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ABSTRACT

The motto of the national science education reform efforts is "science for all" regardless of gender, ethnicity, socio-economic background, or any special need. The main issue of this statement is the modification of science activities so that a wider range of students can benefit from it, which is a difficult task. For teachers, the dilemma is being able to reach students with special needs. This paper demonstrates and provides examples of general instructional strategies that can be used to modify science activities so that they can address the educational needs of a wide range of students. (Contains 19 references.) (YDS)

MAKING SCIENCE ACCESSIBLE: STRATEGIES FOR MODIFYING SCIENCE ACTIVITIES TO MEET THE NEEDS OF A DIVERSE STUDENT POPULATION

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The inclusion of students with special needs in the regular classroom has clearly become part of the overall educational landscape. Despite the sincere interest of many teachers to address the educational needs of all of their students (Scruggs & Mastropieri, 1994), the current emphasis on inclusion remains a source of frustration, misunderstanding, and distrust by teachers, parents, and students. Many regular educators are ill-prepared or supported to accept the challenges of teaching students with special needs. All science teachers and educators have their favorite science activities that demonstrate key science concepts. One of dilemmas that they often face is how to modify these activities so that they are accessible to a wider range of students. This presentation will demonstrate some general strategies that can be used to modify activities, and provide some specific examples of modified activities.

Rationale

Science education is in a unique position to serve the needs of students with special needs in that accommodations can easily be made part of the normal variation in instructional modes. Hands-on learning, cooperative groups, dialogue and discussion, and authentic assessment, which figure prominently in current thinking on effective science teaching (Champagne, Newell, & Goodnough, 1996; Gabel, 1995), are also opportunities for accommodating students with special needs (Mastropieri & Scruggs, 1996).

National science education reform efforts emphasize science for ALL students. (National Research Council, 1996; American Association for the Advancement of Science, 1989). These reforms call for quality education for *all* students regardless of cultural background, socio-economic background, physical condition or learning ability. "All students, regardless of sex, cultural or ethnic background, physical or learning disabilities, future aspirations, or interest in science, should have the opportunity to attain high levels of scientific literacy," (NRC, 1996, pg. 22).

Few people would argue with these goals. Implementing these goals, and taking the necessary steps to meet them though can be a confusing and difficult task. As inclusion becomes more of a norm in schools, a wider range of teachers now find themselves responsible for teaching students with a greater diversity of needs. Research indicates that teachers take this responsibility very seriously , but feel ill prepared to do so (Bunch, Lupart, Brown, 1997). Many of these teachers find they lack the familiarity and experience in making accommodations necessary to meet the unique and diverse needs of these learners (Trump & Hange, 1996; Yasutake & Lerner, 1996). This can lead to feelings of isolation and uncertainty when dealing with students who have different needs.

Science teachers are also very concerned with issues of safety; especially in those areas of science where there is increased risk of injury to students due to the nature of the activities. When faced with this setting some teachers choose to "protect" the student by having them take a more passive role in the activity. This may protect them from the possibility of injury, but it also limits their opportunities for learning.

In a study exploring beliefs about teaching those with disabilities, Goodlad (1993) used questionnaires and interviews with general and special education interns and faculty. General educators "commonly viewed themselves as inadequately prepared in many of the specific skills that are generally considered to be important in providing instruction to students with special needs (pp. 235-236)." These teachers rated themselves low on their ability to individualize instruction and rated their competence to adapt instruction for students with disabilities lower than any other skill.

It doesn't take a great deal of experience for a teacher to quickly learn that modifications or strategies that benefit one student, may limit access for another student. Finding balance and strategies for personalizing the learning opportunities is a daunting task. This often leads them to minimize modifications and move back toward more traditional ways of teaching with the belief that this is fairer to a larger proportion of the students.

Guidelines for Adapting Science Activities

There are a wide range of resources available to help a teacher think about adapting activities. The following list is modified and expands material by Berda and Blaisedell (1998) and the includes strategies used by authors of this paper.

Strategies to support all students

- Don't ignore the disability
- Talk to the student about what types of accommodations they want/need
- Make sure students have a comfortable way of asking for help (journal, question book, e-mail, special signal, etc.)
- Discuss scientists who have disabilities and their contributions whenever possible
- Have students familiarize themselves with the room prior to class and without peers
- Arrange furniture so that all students have clear access to the information being presented
- Speak clearly and naturally
- Be aware of your position in the room and the volume of your voice.
- Write legibly
- Make notes and assignments using the computer so font size can be increased if needed.
- Use simple language when giving directions.
- Provide directions and information in both verbal and written form (large print – 14 pt font or larger)
- Use diagrams and pictures as often as possible

- Give out instructions in advance and repeat just before activity
- Run through the activity and actually demonstrate the steps prior to the activity – model what you want them to do.
- Use cooperative learning strategies and assign roles in the groups
- Use computers to help students organize information and submit written material
- Offer students the option of recording their responses.
- Make labs multi-sensory and or draw on multiple modes of learning.
- Use materials with strong textures and bright, primary colors
- Increase the tactile nature of the materials used.
- Use non-skid shelf liner or mats to keep materials in place.
- Allow students to adequate time for activity – don't rush through the material.

Strategies to support students with Attention Deficit Disorder

- Make sure students understand all the instructions before beginning the lab
- Repeat instructions and have students repeat back to you the instructions.
- Make instructions clear and precise – well defined tasks
- Assign one task at a time
- Provide materials and tools to organize work – charts, computer data bases, data tables, etc…

Strategies to support students with hearing impairments

- Seat the student where they are most comfortable
- Reduce background noise
- Signal for student's attention before speaking
- Keep your face visible when speaking
- Speak slowly and clearly
- Repeat other student questions and comments
- When demonstrating an activity, alternate between speaking and working with the material so that students can focus on one thing at a time.
- Use only one source of visual material at a time
- Use overhead projectors, visual aids and demonstrations as much as possible so that you can face the classroom.
- Use captioned films
- Provide all instructions and assignments in writing
- Supplement sound stimuli in experiments with visual stimuli
- Use new vocabulary in various contexts.
- Work from the concrete to the abstract.
- Provide extra time as needed

Strategies to support students with motor difficulties

- Plan for access problems – all aisles should be 42 – 48 inches wide.
- Alter table height for wheelchair access. Spaces under work surfaces should be 29 inches high, 36 inches wide and at least 20 inches deep. The work surface should be no more than 32 inches off the floor.
- Increase the size of laboratory equipment for easy gripping
- Ask students if they want help before offering it ("Would you like…" rather than "Here, let me….")
- Do not lean on or move a student's wheelchair unless asked
- Have students work with a partner
- Place materials within easy reach
- Be aware that some students may not a strong sense of temperature – they can be hurt themselves when using hot or cold water.
- Provide extra time as needed

Strategies to support students with vision impairments

- Seat the student where they are most comfortable
- Reduce background noise
- Call on the student by name
- Identify yourself and those in the group when you begin a conversation
- Be specific when giving directions. Avoid phrase such as: over there, here, like this.

- Give directions in relation to the student's body
- Verbalize all written notes and instructions
- Be specific when describing what is happening in the experiment. For example, the worm moved 4 centimeters away from the light.
- Let the student know when you are ending the conversation
- Increase the tactile components of labs.
- Keep materials and furniture in the room in the same place.
- Keep things up off of the floor and/or out of walking aisles
- Mark measuring tapes with stables or bead of glue.

Guidelines for helping pre-service teachers and practicing teachers develop skills and strategies to support students with disabilities

The activities and suggestions in this section are divided into three main categories. Building Awareness; Identifying and Developing Modifications; and Planning for Action.

Building Awareness

Show and discuss the Richard LaVoie (Lavoie, 1994; Lavoie, 1997; Lavoie, 1989)videotapes and materials. The tapes and guides are available for purchase through The Public Broadcasting System. These three tapes provide a range of information on definitions and implications for learning disabilities, the implications for learning disabilities and development of social skills; and the implications of learning disabilities for classroom management and discipline issues. While not geared specifically for a science class, they are powerful tools to get students past the "blaming the victim" mentality that many beginning teachers develop when they first have difficulty working with a learning disabled student.

A second awareness activity that is fairly easy to infuse into a teacher education program is to have a pre-service teacher shadow a special education teacher for a day or two and write up their reflection of that experience. A few questions that could be used to get them started include: How many students is the teacher responsible for? What types of disabilities do these students represent? How many general education teachers is the special education teacher working with? How many different disciplines (i.e. science, mathematics, literature, social studies, etc…) is the special education teacher supporting?

Identifying and Developing Modifications

While demonstrating or having methods student explore a typical science activity or inquiry lesson have one member in each group role play a disability. To do this in a methods class provide one student with a pair a chemical safety goggles that have had front panels covered with transparent tape. This allows students to see light and dark shapes, but not clear images. Another student could be asked to wear oven mittens during the activity. One student could wear ear plugs. One student must remain seated throughout the activity. One student could have a length of wooden dowel taped to their arm so that the arm has limited movement, another student could have a dowel taped to their leg above and below the knee for limited range of movement of the knee. Prepare a task that requires reading or following a set of written directions to complete and black out every other line of text for one of the students. Other modification can be made depending on the size of class and number of groups in the class.

At the end of the activity have the class debrief both the activity and the implications for having a group member that was role playing a disability. Some questions to get the discussion started include: How does the group have to adjust to help the student complete the activity? The group can debrief by brainstorming what tools and resources a teacher in that classroom should have provided. This activity gets them thinking about modification they might include in lesson plans they are writing.

Planning for Action.

Have teachers develop action plans to support students. See sample assignment that follows. The example provided can be used for a methods course or as part of a larger project.

Action Plan -- Learning Styles

As science teachers we have a responsibility to teach all students. Each classroom will have students with a wide range of learning styles and abilities. How are you going to ensure that you are meeting the needs of your students? What resources are available to help you support students? "Learning Styles" is a huge category and can mean many different things to different people. To limit the focus of this action plan choose one of the following categories and address three areas in each of this categories.

A. Learning Disabilities (dyslexia, attention deficient disorder, etc.)

B. Physical Limitations (hearing, visually, or mobility impaired, etc.)

C. Gardner's 7 Intelligences

D. Your proposed category (Check with me about additional categories or interests that you have that might fall under learning styles.)

Use the following to guide your development of an action plan. This is not meant to be the way that you present your plan. Several of these items could be grouped together. How you develop your plan and present it is a personal decision, but these are the items that you will be evaluated on (see grading rubric).

- Description of situation or rationale for need for action. (Minimum of 2-3 paragraphs)
- Background information (Are there appropriate laws, regulations mandating support? Is the school or another agency providing support? Is there a school focus or school support for this area?)
- Identification of individuals involved. (Detail who is involved and what responsibility each individual has)
- Identification of available resources.
- Identification of 3-5 options for each area.
- Prioritization of options (which would you do first, second etc....).
- Follow-up plans (How are you going to that that what you have implemented is working or if you need to modify your plan?).

To get you started following here are some ideas that past students have used or thought about using:

- Write this up as a newsletter or news paper article telling the reader your plans,
- Use something PowerPoint and think of it as a presentation to a school and/or parents;
- Use a graphics program to show plan as a concept map or flow chart
- Use HyperStudio with links and buttons

- Take an existing lesson plan or unit and annotate it to demonstrate your plan

This is a time for you to integrate all the resources you have available, things such as: What you have learned about adolescent development; Learning styles; Your special education inclusion course; Course discussions; The film "How difficult can this be?"; Class materials/resources; Your cooperating teacher and other school resources.

Science Activities Modified to Meet the Needs of Students with Disabilities

The following three activities have been modified to increase the variation of sensory and learning styles than may by typical of this type of activity. These sample lessons are provided so show a few of the modification that can make science more accessible to students with disabilities. Activities are provided in three areas:

- Science Skills – Sampling
- Life Science – Population Dynamics: Survival Strategies
- Physical Science – Refraction

Science Skills - Sampling

This provides an introduction to sampling procedures that are commonly used to explore science concepts.

Science Concepts Address:

- Sampling
- Graphing
- Estimation

- Population dynamics
- Survey dynamics
- Simple calculations

Materials per student team or pair

- Folding checker board (or paper marked out in a grid pattern – 5 cm squares work well)
- Colored glue or pipe cleaners
- 6 different color Beans or large beads (pony beads work well). – 100 of one color (color A – 200 if doing the extension; 25 of each of the other 3 colors (colors B, C, & D – 100 of each if doing the extension); 15 each of colors two different colors (colors E & F (50* of each if doing the extension)
- Large shirt size box - optional
- Zipper-style sandwich storage bag
- 7 Small cups (8-10 ounce size)
- Graph paper or paper to make graphs
- Markers or colored pencils
- *Optional – empty grated cheese plastic canisters (like the type pre-grated parmesan cheese is often sold in – that have the sprinkle and pour options in the lid).

Directions

Pre-lab set up:

In the sandwich back – count out 100 of color A, 25 each of colors B, C & D, 15 of color E and 10 of color F (total of 200 beads in this bag). The contents of this bag go in one of the cups. Remaining beads/beans go into remaining cups – one cup per color. Using glue outline the squares of the checkerboard or paper grid. Using the glue raises the boarders of the squares and allows individuals with vision limitations to still be able to count. If you do know want to use glue you can also use pipe cleaners form a square the size of one of the squares of the checkerboard. This can then be placed randomly on the board. A shirt box can be used to hold paper grid or checkerboard.

Activity Directions

- Count the number of squared on the checkerboard or grid. Record this number in the data table.
- Pour/scatter the beads/beans in the cup evenly onto the grid. A grated cheese container works well for this in place of the cup.
- Choose one of the squares in the grid. (The square chosen should have at least one bead/bead in it. The process of choosing a square can be done a variety of ways depending on the size of the grid. Students could number and letter the x and y-axis and have these numbers and letters in a basket to randomly draw coordinates. If the grid is smaller than 6 x 6 two position could be determined by numbering off the grid and rolling a dice for location (first roll x-axis second role y-axis). Younger students could close their eyes and randomly put their finger down on a square.

- Record the number of beads/beans of each color in the chosen square on the data table.
- Multiply the number of beads/beans of each color by the total number of squares in the grid. Enter that number on the data table.
- Pour the beads back into the container.
- Repeat steps 2 – 6 two more times. For a total of 3 trials.
- Average the 3 trials and record the average in the data table.

Assessment Strategies/Questions

Are the estimated population and the real population close to the same number? How do these numbers differ?

Explain what may cause a difference.

Why do you average 3 different trials rather than using only 1 trial?

When would you use a sampling procedure like this?

Create a graph showing the differences between calculated populations and real populations.

Design an experiment that would use this type of sampling, include in this design that data form that could be used to collect the data.

Follow-up options and extensions

Option #1: Using the activity total numbers assuming 100% reproduction – add beads to container. For example if experimental number for color A was equal to 85 add an additional 85 beads of color A to container. Repeat the trials with these new numbers.

Does accuracy increase or decrease with larger initial populations?

Option #2: Fill 1 one-liter beaker with a mixture of beads. Have students measure out 10 milliliters of beads and calculate the population of beads in the liter container.

How is this method of sampling similar and/or different from the technique used in this activity? When would you use this type of sampling and estimation?

Option #3: Use a digital camera to take a picture of the grid and population. Is this strategy as accurate is a direct observation? Why or why not?

Option #4: Scatter the population over an area that is not marked out in a grid. Have students design a method for determining the population.

Option #5: Provide students with a digital picture of a population and an overhead transparency marked in a grid pattern to do this activity. This can lead to a nice exploration of cartography and how maps are made of planets or inaccessible areas of earth using satellite images.

<u>Additional Teaching Suggestions</u>

- Vary the size of the population pieces to accommodate students who have motor difficulties.
- Vary the size of the grid using flooring tiles for the squares and marking off a grid with masking tape.

Comparison to real numbers.	
Total Population	Population by color

Real = 200	Activity	Real numbers A = 100 B = 25 C = 25 D = 25 E = 15 F = 10	Activity A = B = C = D = E = F =

Sample Data Table

<table>
<tr><th></th><th>Total number of squares</th><th>Number of individuals in one square.</th><th>Estimated population of each color</th><th>Estimated total population</th></tr>
<tr><td>Trial #1</td><td></td><td>A =
B =
C =
D =
E =
F =</td><td>A =
B =
C =
D =
E =
F =</td><td></td></tr>
<tr><td>Trial #2</td><td></td><td>A =
B =
C =
D =
E =
F =</td><td>A =
B =
C =
D =
E =
F =</td><td></td></tr>
<tr><td>Trial #3</td><td></td><td>A =
B =
C =
D =
E =
F =</td><td>A =
B =
C =
D =
E =
F =</td><td></td></tr>
<tr><td colspan="3" rowspan="2">Color A =

Color B =

Color C =

Color D =

Color E =

Color F =</td><td>Average estimated population by color</td><td>Average estimated total population.</td></tr>
<tr><td>A =
B =
C =
D =
E =
F =</td><td></td></tr>
</table>

National Science Standards

Content Standard A: Understanding about scientific inquiry (K-4) pg. 123

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events and organisms; classifying them; and doing a fair test (experimenting).
- Simple instruments, such as magnifiers, thermometers, and rulers provide more information than scientists obtain using only their senses.
- Scientist develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
- Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigation.
- Scientists review and ask questions about the results of other scientists' work.

Content Standard A: Understanding about scientific inquiry (5-8) pg. 148

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discover of new objects and phenomena; and some involve making models.

- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.
- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientist to analyze and quantify results of investigations.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence and suggesting alternative explanations for the same observations.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

Content Standard A: Understanding about scientific inquiry (9-12) pg. 176

- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.
- Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.
- Scientist rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data and therefore the quality of the exploration, depends on the technology used.
- Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.
- Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modifications; and it must be based on historical and current scientific knowledge.
- Results of scientific inquiry – new knowledge and methods – emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections

between natural phenomena, investigations and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Life Science – Population Dynamics: Survival Strategies

A wide variety of strategies allow living organism to survive in their environment. The following set of activities help students understand how and why some of these strategies are effective.

Science Concepts Address:

- Camouflage
- Preditor/prey relationships
- Mimicry
- Population dynamics

Materials per student team or pair: Birds and Worms – Project Learning Tree(American Forest Foundation, 1993)

- 100 small objects to represent worms or bugs, some suggestions: Multicolored pipecleaners – cut in 3-4 inch lengths (20 segments of 5 different colors – works well), pieces of yarn, paper shapes, paper clips. If done outdoors it is best to keep to biodegradable materials such as: beans, dog food, colored pasta. Be sure to start out with equal numbers of each color, for example 25 each of 4 colors, 20 each of 5 colors, 10 each of ten colors. You will need double of these materials for the extension. At least one of the colors should match the "field" or habitat.

- A large piece of white newsprint or poster paper.
- Markers
- Paper
- 1 sheet of white paper (8.5" x 11") for each team
- Pencils
- "Field" or Habitat – If doing this indoors it is helpful for clean up to do this on a sheet of wrapping paper, blanket, sheet or similar material. If doing this outdoors you may want to mark off the boundaries of the habitat.

Directions – Birds and Worms

Pre-lab set up:

- Count out initial population – 100 works well and makes for easy graphing but is not required. Record how many of each color you start out with on one side of the white paper.
- Determine your habitat location and spread out the "field" or mark boundaries of habitat
- Scatter worms/bugs in the habitat.

Activity Directions

- Divide the group into equal sized teams. Three to five teams per class works well.

- Describe the activity to the class. For this activity the students represent hungry birds. Scattered in the habitat is a variety of types of food for them. Show them what the food looks like or describe it to them.
- Have students line up within their teams. Students should number off within their team in the order they are in line.
- When the teacher says "Go" the first bird in each team will "fly" over the habitat and pick up the first piece of food that they see. When they get back to their team the next person "flys" over the field. The round is over when each member of team has gotten a piece of food.
- Using the large piece of paper make a chart with as many columns are there are members of each team. Each column is representative of their placement in the line. The students should place their worm in the column representative of their position in the line. A sample chart follows:

Team Name	1st Bird	2nd Bird	3rd Bird	4th Bird	5th Bird	6th Bird	7th Bird	8th Bird

- Have students count the number of each color of bird/bug that was collected by the class.

Option 2 or extension

- Have a white sheet of paper place about 1 meter in back of the last person in the line. Draw columns on the paper and number each column to correspond with student numbers Each bird puts down the piece of food they picked up on the white piece of paper. The food should be placed in the order it was picked up. That bird moves to the back of line and waits for it's turn to "fly" over the field. Each bird should visit the habitat 2-4 times depending on class size and amount of food available. At the end of the activity the white paper should have all the food collected by that bird team in the order it was picked up.
- Collect class data on data chart similar. See assessment questions below. The activity done in this way helps students understand that when food supplies are less plentiful, camouflage is less beneficial than during times when food is plentiful. Another way of documenting this is have student use a stop watch and time how long it takes their team to get food for each round.

Assessment Strategies/Questions

- Prepare a graph representing the information gathered.
- Is there any pattern in the order the worms/bugs are found? Does this pattern have any significance?
- What color was the easiest to find? What color was the hardest to find?
- What type of worm/bug has the best camouflage for this environment and why?

Follow-up options and extensions

- Using the same worms/bug try the activity on a different colored "field." How did this change the results?
- In place of color use texture or shape. One way of doing this is to fill a large bowl with marbles. Place in this bowl "food" pieces in a variety of shapes and textures such as: dice, pasta, yarn, fabric, ping pong balls, nuts, bingo chips, etc.
- An extension described in the FOSS Animals 2 x 2 kit [Lawrence Hall of Science, 1992] – has the teacher prepare a large paper grocery bag lined with newspaper. Fill the bag with shredded newspaper. Cut out equal numbers of colorful fish from construction paper, and twice that number of newspaper fish. For example: 20 red fish, 20 yellow fish, 20 blue fish, 20 green fish, 40 newspaper fish. Record data from "fishing trip" similar to that for "Birds and Worms."

Materials per student team or pair – Safety in Numbers

- 10 – 20 marbles or other small objects to represent birds
- Solid colored cup to hold objects
- Mailing tube for posters, or card board tube from wrapping paper (coffee cans or oatmeal boxes also work well)
- Small box – for optional activity

Directions – Safety in Numbers

Activity Directions

- Have one student represent the birds of the flock. The other partner represents the predator for the birds. Their job is to determine the size of the flock.
- The individual representing the flock chooses a number of "bird" holding them so that the predator cannot see how many there are drops them down the tube or into the canister. Based on the sound the predator estimates how many birds are in the flock.

Real Population	**Estimated Population**

Option 2 or extension

- In place of dropping objects. A small box with items placed in it and then allow the predator to shake the box to determine the population can also be used.

Assessment Strategies/Questions

Is there more accuracy in estimating small numbers of birds in a flock or larger numbers?

What factors influenced the accuracy of the estimate?

National Science Standards

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- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.
- Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.
- Scientist rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data and therefore the quality of the exploration, depends on the technology used.
- Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.
- Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modifications; and it must be based on historical and current scientific knowledge.
- Results of scientific inquiry – new knowledge and methods – emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections

between natural phenomena, investigations and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Physical Science - Refraction

This is a modification of the penny in a cup activity often done to demonstrate the concept of refraction.

Science Concepts Address:

- Refraction
- Implications of thickness of atmosphere and how it affects the bending of light.

Materials per student team or pair

- 2 drinking cups
- 2 shiny pennies or other coins
- modeling clay – 2 marble sized pieces
- water

Directions

Place the one piece of clay in the center of each cup.

Place the coin on top of the clay so that the coin in centered in the bottom of the cup.

Fill one cup 1/2 to 3/4 with water.

Place both cups on the edge of the table. The cups should be side by side at the edge of the table.

Stand close to the table.

Slowly move back from the edge of the table while observing the cups.

Stop when you can no longer see the coin in either cup.

Assessment Strategies/Questions

Describe what you observed and develop and explanation for this observation.

Diagram your explanation.

Does the distance change on the eye level of the observer? Explain why or why not.

Follow-up options and extensions

Try different liquids such as cooking oil, rubbing alcohol, corn syrup. Mark on the floor the spot where the coins disappear for each liquid. What patterns can you detect?

Have a student hold a string at the corner of their eye and a partner hold the other end of the string parallel to the coin position, using a protractor determine the angle at which each coin disappears. How does this change based on the liquid used?

National Science Standards

Content Standard B: K-4 pg. 123

As a result of the activities in grades K-4, all students should develop on understanding of

- properties of objects and materials
- position and motion of objects
- light, heat, electricity and magnetism*

*Expansion of this concept in regards to this activity (pg. 127)

Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object

National Science Standards

Content Standard B: 5-8 pg. 155

Transfer of energy

Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object – emitted or scattered from it – must enter the eye.

.Modified and expanded version of a published activity. [VanCleave, 1991]

Conclusion

For science to be inclusive, science educators and teachers need to start making the effort to rework and restructure science curriculum to meet the differing ability levels of special needs students. There will always be difference in the abilities of people to do science, however, until we begin to address directly science concepts critical for living, we will continue to have a wide range in the quality of science education offered to our nation's students. We must learn to appreciate and embrace some of the teaching strategies and ways of working with students that teachers in other disciplines use. If we don't make the effort to change how we present science, science will always be seen as elitist and not essential learning for all students.

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