Southeastern Ohio Science Partnership

EVALUATION

OHIO UNIVERSITY

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Prepared By
The Voinovich School of Leadership and Public Affairs

ACKNOWLEDGEMENTS

The Voinovich School of Leadership and Public Affairs conducted this evaluation of the Southeastern Ohio Science Partnership project. Senior Project Manager Margaret Hutzel is the project manager and Assistant Professor, Dr. Marsha Lewis, Ph.D. consults on evaluation design and data analysis. Research Associate Natalie Wilson conducted observations of the professional development sessions. Student Research Associate Nick Strahan conducted data entry and analyses. The Voinovich School wishes to thank the University of Rio Grande, Gallia-Vinton Educational Service Center, Chesapeake Union Exempted Village School District, Vinton County Local School District and The Ohio Department of Education for their participation in and support of the external evaluation activities.

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EXECUTIVE SUMMARY

This Executive Summary addresses Ohio University's Voinovich School of Leadership and Public Affairs' Year 1 evaluation findings on the Southeastern Ohio Science Partnership project. The project is a Math Science Partnership among the University of Rio Grande (URG), The Gallia-Vinton Educational Service Center (GV-ESC), Vinton County Local School District (VCLSD) and Chesapeake Union Exempted Village School District (CUEVSD). The purpose of the partnership is to connect K-12 teachers with math and science faculty at nearby colleges and universities in order to facilitate ongoing, high-quality professional development in the math and science content areas required by Ohio's Academic Content Standards. Collaborating with faculty at URG and the GV-ESC, VCLSD and CUEVSD science teachers in grades 3-8 were provided 35 hours of professional development in physical science content knowledge and teaching pedagogy. Thirteen individuals participated in the day-long workshops, including twelve teachers and one administrator.

The evaluation of the summer workshop finds:

- Participants showed a statistically significant increase in content knowledge as indicated by analysis of a pre-and post-test instrument developed using both Misconceptions-Oriented Standards-Based Assessment Resources for Teachers: Physical Science (MOSART)[1] and Diagnostic Science Assessment for Middle School Teachers (DTAMS)[2] instruments. Furthermore, participants indicated in exit tickets and group interviews that their content knowledge had increased as a result of the professional development.

- Participants reported an increased understanding of state content standards on the post-test evaluation instrument.

- Participants showed a statistically significant increase in pedagogical knowledge as indicated by analysis of a pre-and post-test instrument developed using a Pedagogy of Science Teaching Test (POSTT)[3] instrument.

[1] President and Fellows of Harvard College (2011). Project MOSART. National Science Foundation
[2] University of Louisville. DTAMS—Middle Science Teacher Assessments
[3] Western Michigan University Mallinson Institute for Science Education. The Pedagogy of Science Teaching Test (POSTT)

Southeastern Ohio Science Partnership

YEAR 1 EVALUATION

Introduction

As part of the 2001 reauthorization of the Elementary and Secondary Education Act, the U.S. Department of Education created the Mathematics and Science Partnership (MSP) program with the stated goal of increasing the academic achievement of students in mathematics and science by enhancing the content knowledge and teaching skills of classroom teachers.[4] The Ohio Department of Education administers the Ohio program. The program requires partnerships between high-need school districts and the Science, Technology, Engineering and Mathematics (STEM) faculty in institutions of higher education. The intent of the partnership requirement is to link K-12 teachers with math and science faculty at nearby colleges and universities in order to facilitate ongoing, high-quality professional development in the math and science content areas required by Ohio's Academic Content Standards.

The Ohio Department of Education awarded funding for a Mathematics and Science Partnership (MSP) program that aims to support science teachers within the Vinton County Local School District and the Chesapeake Union Exempted Village School District. Ohio University's Voinovich School of Leadership and Public Affairs staff completed a needs assessment for Chesapeake Union Exempted Village Schools and Vinton County Local School District (CUEVS and VCLSD). The needs assessment included a review of student performance overall and on strands of the Ohio Achievement Assessment, seven administrator interviews (two from CUEVS and five from VCLSD), and an online teacher survey. Results of the needs assessment were used to inform the Southeast Ohio Science Partnership.

A five-day workshop was held at the University of Rio Grande from 8:00am- 3:30pm during the week of August 3rd, 2015. Twelve teachers and one administrator from both Chesapeake Union Exempted Village School District and Vinton County Local School District participated and the program was led by Rio Grande Associate Professor of Chemistry, Dr. Jacob White and Associate Professor of Biology, Dr. Robert Hopkins II.

The objectives of the PD were threefold:

1.) Increase participating teachers' familiarity with new state standards
2.) Increase pedagogical knowledge of inquiry-based science instruction
3.) Increase science content knowledge in the physical sciences.

[4] U.S Department of Education (2014). Mathematics and Science Partnerships. Academic Improvement and Teacher Quality Programs: http://www2.ed.gov/programs/mathsci/index.html

This report evaluates the project's progress toward these three objectives and provides an evaluation of Year 1 implementation and outcomes.

Project Description

The implementation plan included professional development for elementary and middle school science teachers with a focus on content standards, content knowledge, and inquiry-based instructional strategies during the summer of 2015. Thirteen participants, including twelve teachers in grades3-8 and one administrator were provided five day-long professional development sessions held at the University of Rio Grande. Figure 1 lists the daily topics for the program.

Figure 1. Content of Day-long Professional Development Sessions

Day 1	**Morning:** Review of Ohio Science Standards and Model Curriculum; Review New State Science Test Specifications. **Afternoon:** Inquiry-based Science Instruction
Day 2	**Morning:** Matter—Historical Development, Classifications, & Learning Progressions **Afternoon:** Advanced Classifications of Matter and Pedagogical Considerations
Day 3	**Morning:** Changes in Matter—Conversions, Conservations, and Learning Progressions **Afternoon:** Conservation Tasks and Pedagogical Considerations
Day 4	**Morning:** Density, Heat, and Temperature **Afternoon:** Light and its interaction with matter
Day 5	**Morning:** Lesson Sharing and Curriculum Mapping **Afternoon:** Next steps and wrap up

Year 1 Evaluation Overview

Ohio University's Voinovich School of Leadership and Public Affairs serves as the external evaluator for the project. This report focuses on implementation and outcome evaluation findings for the summer workshop. Should funding be secured for project activities into the academic year, this program evaluation would continue.

Methodology

During the initial phase of the project in the summer of 2015, the evaluators used several methods to assess implementation and outcomes of the project including:

- Analysis of pre- and post-tests of participating Chesapeake Union Exempted Village and Vinton County Local School District teachers' physical science content knowledge and pedagogical knowledge;
- Analysis of participating teachers' group interview responses;
- Observation of selected professional development sessions;
- Participants' Exit ticket review.

Evaluation Findings

Content Knowledge

Evaluation Question 1: Does the project result in a statistically significant increase in Physical Science content knowledge of participating teachers?

Participating teachers were administered a pre- and post-test of physical science content knowledge. The pre-test was administered at the beginning of the first professional development workshop on Monday August 3rd and the post-test was administered upon conclusion of the PD on Friday August 7th.

The primary instrument chosen for use in the teacher science content assessment portion of the pre- and post-test was the MOSART[5] or Misconceptions-Oriented Standards-Based Assessment Resource for Teachers: Physical Science. The MOSART assessments were developed specifically for the National Science Foundation- funded Math-Science Partnership projects and are publicly available. In addition to the twenty MOSART assessment items, six relevant items from the Diagnostic Science Assessments for Middle School Teachers (DTAMS) were selected by the principle investigators and were included to further assess teacher content knowledge. The DTAMS assessments were specifically designed to assess teacher content knowledge so that researchers and evaluators can determine teacher knowledge growth over time.[6]

Matched pre- and post-test data was available for all 13 participants. A Wilcoxon Signed Rank Test indicated that the five day professional development elicited a statistically significant positive change in the participants' physical science content knowledge (Z= 2.831, P= .005). The pre-test median score was 17 and the post-test median score was 19.

Figure 2.Chesapeake Union Exempted village and Vinton County Science Teachers Content Knowledge Pre- to Post-test scores (out of 26 possible points)

Chesapeake/Vinton Participants	**n**	**Pre-test Md (SD)**	**Post-test Md (SD)**
	13	17 (2.599)	19 (2.136)

Additionally, participants indicated in their exit ticket responses and in the group interview at the conclusion of the professional development that the general instruction and subsequent discussions were beneficial, and they found working in groups to be particularly beneficial. The

[5] President and Fellows of Harvard College (2011). Project MOSART. National Science Foundation
[6] University of Louisville. DTAMS—Middle Science Teacher Assessments

content knowledge provided was helpful in refreshing and reinforcing their content knowledge. For example, when prompted in a daily exit ticket, all participants indicated that their understanding of classifications of matter had been increased due to the professional development training for that day. They also noted that using models to illustrate some of the concepts was beneficial to their understanding and they thought it would ultimately be beneficial to the understanding of their students with some indicating that they plan to use the same or similar models. Furthermore, the corresponding labs were reported to help cement content knowledge as well as provide useful classroom ideas.

Ohio Revised Science Content Standards

Evaluation Question 2: Does the project result in participating teachers' increased familiarity with the Ohio Revised Science Content Standards in Physical Science at both their respective grade bands as well as adjacent grade bands?

On both the pre- and post-test, participants were asked how familiar they are with the state content standards for their grade level, and then for the grade bands adjacent to the level they teach. These questions were matched pre- and post-test and analyzed for any changes. The response options were, "Not at all", "Somewhat", and "Very familiar".

Seven of the thirteen participants recorded a positive pre- to post-test change in their familiarity of respective grade level content standards while six participants' answers remained constant. Nine recorded a positive change in their familiarity with adjacent grade bands content standards. One participant recorded a negative change while the remaining three indicated that their familiarity remained the same pre- and post-test.

Figure 3. Change in Teacher Responses on Familiarity with Content Standards

	Familiarity increase	No Change	Familiarity Decrease
Familiarity with grade-level state content standards	53.8%	46.2%	0%
Familiarity with adjacent grade-level state content standards	69.2%	23.1%	.08%

Participants reported in the group interview that discussions of content standards were beneficial as they obtained and discussed various interpretations of the standards. Additionally, the use of content standards was used throughout the professional development in both discussions and activities as observed by the evaluators.

Pedagogy

Evaluation Question 3. Was the project successful in increasing participants' familiarity with and usage of model-based and inquiry-based strategies for the teaching of Physical Science?

Participants completed a section on both the pre- and post-test evaluating pedagogical knowledge, with a focus on knowledge regarding inquiry-based instructional strategies. Twelve selected items from Western Michigan University's Pedagogy of Science Teaching Test 1 (POSTT)[7] were used to assess the participants' pedagogical knowledge. Matched pre- and post-test data were available for all 13 participants.

A Wilcoxon Signed Rank Test indicated that the five day professional development elicited a statistically significant positive change in the participants' pedagogical knowledge (Z= 2.917, P= .004). The pre-test median score was 5 and the post-test median score was 10.

Figure 4. Chesapeake Union Exempted village and Vinton County Science Teachers' Pedagogical Knowledge Pre- to Post-test scores (out of 12 possible points)

Chesapeake/Vinton Participants	**n**	**Pre-test Md (SD)**	**Post-test Md (SD)**
	13	5 (2.532)	10 (2.075)

Exit ticket and group interview review indicated that participants believed instruction on, and discussions of, inquiry-based instructional methods were important initial activities and were subsequently mentioned by participants throughout the PD as observed by evaluators. Specifically, participants noted in exit tickets, the importance and benefits of learning how to "shift" lessons towards inquiry-based instruction and many reported in the group interview that they would apply this knowledge to their lesson plans and classrooms.

Additional Evaluation Findings

Participants indicated in both the post-test instrument, exit tickets, and group interview that a number of aspects of the professional development were most beneficial. The most commonly cited aspect was the activities, especially the labs, which participants indicated improved both their understanding of content knowledge and inquiry-based instructional strategies. They also indicated that not only were these items beneficial to their understanding, but they were easily

[7] Western Michigan University Mallinson Institute for Science Education. The Pedagogy of Science Teaching Test (POSTT)

transferrable to their classrooms where most felt they would be ultimately be beneficial to their students as well. No participants cited any aspect of the PD as being least beneficial.

Additionally, participants were asked what aspects of the PD they liked the most and what aspects they liked the least. All 13 indicated that discussion and collaboration with other teachers, as well as learning to shift lessons towards inquiry-based instruction were their most-liked aspects. Five participants reported items as being least liked. These items included: the in-depth approach to some of the content knowledge, the single content focus (physical science), and the activities focused on standards alignment, and the week-long professional development occurring during summer break. The remaining seven participants did not cite any least liked aspect of the PD.

When asked in the exit tickets and the group interview what recommendations participants would make for future professional development the majority reported they would prefer a similar design of the current PD but with a focus on other content areas, such as Earth and Space Science and Life Science, and additional instruction on other pedagogical practices. Additional recommendations include:

- A focus on mathematics
- Additional observation and guidance during the school year
- Expansion of the PD to include teachers from other grade levels
- Continued co-district professional development

Additionally, when asked what timeframe works best, participants indicated that they enjoyed the weeklong summer session but were open to the possibility of utilizing days during the school year, either partial or full. Participants did not recommend any weekend or after school professional development times.

Conclusion

The program achieved success in regards to its three stated goals. Participants showed a statistically significant increase in both Physical Science content knowledge and pedagogical knowledge, especially in regards to inquiry-based instruction. Additionally, participants reported an increase in knowledge regarding state content standards.

Exit tickets and a group interview were utilized to inform possible future professional development opportunities, an option which all 13 participants were interested in. The majority recommended a similar professional development design, but with the remaining content strands. This evaluation sought to measure desired outcomes of this specific professional development session, but can also be used to inform additional professional development.

Appendix A

Unique Personal Identifier – You will put an identification code on all information you submit for collection as part of the evaluation of this project. Here is how you determine your code that is unique to you. Please create your unique identifier.

Unique Identifier	**First 2 Letters of your Mother's Maiden Name**		**Your Birth Month**		Your Birth Day	
EXAMPLE	**G**	**R**	**1**	**2**	**0**	**5**
Your Unique Identifier						

In which district do you teach: ☐ Chesapeake ☐ Vinton

How many total years have you taught students in grades K-6? ____ years

How many total years have you taught students in grades 7-12? ____ years

Please indicate whether or not you meet either of the following qualifications.

Are you a National Board Certified Teacher? ☐ yes ☐ no

Are you a Highly Qualified Teacher of science? ☐ yes ☐ no If yes, which area(s):
_____

What is the highest college degree you have earned? ☐ Bachelors ☐ Masters ☐ PhD

Beyond the degree, how many additional **semester** hours have you earned? _____ hours

Which of the following college-level science courses have you completed (Check all that apply)?

☐ Biology ☐ Physics ☐ Geology ☐ Chemistry ☐ Other _____

How often do you use inquiry-based instruction in the classroom?

☐ Never ☐ Rarely ☐ Sometimes ☐ Frequently ☐ Always

How familiar are you with state content standards for your grade level?

☐	☐	☐	☐	☐
Not at all		Somewhat		Very familiar

How familiar are you with the state content standards for grade bands adjacent to the level you teach?

☐	☐	☐	☐	☐
Not at all		Somewhat		Very familiar

Thanks! Please continue to the next instrument!

Appendix B

Unique Identifier	First 2 Letters of your Mother's Maiden Name		Your Birth Month		Your Birth Day	
EXAMPLE	**G**	**R**	**1**	**2**	**0**	**5**
Your Unique Identifier						

Unique Personal Identifier – You will put an identification code on all information you submit for collection as part of the evaluation of this project. Here is how you determine your code that is unique to you. Please create your unique identifier.

How often do you use inquiry-based instruction in the classroom?

☐ Never ☐ Rarely ☐ Sometimes ☐ Frequently ☐ Always

How familiar are you with state content standards for your grade level?

☐ ☐ ☐ ☐ ☐

Not at all Somewhat Very familiar

How familiar are you with the state content standards for grade bands adjacent to the level you teach?

☐ ☐ ☐ ☐ ☐

Not at all Somewhat Very familiar

What did you like best about this professional development?

What did you like least about this professional development?

Appendix C

Thinking about Science Teaching

Dear Teachers:

This assessment is composed of classroom science teaching vignettes similar to teaching practices one can find in any classroom today. Practicing teachers contributed ideas for many of the vignettes; others are based on teacher observations, or on science curriculum standards. Please read each vignette and respond accordingly by circling your answer.

Frog dissection 1

Mr. Goodchild is doing a frog dissection with his 8th graders to help teach them about anatomy. Of the following, which would be the best choice for didactic direct instruction?

A. It should be used as a stand-alone step-by-step activity for students to explore the frog's anatomy and raise discussion questions on their own.

B. It should be used as a follow-up step-by-step student activity after Mr. Goodchild explains exactly what students will need to notice about the frog anatomy.

C. It should be used as a step-by-step student activity while answering probing questions, followed up by teacher-led discussion and clarifications.

D. It should be used as a step-by-step demonstration by Mr. Goodchild while he explicitly points out what students need to know about frog anatomy.

Organisms respond to environment

Ms. Pendleton wants to teach her 1st grade students that living organisms respond to their environment. The students did an experiment on how earthworms respond to their environment. Then in small groups they discussed a series of questions about the experiment. Ms. Pendleton now needs to wrap up the lesson.

Of the following, which one would be open inquiry?

A. Have the students come up with a general conclusion based on the evidence they gathered from their earthworm experiment, guiding them toward the concept objective.

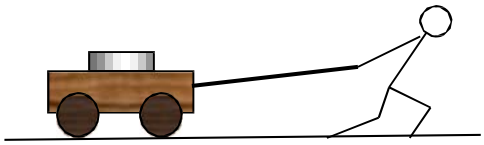
B. Restate the concept objective for the students, and ask students to provide supporting evidence from their earthworm experiment.

C. Have students report their conclusions, based on the evidence gathered from their earthworm experiment.

D. Restate the concept objective for the students, relating it to the observations they gathered in their earthworm experiment.

Lesson on force and motion

Ms. Brandt is preparing a lesson to introduce her 5th grade students to the relationship between force and motion, namely that a net force will cause an object to speed up or slow down (Newton's 2nd Law). The classroom has available a loaded wagon to which a pulling force can be applied. Ms. Brandt is considering four different approaches to the lesson.



Of the following, which one is an example of guided inquiry?

A. Write a clear statement of Newton's 2nd Law on the board and explain it carefully to my students. Then I would demonstrate the law by pulling on a loaded wagon with a constant force in front of the class as they observe the motion.

B. Raise the question of what kind of motion results from a constant force. I would then guide my students to explore the question themselves by pulling on a loaded wagon and observing what happens. From the evidence they would then propose a possible law.

C. Write a clear statement of Newton's 2nd Law on the board and explain it carefully to my students. I would then have the students verify the law by pulling on a loaded wagon themselves and confirming what type of motion results.

D. Raise the question of whether there is any relationship between force and motion. My students would then be free to explore this safely in the lab. Afterward we would have a class discussion of their findings.

Air is matter

Ms. Harvey's class has been learning about matter. She now wants her 4th grade students to learn that gases (like those in air) are also a form of matter. She plans to introduce her lesson by raising some questions with her students about whether air is matter, and how they could find out.

Ms. Harvey is still considering what to do next. Thinking about how you would teach this lesson, which of the following would you do if your aim was open inquiry?

A. I would ask students to think up ways to test if air is matter using whatever equipment we have in the classroom. I would then allow them to go ahead and try their ideas.

B. I would help the students develop ways to test the question of whether air is matter, allow them to investigate with fans, and use their findings to conclude that it is.

C. I would tell the students that air is indeed matter, and that although air is not very dense, there is something there that can be felt. I would then ask them to use fans at their desks to see if they could find evidence that air was indeed matter.

D. I would tell the students that air is indeed matter, and that although air is not very dense, there is something there that can be felt. I would then demonstrate this property to the class by having them feel the air from a fan.

General wrap-up of unit

Mr. Nelson's 6th grade students have just completed a unit in their earth science class. As a "wrap-up," Mr. Nelson would like students to re-examine the three learning objectives that served as the focus for this entire unit.

Of the following, which would you do to use didactic direct instruction?

A. I would ask the students what the main things are that they have learned in the unit, according to their own ideas of what is important or interesting, and have them list these as the unit wrap-up.

B. I would restate the three learning objectives for the students, and then relate each of them to the specific concepts that arose in the unit.

C. I would ask the students to reflect back on their work, and identify for themselves what the important central ideas of the unit were, then have them relate these to the original learning objectives.

D. I would restate the three learning objectives, then ask the students to say how the various concepts that arose in the lesson related to each of these.

Structure and function

Mr. Danzit will be teaching his 3rd grade students a lesson on "structure and function" as applied to digestive systems. He has a set of pictures showing the mouths of different animals, including a finch beak, a dog jaw with teeth, and horse jaw with teeth. He also has a chart that he can distribute to the students, which will allow them to fill in information about what each of these animals can and cannot eat.

Of the following, which is the best statement on how Mr. Danzit should begin the lesson if he aims to use guided inquiry?

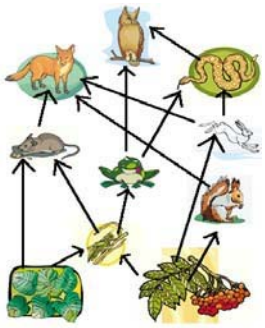
A. Mr. Danzit should begin the lesson by carefully explaining the concept of structure and function as it relates to the digestive system, specifically mouth parts. He should then ask the students to fill out the chart using the pictures and his discussion as a guide.

B. Mr. Danzit should allow the students to explore a set of photos showing animal mouths. He should then have the students write their own stories about how these animals are similar and different, including what they eat.

C. Mr. Danzit should begin the lesson by carefully explaining the concept of structure and function, while helping students fill in their charts, so they can clearly see examples of this concept as it relates to digestive systems.

D. Mr. Danzit should begin the lesson by showing his students a picture of a shark mouth, asking student what this animal might eat. After a discussion, he should give each student a copy of the chart and the other pictures, asking students to complete the chart based on their early discussion.

Field trip



Ms. Piper is taking her 3rd grade class to the local nature center. Because they are currently studying food webs, she would like to use the field trip as a way to learn more about this topic.

If active direct instruction is your aim, how would you most likely use a field trip to teach students about food webs?

A. I would inform them that on our upcoming field trip they will be looking for examples of food webs. During the field trip, students could make their own list of interactions they observe relating to food webs, which we would discuss later as a group.

B. I would inform students before the field trip that we are going to look for specific examples of food webs, providing them a checklist of interactions they should see. During the field trip, I would point out to them interactions, having them mark off each as we go.

C. I would not tell students exactly what to look for during the field trip, but would ask them to make observations about any of the interactions they see between organisms. Afterwards we could discuss what they saw relating to food webs.

D. I would inform students before the field trip that we are going to look for specific examples of food webs, providing them a checklist of interactions they should see. During the field trip, students could look for those examples and mark them off as we go.

Predator and prey

Mr. Peoples is conducting a unit on food chains and is about to introduce his 7th grade students to predator/prey relationships. He has a good computer simulation game for this subject that he can use with his class.

Of the following, which is the best advice for conducting this lesson as open inquiry?

A. Mr. Peoples should explain to his students that balance typically exists in nature such that the numbers of predators and their prey are related. For example, he can tell them that a rabbit population will increase if disease reduces the coyote population in the same region. He should then project the simulation game to demonstrate relationships between rabbit and coyote populations.

B. Mr. Peoples should explain to his students that balance typically exists in nature such that the numbers of predators and their prey are related. For example, he can tell them that a rabbit population will increase if disease reduces the coyote population of the same region. Using the computer simulation game, he should have the students monitor and record the rabbit levels over a simulated ten year period during which the population of coyotes rises and falls, so that they can confirm the predator/prey concept he explained.

C. Mr. Peoples should ask what would happen with rabbits if many coyotes died suddenly of disease. After some discussion, Mr. Peoples should suggest that the students explore their ideas using the computer simulation game he has for this subject, by recording yearly counts over a simulated period of ten years. The students will then have data to be used in a class discussion on predator/prey relationships.

D. Mr. Peoples should begin by asking the students what they know about predators and prey. Without responding other than to encourage their ideas, Mr. Peoples should then show them the computer simulation game he has for this subject and invite them to use the simulation in any way they wish to explore their ideas. The lesson would end with students writing up their findings.

Soil porosity

Ms. Cubbage's 7th grade science class has been learning about soil types by observing soil color and texture (particle size). While making observations of soil samples, the students notice that some soil types seem more "fluffy" than others. Ms. Cubbage realizes that her students are referring to *porosity* (how densely the materials are packed together, ability to allow water to move through) which is one of the key concepts later in her unit.

If your aim was to use guided inquiry, which of the following ways would you respond to the students' observation?

A. I would congratulate the students on such a good observation, then explain to them *porosity* is a description of how densely packed soils are. I would then tell students how to test soils for it, and follow up by doing tests on our soil samples for porosity.

B. I would congratulate the students on such a good observation, and ask them what they thought they were looking at. Through discussion I would try to get them to think about packing and how one might test for packing. We would do tests and based on their findings, I would introduce the concept of *porosity*.

C. I would recognize that what is most important here is that the students were being independent investigators, not necessarily that they were stumbling upon the idea of *porosity*. I would simply encourage their scientific attitudes and have them continue their investigations.

D. I would congratulate the students on such a good observation, then explain to them that what they observed was called *porosity*. Using a demonstration, I would show the students that more porous soils are less packed and that water moves more easily through porous soils.

Magnets and materials

Mr. Golden has introduced the topic of magnetism to his 1st grade students, and they have learned that bar magnets attract certain kinds of materials that have iron in them. For today's new lesson, he has available bar magnets and a variety of food containers, made of plastic, iron, aluminum, steel, and glass.

How you would conduct this lesson if your aim was active direct instruction?

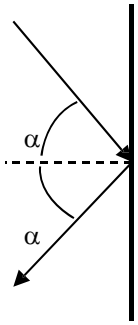
A. I would tell the students that our assignment for the day is to solve the puzzle of which food containers contain iron and which do not. Students would be asked to think of how they could find out, and they would either come up with or be prompted to use bar magnets to test the various kinds of food containers.

B. I would remind the class that magnets attract materials which contain iron (including most steels), and then show them how the bar magnet attracted the containers made from steel or iron, but not any of the other containers.

C. I would tell the class to recall that magnets attract materials which contain iron (including most steels), and then have small groups of students use bar magnets to sort the food containers into those which do contain iron and those which do not.

D. Each group of students would be provided with a bar magnet and the various kinds of food containers. I would not outline a specific task but ask them to find out what they can about the collection, and report back their observations and conclusions.

Light reflection



Ms. Baker is teaching her 8th grade students the law of reflection: when a ray of light strikes a mirrored surface, it leaves at the same angle as when it arrived. Ms. Baker has to decide how she will teach the lesson.

Thinking about your own teaching, how would you teach the lesson if your aim was didactic direct instruction?

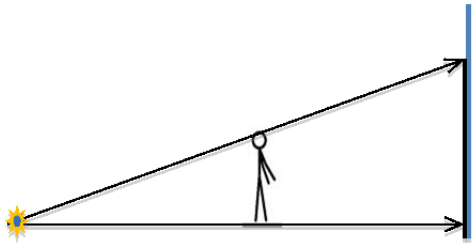
A. I would write the law of reflection on the board and illustrate with a diagram. Next I'd show them a real example, using a light ray source, mirror, and protractor. Then we would discuss any questions the students might have.

B. I would ask students to find out what they can about light behavior around mirrors by exploring on their own with an assortment of available items, including light ray sources, mirrors, and protractors. Then the students would report back on what they did and what they found out.

C. I would first pose a question about reflection for the students to explore. The students could investigate using light ray sources, mirrors, and protractors, and then discuss their findings. I would close the lesson by giving them a summary of the law of reflection.

D. I would write the law of reflection on the board and illustrate with a diagram. Then I'd have the students verify the law using light ray sources, mirrors, and protractors. We would then discuss their findings.

Light & shadows (a prediction task)



Ms. Adams's fifth grade students have learned that light travels in a straight path and that shadows arise when an object blocks light. Ms. Adams wants her students to be able to *apply* these ideas to make predictions about shadow behavior. She turns out the main room lights, and has one child Sam stand in the light from a lamp on the floor, casting a shadow on the wall. Students draw ray diagrams in their notebooks showing how Sam's shadow is being formed. Ms. Adams says that once we understand how shadows form we can *predict* what will happen to the shadow if Sam moves further from the lamp.

If she wanted to use active direct instruction, how would you suggest Ms. Adams continue this part of the lesson?

A. Have students follow her directions to make a second diagram in their notebooks with Sam further away, and point out to them how this shows the shadow becomes smaller. Then have Sam move to confirm the prediction.

B. Draw a ray diagram on the board to show that the shadow will be smaller when Sam is further from the lamp. Then have Sam move to confirm this prediction.

C. Ask students to predict what will happen to the shadow, in whatever way they wish, and explain their predictions. Then have Sam move to check the predictions. If there are discrepancies let the students discuss and resolve.

D. Ask each student to make their own prediction of what will happen to the shadow, based on what they have learned about shadow formation, using a ray diagram. Then have Sam move to check their predictions. If there are discrepancies, discuss with the students and resolve.

Appendix D

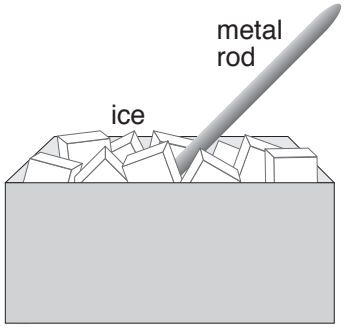
PHYSICAL SCIENCE TEST

For some questions, there may be more than one correct answer. However, each question has only one best answer. Choose the single best answer from the five choices for each question.

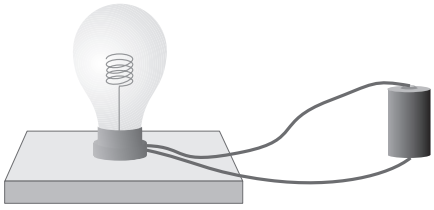
1. Jack opens a can of soda pop and lets it sit on his kitchen countertop. He goes off to do some chores and forgets about the opened can. When he returns several hours later, the weight of the opened can of soda pop will:
   a. be more than the unopened can.
   b. be less than the unopened can.
   c. be the same as the unopened can.
   d. depend on the relative humidity.
   e. depend on the type of soda pop.

2. Helium gas is used in balloons. When helium gas is cooled enough, it becomes a liquid. What do you think happens when helium turns into a liquid?
   a. The helium has turned into water.
   b. Some of the helium has turned into water.
   c. The helium has turned into a different liquid.
   d. Some helium has turned into water, some into another liquid and the rest is helium.
   e. It is all still helium, but in a liquid form.

3. Sue sticks one end of a metal rod into a box filled with ice. The end of the rod that is covered with ice becomes cold. After a while Sue places her hand on the upper end of the rod outside the box and feels that it is cold. What do you think has happened?
   a. Cold has transferred from the lower end of the rod to the upper end.
   b. The rod gave up heat to the ice.
   c. Cold moved from Sue's hands towards the rod.
   d. Heat moved from the rod to Sue's hand.
   e. It depends on the original temperature of the rod.



4. A light bulb is connected to a battery by wires. The bulb is lit up. Nadia wants to know what is flowing through the wires. If a scientist were to cut the wire and look at it with a powerful magnifying glass, what do you think she would see?
   a. Chemicals from the battery flowing through the wire.
   b. Light flowing through the wire.
   c. The wire will be hollow with nothing flowing through it.
   d. Tiny sparks flowing through the wire.
   e. The wire will be solid.



5. John has built a special greenhouse in his backyard. By turning a special dial, John can choose which type of sunlight can enter the greenhouse. When only ultraviolet light is allowed to enter the greenhouse, what do you think will happen while John is standing inside the greenhouse?
   a. John can see objects inside the greenhouse.
   b. It is warmer inside the greenhouse than it is outside.
   c. After a few hours, John begins to sunburn.
   d. John can see objects outside the greenhouse.
   e. John can only see a few objects.

Rio Connection: Increasing Continuity throughout the Science Curricula
Teacher Content Knowledge Pre-test

1. You are interested in determining the most effective antacid tablet brand to neutralize stomach acids. You select two brands, A and B, and to test the tablets you decide to react each tablet with an acid and measure the pH. Which of the following would be the best experimental setup for this purpose?
    a. Alternate putting equal amounts of brand A and brand B tablets into one container of acid until you get a neutral pH.
    b. Put equal amounts of brand A and B tablets into one container of acid and measure the resulting pH.
    c. Put equal amounts of brand A and B tablets into separate containers, add identical amounts of one acid to A and a different acid to B, and measure the resulting pH of each container.
    d. Put equal amounts of brand A and B tablets into separate containers, add identical amounts of the same acid to each, and measure the resulting pH of each container.

2. When dissolving a solid in a liquid, the resulting mixture is called a
    a. solvent.
    b. substance.
    c. solution.
    d. solute.

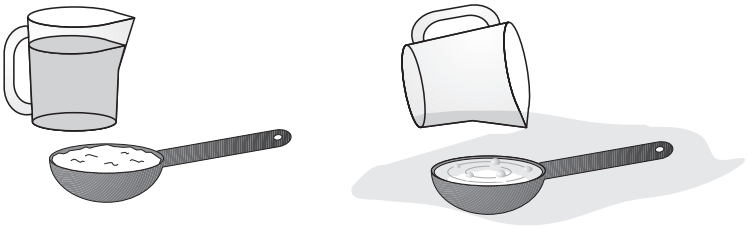
3. In the periodic table of the elements (ignoring the transition metals), the number of elements that appear in the first few horizontal rows is the same as the number of
    a. energy levels electrons inhabit.
    b. electron capacity in the outmost shell.
    c. isotopes an element can form.
    d. protons and neutrons in the nucleus.

4. As a water puddle outside is undergoing the process of freezing on a cold winter day,
    a. its temperature falls.
    b. vibrations between molecules are slower and slower.
    c. vibrations between molecules are faster and faster.
    d. its molecules change shape.

5. In some developing countries with hot, desert-like climates, people are able to cool their rooms without electricity. One technique involves spraying or splashing water on the concrete or adobe walls inside the house. Why does this process cool the rooms?
    a. The extra humidity in the air from the splashed water causes more dense, cooler air to sink down to the rooms whereas hotter, less dense air rises up and out of the rooms, leaving the rooms cooler than before.
    b. The water splashed on the inside walls is transported through the air to people's skin, increasing their bodies' abilities to cool off and making the room seem cooler even though it really isn't any cooler than before.
    c. The hot, dry air inside the rooms evaporates the water splashed on the walls; this evaporation removes the heat from the air and results in the air being cooler than before the evaporation.
    d. The water on the inside walls helps seal the walls airtight against the hot outside air, which prevents the hot outside air from coming into the rooms.

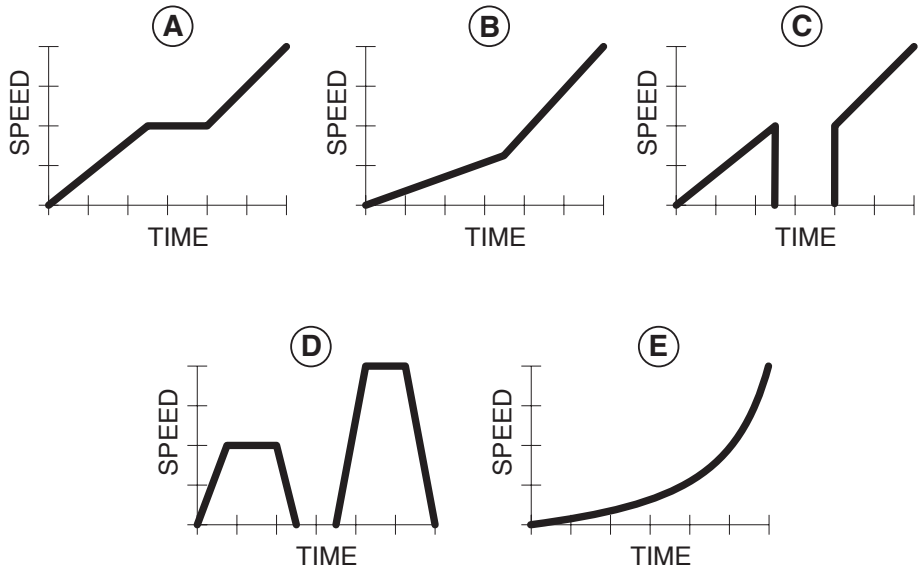
6. Information needed in order to classify energy as either kinetic energy or potential energy is whether the energy is
    a. highly concentrated or whether it is dispersed widely.
    b. manifested in motion or whether it is stored energy.
    c. being transferred to a new system or whether it remains inside the system.
    d. visible to observation or whether it is hidden energy.

6. Suzanne is baking a cake and has placed several ingredients on the countertop to use. She has scooped some baking soda into a measuring spoon. She accidentally knocks over a cup of vinegar and several drops spill onto the spoon with the baking soda. The baking soda begins to fizz where the vinegar spilled on it. When the fizzing stops, Suzanne notices that about half of the baking soda in the spoon is gone and there is now a liquid on the spoon. The baking soda "disappeared" because it:



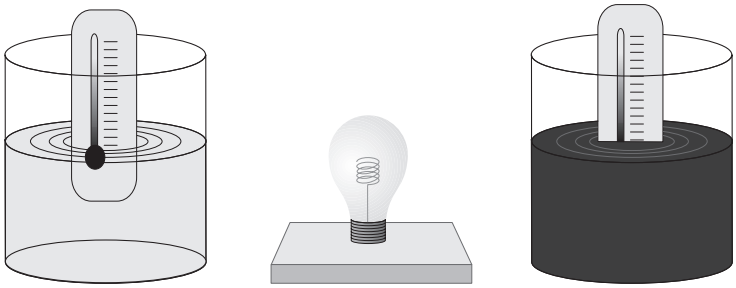
   a. melted.
   b. combined with the vinegar and produced a new liquid.
   c. dissolved in the vinegar, but is still in the liquid.
   d. evaporated.
   e. was pushed off of the spoon by the fizzing.

7. Carolyn walks a half mile to school. One morning, halfway to school, she stopped to watch a bird building a nest. When she realized she was late, she ran the rest of the way to school to avoid being marked late. Which graph below shows Carolyn's speed during her walk to school?

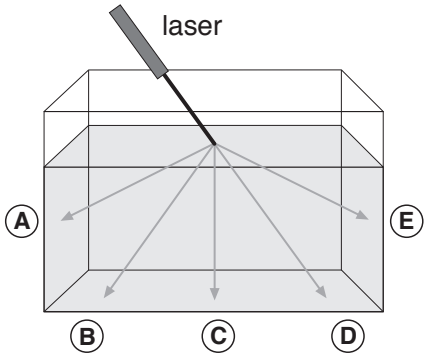


GO TO QUESTION 8 >>

8. Two identical jars are placed on a table with a light bulb between them. The bulb is turned on. One jar is filled with water and the other jar is filled with black ink. There is a thermometer hanging in each jar. What do you think will happen?
   a. The jar with water will be hotter than the jar with black ink.
   b. The jar with black ink will be hotter than the jar with water.
   c. There will be no difference in the temperature of the two jars.
   d. The temperature in both the jars will drop.
   e. The temperature in the jar with black ink will first drop and then increase.



9. Look at the set up below. It shows a fish tank filled with water; the sides and bottom of the tank are all clear glass. If a red laser pointer were aimed into the tank as shown, at which lettered point do you think the laser beam would hit the glass?



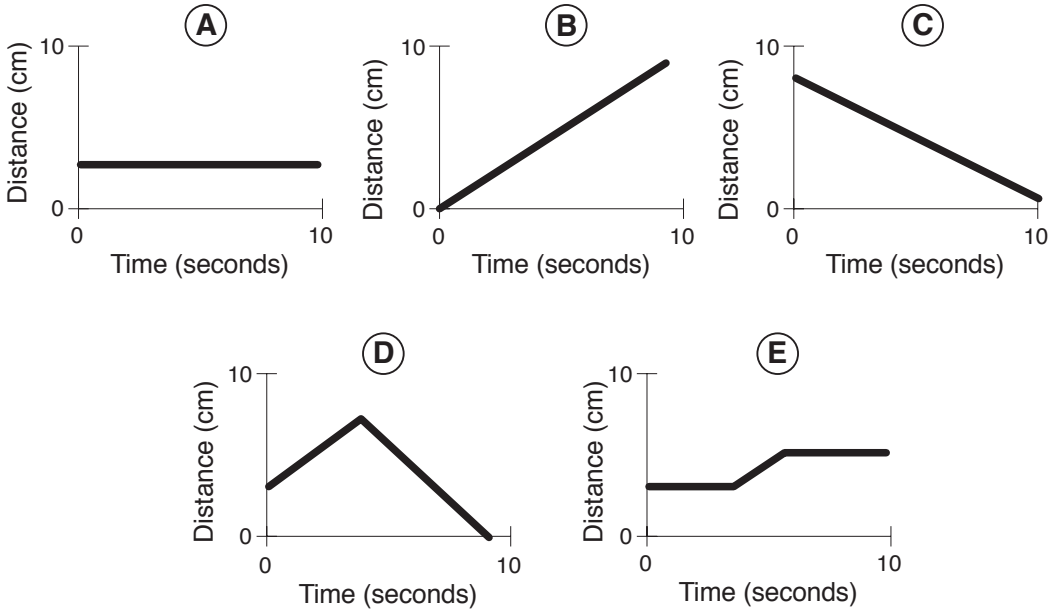
10. Someone claims to have invented a system that converts sound energy into electrical energy. The inventor plans to put this system into a portable CD player so that the player's own sound can be used to recharge the player's own batteries. What do you think will happen when this CD player system is tested?
   a. The system should work fine, allowing unlimited running time for the player.
   b. The system will work, but the player's volume will have to be kept in a narrow range, not too low, not too loud.
   c. The system will work, but the player's volume will vary from low to high depending on whether or not the battery is being charged.
   d. The system will be limited by the design of the battery: if it takes too long to fully charge, the battery may go dead.
   e. The system will not work and the CD player will stop running after the battery is fully discharged.

11. It is a sunny day. Sean sits by the window and enjoys the sunshine. His mother tells him not to sit there for too long. However, Sean does not agree with her. Which one of the following statements do you agree with?
   a. Sean can get skin cancer from the ultraviolet radiation coming in with the sunlight.
   b. Ultraviolet radiation is completely blocked by the window glass.
   c. Ultraviolet radiation will not affect Sean in any harmful way.
   d. Sean's risk depends upon the amount of sunlight.
   e. The thickness of the window is important.

12. As part of an experiment, Jason mixes 2 cups of water at 200˚F with 10 cups of water at 50˚F. The temperature of the combined water is:
    a. 200˚F.
    b. closer to 200˚F than to 50˚F.
    c. 125˚F.
    d. closer to 50˚F than to 200˚F.
    e. impossible to estimate.

13. Mike thinks that he can turn copper into gold. He mixes a small amount of gold with a large amount of copper and heats them up until they melt. What do you think has happened?
    a. All the copper has turned into gold.
    b. Some of the copper has turned into gold.
    c. The copper has not changed into gold. It's just a mixture of gold and copper.
    d. Copper and gold have turned into something completely new.
    e. Not enough information to answer the question.

14. Kaitlyn is watching a wind-up toy walking across a table. She observes that the toy covers 1 cm every second for 10 seconds. Which graph below do you think most closely represents the toy's journey across the table?

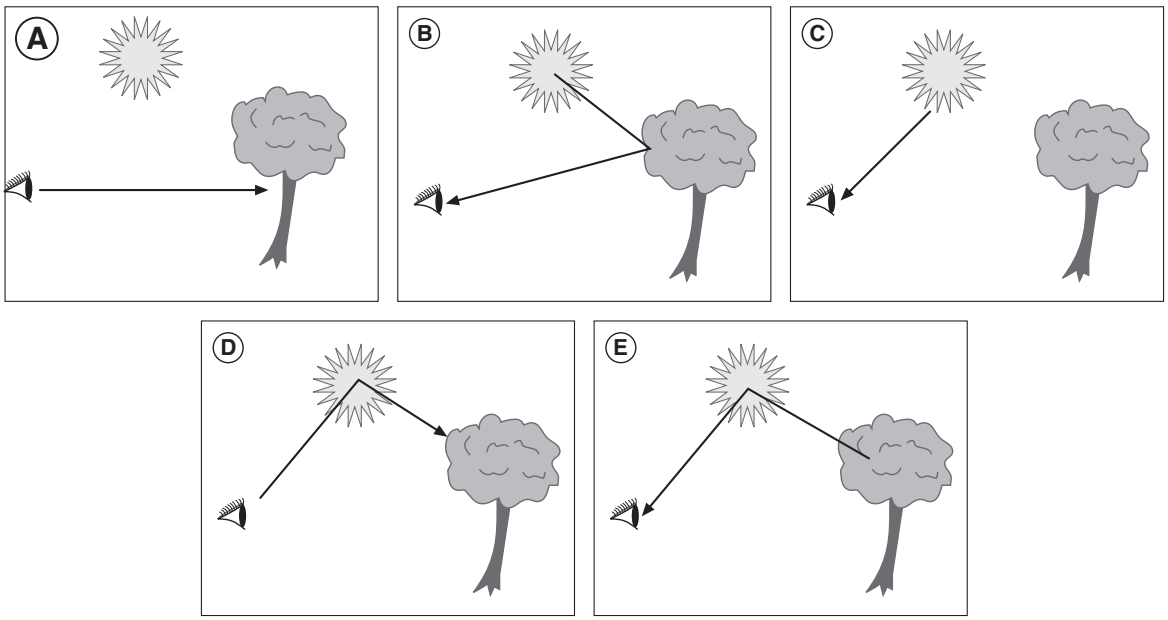


15. A person claims that diamonds and the graphite in an ordinary pencil are made of the same material. A scientist's response would be that the claim is:
    a. False. The two substances are too different to be made of the same material.
    b. False. Every substance is unique; no two substances are made of the same material.
    c. Not able to be answered with the information given.
    d. True. The substances look different because what's inside them is arranged differently.
    e. True. The material is held together by a different substance, causing the different properties.

16. A see-saw has cinder blocks attached to it on both ends. The single block weighs 20 pounds and the two small blocks weigh 10 pounds each. What do you think will happen to the see-saw when its allowed to move?

a. The side with the single block will move downward.
b. The side with two small blocks will move downward.
c. The see-saw will not move.
d. The side with the single block will first move downward and then upward.
e. The side with the small blocks will first move downwards and then upward.

17. Zahra is sitting in her backyard, looking at a tree. With which of the following statements about how she is able to see a tree do you agree?
a. Light from her eye reaches the tree and she sees the tree.
b. Light from the Sun reaches the tree and then her eye and she sees the tree.
c. Light from the Sun reaches her eye and she sees the tree.
d. Light from her eye reaches the Sun and then the tree and she sees the tree.
e. Light from the tree reaches the Sun and then her eye and she sees the tree.



18. Imagine that you go to leave a room with an overhead light. The light is on. You move the wall switch to turn off the light, but the light stays on. What is probably wrong?
a. The battery that powers the switch is dead.
b. There is a break in the wire to the light bulb.
c. The switch can no longer stop the flow of electricity through the wires
d. The light fixture is broken.
e. A surge of electricity is occurring in the building.

GO TO QUESTION 19 >>

19. A solid rubber ball sinks when placed in water. What will happen if the ball is cut in half and one of the smaller pieces is placed underwater?
    a. The smaller piece will rise.
    b. The smaller piece will sink.
    c. The smaller piece will stay motionless.
    d. The smaller piece will dissolve.
    e. There is no way to predict what will happen.

20. A pebble is dropped into a cup of water and sinks to the bottom of the cup. A solid metal bead of exactly the same size is dropped into the same cup and sinks to the bottom of the cup. How do the pebble and the metal bead compare?
    a. The metal bead and the pebble have the same density.
    b. The metal bead and the pebble are the same mass.
    c. The metal bead and the pebble are denser than water.
    d. The metal bead and the pebble contain the same materials.
    e. The metal bead and the pebble are as dense as the water.