be extended, refined, or differentiated. Suggestions have been made in this section. This would also be an appropriate place for teachers to make notes of their own on ways to enhance the lesson or add additional activities.
- **Assessment:** Multiple suggestions are made in this section. These may include traditional quizzes or tests, completed student projects (forms of formal assessment), observation and questioning (or other forms of informal assessment), and so forth.

Physical Science

Properties and Changes of

Properties in Matter

Students often find the concept of matter confusing. Furthermore, the fact that *mass* and *weight* are “interchangeable” terms on Earth further complicates understanding.

“What’s the Matter?” gives students the opportunity to build models and then use them to answer difficult, application-level questions about solids, liquids, gases, and plasma. It also allows students the opportunity for inquiry-based learning since step-by-step directions are not being provided to the students. Questions about substances that seem to be partially a solid and partially a liquid are also raised.

“How Dense Are You?” measures the density of a student in addition to other smaller items. Comparison is also made to water by using salt water in varying concentrations in solution. Vegetable oil and other oils are also compared to honey, maple syrup, and corn syrup. The formula $D = m/V$ is used to explain the relationship of density to mass and volume.

“The Case of the Mixed-up Powders” twists the traditional unknown white powder lab by having students apply what they know about properties of matter to solve a mystery. Common household compounds are utilized to save the teacher time and money in laboratory preparation.

What's the Matter?



SCIENCE TOPICS

matter, mass, weight, solid, liquid, gas, plasma, inquiry using models



EDUCATIONAL GOALS

Students will

- build three-dimensional models of a solid, a liquid, and a gas.
- explain using their models why each state of matter behaves as it does.
- support their explanations through class discussion.
- make predictions based on their models.



MULTIPLE INTELLIGENCES

visual/spatial, verbal/linguistic, logical/mathematical, bodily/kinesthetic, interpersonal, and intrapersonal



MATERIALS

paper towels, toothpicks, gumdrops or miniature marshmallows (or substitute), salt (optional), microscope (optional)

PROCEDURE

Place students into groups of two to encourage interpersonal communication. Give students a paper towel and a supply of marshmallows or gumdrops and toothpicks. Allow students to design atomic models of a solid, a liquid, and a gas on their own. To encourage student inquiry, tell students that their model of a solid must be able to hold the weight of a large object. The model of a liquid should be somewhere in between the model of the solid and the gas in its durability. In other words, the molecules should be spaced farther apart. The model of a gas should just be able to stand on its own. The “molecules” should be spread apart even farther than in the liquid. To direct students as they work, use Socratic teaching techniques, which means answering any student questions with an additional question and not an answer. This will facilitate the inquiry process and let students correct their own mistakes as they go along. After students have had about 15 minutes of uninterrupted work time, ask the entire class which state of matter takes the shape of its container—a solid, a liquid, or a gas? The students should answer a liquid. Give students a chance to change their models if needed.

Depending on the accuracy of the models they have created, students may want to change their original plans.

DIFFERENTIATION

More advanced students may also be given the fourth state of matter (plasma) to work on. This is a more difficult model to create since plasma is a highly charged gas. Before students begin working on the models, they could be shown a solid, a liquid, and a gas and reminded that the solid keeps its shape, the liquid takes the shape of its container, and the gas fills the container completely. Additionally, students can be shown salt crystals under a microscope to give them an idea of what they should use for a crystalline model.

Varied Homework

Students who need a more challenging assignment should be asked to make a mixture of white school glue, water, and borax (sodium borate—available in the laundry powder section of most grocery stores) and describe its characteristics. They should be able to describe this mixture as a solid, a liquid, or a gas and support their reasoning. Students who need a less challenging assignment should be asked to make a mixture of cornstarch and water and describe its characteristics. They should also be able to support whether or not they feel it is a solid, a liquid, or a gas. It is better to give less direction to students about the proportions of each of the ingredients within the mixtures. Encourage inquiry and allow students to vary the ingredients while noting in their journals the amounts of each tried and the result.

ASSESSMENT

Assess the construction and durability of the models created. All three models should be based on a cube or crystalline structure; however, the gumdrops should be tightly packed for the solid and very loosely packed for the gas. The gumdrops should be somewhere in between for the liquid. Remind students that the structures of liquids and gases are not crystalline. In liquids, molecules and atoms move around one another but do not move apart. In gases, molecules move almost independently of one another and are far apart.

Assess students' verbal explanations of why the phases of matter behave the way they do and their level of participation in a class discussion.

Assess students' written answers to the questions asked in the activity.

What's the Matter?

The three most commonly studied states of matter are solids, liquids, and gases. Sometimes it is easier to understand concepts such as matter by building or using a model. A *model* is defined as a representation of an object, which is then used to explain things in a new way.

Directions: Place the paper towel on your desk or lab table so that you and your partner can share the toothpicks and gumdrops or miniature marshmallows that your teacher provides. Using the toothpicks to hold together the gumdrops or marshmallows, build a model or representation of a solid, a liquid, and a gas. Build your model of the solid so that it can support the weight of a heavy object. Your teacher will help you test this in class.

In your science journal, draw the objects you created, being sure to label each one. Then answer the following questions on the lines below or on a separate sheet of paper in your science lab journal.

1. Was your solid able to hold a great amount of weight? Why or why not?

2. What could you do to improve your design of the solid? the liquid?
the gas?

3. Make a prediction based on your models about which state of matter allows the most freedom of movement within the structure.

For homework, your teacher may assign you to make a mixture. Record your own lab procedure in your science lab journal. After the lab, record observations in your journal about whether you feel this mixture is best described as a solid, a liquid, or a gas and why you think this is so.

Why Should You Wear a Seat Belt?

One of the first things consumers want to know before they buy a car is its crash test (safety) data. Many of the new cars today have bumpers that can be hit at a low rate of speed without damage to the passenger, driver, or car. Cars are also equipped with antilock brakes, airbags (both front and side), and other safety features. Seat belts keep passengers safe by locking in place so passengers are not ejected from a moving vehicle if an accident occurs.

Understanding all the forces involved around a moving (or quickly stopping) car require studying Newton's laws of motion. This lab will allow you to experiment with forces, acceleration, inertia, mass, weight, and gravity.

Directions: Record definitions (in your own words) for the terms below.

force: _____

acceleration: _____

inertia: _____

mass: _____

weight: _____

gravity: _____

Now work with a partner to design (or attain) a vehicle to test for safety. You and your partner should agree on a "passenger" for your vehicle such as a ball of clay, raw egg, or a substitute of your choice. You will be designing a "seatbelt" to hold your "passenger" in place during a crash test. Be sure to record all data from your experiment in your science lab journal. Suggested instruments to gather data include stopwatches, metersticks, and/or a balance. Remember Newton's second law of gravity: $F = ma$ where F = force, m = mass, and a = acceleration. This law should be explored during your experiment. You may decide to vary first one variable and then another during your experiment until you fully understand how Newton's laws of motion work.

Physical Science

Transfer of Energy

Energy is transferred in many ways. It is also associated with electricity, heat, light, mechanics, chemical reactions, and sound. The next three activities will take some of these properties and show how energy is transferred.

In “Electric Slide,” students will use a popular song and dance to help them memorize Ohm’s law. They will apply mathematical principles to science in order to understand voltage, amperage, and current in an electrical system.

In “Do You Hear What I Hear?” sound is discussed in light of the properties of energy it possesses.

“Convection, Conduction, and Radiation Station” places students into the role of a news reporter for WHOT television. In this scenario, students will explore transference of heat between solids, liquids, and gases.

Electric Slide

SCIENCE TOPICS

electricity, Ohm's law, current, resistance, voltage

EDUCATIONAL GOALS

Students will

- dance the Electric Slide while chanting Ohm's law.
- apply Ohm's law to sets of problems.

MULTIPLE INTELLIGENCES

verbal/linguistic, logical/mathematical, musical/rhythmic, bodily/kinesthetic, interpersonal, and intrapersonal

MATERIALS

copy of a song to do the Electric Slide dance to, dance directions printed from the Internet (if needed), and CD or MP3 player for song

PROCEDURE

Clear space in your classroom or go outside or to an open space for this activity. Have students line up in rows behind the person who will be teaching them the dance steps to the Electric Slide. Hand students copies of the student page with the words that will be repeated as students do the Electric Slide. Once students have mastered the dance steps, the words to Ohm's law may be added. Once most students have mastered them together, allow them to work independently on the problems using Ohm's law.

DIFFERENTIATION

Students may work in groups instead of independently. Students may use another form of line dancing with a different song, but the same words to practice this concept. If students are having difficulty using the math formula and converting it from one form to another, you may wish to assist particular students by giving them all three forms of the formula. For example, $V = IR$ will be given to most students, and they will need to change the formula in order to solve for the variables other than V . Less advanced students may be given the other two formulas derived from $V = IR$, $I = V/R$, and $R = V/I$.

ASSESSMENT

1. Assess class participation for learning the Electric Slide and the chant.
2. Review answers to questions on Ohm's law.
3. Review journal reflection from the lesson.

Transfer of Energy

Differentiated Instruction for Science



Electric Slide

Electricity has become so common in our society that it is hard to imagine living without it. Many times at dinner, it is nice to be able to dim the lights to create a softer light. How do dimmer switches work? They rely on a mathematical formula called Ohm's law that relates three principles of electricity: voltage, current, and resistance. Voltage is measured in volts, while current is measured in amps (short for amperes). Resistance is measured in ohms. Ohms are named after Georg Ohm, who did experiments with electricity. Specifically, the formula for Ohm's law can be written $V = IR$, where V is the voltage, I stands for current, and R stands for resistance.

Directions: You will have an opportunity to do the Electric Slide dance today! After your teacher decides you have mastered the steps to the Electric Slide, you will begin to do the Ohm's law chant. Every time the words to the song are "it's electric!" you will instead shout "it's Ohm's law!" Other than those moments in the song, you will continually repeat by singing along with the tune that $V = IR$. For a challenge, if you can manage to do the dance steps and not forget part of the chant, too, you can add the other mathematical derivatives of Ohm's law.

In your science journal, answer the following questions using $V = IR$ or a derivative.

1. If the voltage in a circuit is 120 volts (which is standard in the United States), and the current is 20 amps, what is the resistance of the lightbulb?
2. If, instead, you are plugging in a dryer that has a voltage of 240 volts and the current remains the same at 20 amps, what is the resistance of the dryer?
3. What is the resistance of a heater connected to a 100-volt outlet if the current is 50 A?
4. What is the voltage of a battery that is connected in a circuit in which the bulb has a resistance of 3 ohms and there is a current of 3 A?

Answer the following journal reflection questions.

5. How does doing the Electric Slide and chanting help you to better remember Ohm's law?
6. Applying Ohm's law in your own words, what happens in general as the voltage in a circuit increases?
7. What happens when resistance is increased? Explain your reasoning.

Rocks Bingo

SCIENCE TOPICS

sedimentary, metamorphic, igneous, various rocks and minerals, properties of rocks and minerals, hardness, cleavage, streak color, luster, fluorescence

EDUCATIONAL GOALS

Students will be able to correctly identify

- minerals found within rocks.
- igneous, sedimentary, and metamorphic rocks.
- rocks and minerals when given a sample.
- properties of rocks and minerals, including hardness, color, cleavage, streak, luster, fluorescence, and so forth when given the proper equipment to measure the properties.

MULTIPLE INTELLIGENCES

logical/mathematical, verbal/linguistic, bodily/kinesthetic, musical/rhythmic, visual/spatial, interpersonal, intrapersonal, and naturalistic

MATERIALS

rock and mineral samples, UV light for fluorescence (optional), nail or penny for scratch test, porcelain plates for streak test, items such as M&M candies to cover ROCKS cards, digital camera (optional)

PROCEDURE

On the board, overhead, or PowerPoint projector, list about 40 words for students to use on their ROCKS cards (minus the free space). Encourage students to use words throughout the list and to mix up their cards as well as they can. Due to having more words than spaces, most cards will be different from one another. Do not allow students to write on the cards once the words are set. You may even want them to use pens so they cannot erase or change their cards, then put the pens away. Students will cover the words that you describe. This gives the activity flexibility since the teacher has control over what is learned from the word list.



- **General Rules:** Students cover the word the teacher describes or demonstrates. This is different from traditional bingo in which the actual number to be called is covered. To make the game more interesting, the teacher may begin with traditional bingo in which students get the free space and then need a total of five in a row in any direction to win. Another variation may be allowing students to make the letter *I* in any direction or the letter *T* in any direction. A “small picture frame” would be “bingo” when all the squares around the free space are covered forming a small square. A “large picture frame” would be “bingo” when all the squares around the outside of the card are covered. A “kite” would be four squares in one corner and a “tail” created by the free space and then the next two diagonal squares. “Four corners” would be just the four corners of the card. Feel free to create your own version! To make the game more challenging (and to allow for differentiation), have the winning student call out something other than the words covered to win. (Read examples below.) The winner may get bonus points, recognition, candy, or other prizes.

If students have had a difficult time classifying rocks as sedimentary, igneous, or metamorphic, then use this activity to review that concept. Only use rock/mineral names in the word list. If possible, use a digital camera to project rock/mineral images for the students and have them cover the names of the rocks on their cards. When there is a winner declared, the winner must call out “rocks!” and then specify igneous, metamorphic, or sedimentary for each of the ones they had covered to win.

If students have a difficult time with streak testing or other rock properties, the teacher could call out “produces a reddish-brown streak.” This would work as long as the teacher has only one choice in the word list that would fit the description.

DIFFERENTIATION

This activity will utilize whole-class instruction with a tiered lesson possible for the entire class. Various levels of difficulty are possible with the bingo cards since the teacher is able to directly control the level of difficulty of the words to be covered, the definitions to be called out, and how difficult it is for the winner to claim the prize.

ASSESSMENT

Students can be individually assessed as they participate in class. The winners can be assessed as they call back their answers to the teacher.

Rocks Bingo

R O C K S				
		Free Space		

Cloud Cover Song

SCIENCE TOPICS

cirrus, cumulus, and nimbostratus clouds

EDUCATIONAL GOALS

Students will

- sing the cloud cover song with their classmates.
- write and perform their own song about cloud types.
- list the various types of clouds and describe each, including the types of precipitation that may result.

MULTIPLE INTELLIGENCES

logical/mathematical, verbal/linguistic, bodily/kinesthetic, musical/rhythmic, visual/spatial, interpersonal, intrapersonal, and naturalist

MATERIALS

You can find the song “Cloud Cover” by Nick Walker on the Weather Dude web site: wxdude.com. Tune clips from this song and others are also available on the web site.

DIFFERENTIATION

Although the lab begins as a whole-class activity, it becomes a small-group activity. This is a good activity for students with learning disabilities or those who are English language learners because the teacher first shows students what to do and then students mimic the activity. Working in groups, students create their own songs about cloud types. Then they perform their songs for the class and reflect on the experience in their science lab journals.

ASSESSMENT

Students’ reflections from the activity can be graded. Original songs can be assessed for creativity and accuracy.



Cloud Cover Song

Sing “Cloud Cover” along with your teacher. Once you have the idea, you and a group of three other students will work together to write your own song about cloud types.

Cloud Cover (Cloud Types)

(Words and Music by Nick Walker. Used with permission.)

This big old ball we call earth has a wondrous atmosphere;
There’s oxygen that we breathe in and water vapor here.
Those tiny drops of H₂O climb high till they take flight,
And when they cool they start to pool into fluffs of grey and white.

CHORUS:

I call it Cloud Cover
I keep one eye on the sky.
I’m watching Cloud Cover,
And perhaps you wonder why.
Because when clouds begin to change
They can let the sun shine or bring rain
So watch the Cloud Cover,
Keep a-watching all those clouds.

They’re thin and high, those cirrus clouds mean weather’s looking fair
Made up of ice, they look so nice like strands of angel hair.
And stratus layers may hang low as a drizzle droplet falls,
Or show me puffs of cumulus like soft white cotton balls.

CHORUS:

I call it Cloud Cover
I keep one eye on the sky.
I’m watching Cloud Cover,
And perhaps you wonder why.
Because when clouds begin to change
They can let the sun shine or bring rain
So watch the Cloud Cover,
Keep a-watching all those clouds.

The nimbostratus might bring rain as a warm front leaves its trail,
And watch with dread as thunderheads bring you lightning storms
and hail. (Ouch!)

(continued)

Cloud Cover Song *(continued)*

Cloud Cover

I keep one eye on the sky.
I'm watching Cloud Cover,
Now you know the reason why.
Because when clouds begin to change
They let the sun shine or bring rain
So watch the Cloud Cover,
Keep a-watching all those clouds.

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Available from Weather Dude web site: wxdude.com.

Now, it's your turn to write your own song about cloud types. Be sure to include information about the precipitation that results from each cloud type. Work with your partners, and write the song in your science lab journal. You will be sharing your song with your classmates. When you are finished, reflect on the work you did and on the work of others in your class.

Selected Answers

Page 24—Electric Slide

1. $R = 6$ ohms (Ω)
2. $R = 12 \Omega$
3. $R = 2 \Omega$
4. $V = 9$
- 5–7. Answers will vary.

Page 31—Convection, Conduction, and Radiation Station

1. convection
2. convection
3. conduction
4. Answers will vary. Sample answer: To remember the difference between convection and conduction, it can be noted that the word *conduction* has the smaller word *duct* within it. A “duct” is a solid; conduction is heat moving through a solid.

Page 43—Extracting DNA from Cheek Cells

1. Some students may have only isolated plant DNA.
2. to loosen the cells from the cheek
3. floating in solution after the alcohol was added
4. to spool it in one direction since it is a long strand
5. lyses (loosens) or breaks the cell membranes to release the DNA from the cell
6. to keep the DNA from being as disturbed/dissolved; yes, it will work with other types since it is using the OH group from the alcohol to pull the DNA out of solution.
7. Answers will vary.

Page 46—Protein Manufacturing

1. Replication is the process of DNA making a copy of itself. It happens as the double helix “unzips” from the enzymatic action of helicase. At that time, adenine pairs with free-floating thymine (and vice versa), and guanine pairs with free-floating cytosine (and vice versa). This occurs in the nucleus of the cell. The DNA remains in the nucleus to minimize the chances of being destroyed.