

# **Appendix F**

## **Grades K–5 Science**

### **Typical Lessons**

### **Ratings of Lesson Components**

### **Overall Lesson Quality**

## Typical Lessons

The following lesson descriptions are based on a random sample of K–5<sup>th</sup> grade science lessons.

### **Kindergarten: Basic Needs of Plants**

This kindergarten class was in the middle of a unit on living and non-living things. Prior to this lesson, they had discussed the characteristics of living things, seeds, and the parts of a plant. After this lesson on the basic needs of plants, the class would move on to how plants grow and change. This lesson was taught because it is in the recently-adopted textbook series, which is also aligned with the state standards. In addition, the teacher believes that students at this age need to work on their reading and fine motor skills, and that they enjoy hands-on work.

The lesson started with a review of what the class had done up to this point with plants. Students sat on the floor, and the teacher asked them to list their activities over the last few weeks, which included planting sunflowers, reading a story about a seed, conducting an experiment by depriving a plant of water, and creating a concept web about what plants need. The teacher showed them the web they had made, and the students recited the needs of plants (sunlight, soil, air, and water).

Next the teacher showed an example of the project the students would be working on in this lesson. The picture consisted of a magazine photograph of a flower, a watering can and sun made from construction paper, and crayon drawings of soil and air. Each part was labeled with the typed words “light, soil, air, and water”; and at the top were the words “What do plants need?” The teacher showed the students what the labels looked like, and read them aloud with the students. She then showed them where on the tables they could find each of the materials and instructed them to make their picture look exactly like hers.

Students worked on their projects for the remainder of the lesson as the teacher circulated and offered help or asked questions. She did the cutting and pasting for some students and simply offered encouragement to others. Many of the students had trouble reading the labels and could not even begin to sound out the words when coached. For these individuals, the teacher read off the word and asked them to place it on the appropriate part of the picture. After half an hour, the teacher called students back to their seats and asked, “Have we learned what plants need?” and students replied in a chorus, “Yes. Water, sun, soil, air.”

## **1<sup>st</sup> Grade: Plant Growth**

This is the third lesson in a kit-based unit on organisms. Prior to this lesson, the students in this 1<sup>st</sup> grade class brainstormed different organisms and discussed how they are alike and how they are different. They also observed different types of seeds and described each of them. The primary purpose of this lesson was to set up an ongoing observation of plant growth and for the students to begin to think about what might happen to the seed. A secondary focus was to continue building students' observation skills, as the students will observe the seeds as they grow into plants over the next several weeks.

The lesson consisted of two parts. In the first half of the lesson, the students planted two seeds in a clear cup. All students at a table had the same kind of seeds but different tables had different seeds. The teacher provided step-by-step instructions on how to plant the seeds and waited until all students had completed a task before she gave instructions for the next one. She elicited minimal input from the students about how the seeds should be planted and offered no explanations about why those particular steps were being used to plant the seeds. There was a brief discussion about how they could keep the seeds warm and wet to help them germinate, during which the students suggested different methods. Based on one student's suggestion, the students put the cups with the seeds back in the plastic bags.

In the second half of the lesson, students individually completed a worksheet on which they circled the type of seed that they had planted and completed a sentence about the planting experience which began, "I would like to find out..." The teacher introduced the worksheet to the group of students by reading to them each of the sentences they were supposed to complete. While the students were working on the worksheet, the teacher assisted them with the spelling of words, often helping them to sound out words and checking what they wrote.

## **1<sup>st</sup>-2<sup>nd</sup> Grade: Temperature**

This lesson on the concept of temperature falls roughly in the middle of a unit on weather. The teacher began with a brief discussion of temperature during which she took a poll asking how many students thought the temperature would differ between inside and outside and which they thought would be warmer. Students were then given an alcohol thermometer and asked to gently hold their thumb on the bulb and watch what happened. After this observation, the teacher asked students to put the thermometers down on the table. She then led a discussion of what the thermometers were measuring when the students had their thumbs on them and what they were measuring now that they lay on the table. While the thermometers were equilibrating, students worked on a sheet on which they had been recording wind observations for several days. Questions on the worksheet were answered, as a class, by looking at their wind graph. About 20 minutes into the lesson, the class returned to the concept of temperature as they read their thermometers and recorded the temperature on another worksheet, coloring a picture of a thermometer to indicate how high the alcohol had risen. The teacher circulated to make sure that students were making and recording their temperature measurements. When students noticed that not everyone had recorded the same temperature, the teacher explained that sometimes instruments in science do not all give the same readings. In the last few minutes of the lesson, the class moved outside to place thermometers on the ground in the shade and measure the temperature. They then returned to the classroom to record the outside temperature.

## **2<sup>nd</sup> Grade: Effect of Temperature on Dissolving Rate**

This 2<sup>nd</sup> grade science lesson was in the middle of a unit on change. In the most recent lesson, the students had performed a dissolving race between a sugar cube and sugar grains. In this lesson, the students compared how quickly granulated sugar dissolved in warm water versus cold water. This lesson was taught because it was the next lesson in a district-chosen unit titled Changes. The purpose was to start the students thinking about change in the natural world and to notice changes that they might otherwise take for granted.

The teacher began the lesson by asking students to give her some examples of changes, after which she reminded them of the sugar cube race they had had in the previous science lesson. When she asked them directly, “What did we learn from the race?” the students remembered that the sugar grains had dissolved more quickly. The teacher then introduced the day’s topic by telling students, “In the summertime, I like to make sun tea. I like to put a little sugar or honey in my tea. I’ve noticed that the sugar dissolves faster when the tea is still warm from the sun than after it has been cooled in the refrigerator.” She then explained that they would be conducting a “dissolving race” in which they would test the rate at which sugar dissolved in warm water versus cold water. While some new vocabulary words were used, such as evaporation and dissolving, the focus was on the concept and meaning of change rather than on definitions.

Before they started the activity, the teacher asked the students to predict which temperature would win the dissolving race. Most students voted for the warm water, but several also voted again for the cool water and then again for waiting to see what happened. The teacher’s aide then distributed materials to pairs of students, and they were instructed to pour the small cups of sugar into the hot and cold water and stir until it dissolved. Once the sugar had dissolved, they were told to stand up and stop stirring. Although there were hand lenses on the trays, the students were not asked to use them and none did. As soon as all students were standing, they were asked to sit back down and asked to describe what happened. One student said, “I think the warm water evaporated the sugar.” The teacher reminded them that evaporation meant going into the air and dissolving meant going into the liquid. When she asked them if the sugar was still in the liquid, half voted for yes and half for no. She then polled the student pairs as to which cup “dissolved first.” Everyone agreed the warm water had won the race.

The teacher wrapped up the lesson by asking the class, “Can you tell me two things that help sugar dissolve faster?” One student suggested small grains and then a second offered that stirring helps, to which the teacher responded, “That’s probably right, but we haven’t tested that yet.” Finally, someone suggested warm water. All the students then helped with cleaning up the tables and putting away the materials, after which the teacher instructed them to draw an example of change on a piece of paper that was divided in half. They worked on these pictures for the remainder of the science period.

## **2<sup>nd</sup> Grade: Properties of Water**

This introduction to a unit on weather in a 2<sup>nd</sup> grade class was “to start students thinking and wondering about weather,” beginning with a guided inquiry activity using water as part of developing student understanding of the water cycle. The class had a wide range of abilities, including two students with mild mental retardation, as well as two students for whom English is a second language.

The teacher began by asking the class to write down what they already knew about weather in sentences and/or pictures with captions. After a few minutes, the teacher asked each student to pick one idea and share it with the class.

The teacher then handed out the wax paper and toothpicks the students would need for the day’s activity and walked around the room using an eyedropper to scatter water droplets on each piece of wax paper. She asked students to use the toothpicks to “explore” the water. The students were quite involved in this activity, commenting on the size and motion of the drops as they prodded them with the toothpicks.

Following this period of open exploration, the teacher suggested that the students try a number of specific moves, including stretching a water drop “into a big, long worm” and cutting a drop into two equal pieces. She then asked the students to write down their observations. The teacher used the subsequent sharing of individual observations to probe for understanding. For example, when one student expressed surprise that “the water bubbles didn’t pop” the teacher said, “Did you expect it to pop?” The student said, “Yes, the toothpick is pointy.”; at which point the teacher commented, “That rounded shape made you think of balloons.”

After the sharing of observations, the teacher asked, “Who knows what a scientist does after observations?” to which a student responded, “Make a conclusion.” The teacher then asked the students to write a sentence describing what they had learned about water based on today’s observations.

## **2<sup>nd</sup>-3<sup>rd</sup> Grade: Plants vs. Animals**

This class is at the start of their third and final science unit of the year which focuses on organisms. The teacher taught this lesson on the differences between plants and animals because the topic is included in the state curriculum/benchmarks and in the kits provided by the district. This lesson was designed by combining aspects of different lesson outlines provided with the “Organisms” kit to make one shortened lesson that could be completed in the 30 minute period allotted for science.

This was the third lesson in the “Organisms” unit. Students had already discussed what organisms are and made distinctions between the Plant and Animal kingdoms. They had also drawn an organism and made a list of its needs. The observed lesson focused on learning more about the two main kingdoms by comparing the similarities and differences of organisms in each of these groups. A secondary focus was to introduce Venn diagrams to the class. The teacher planned to continue talking with students the next day about commonalities between the plant and animals groups, after which students would create two different habitats (terrarium and aquarium) to further compare different organisms in these groups.

The lesson began with the students sitting on the floor in front of the teacher, who was sitting on a chair beside a small easel with a white board on it. In a whole-class, question-and-answer format, the teacher had students recall what they had already covered in previous lessons in this unit as she wrote down key words on the board. She also introduced the current lesson’s activity in this setting, demonstrating with a list on the board how students were to brainstorm what they knew about plants and animals. Students were assigned to small groups to work at their desks. Those in the classroom for whom English was not a first language were given the option to brainstorm in Spanish. Again, in a whole-class format, the teacher elicited students’ thoughts from the brainstorming exercise, writing out their comments on large circles (one for plants, one for animals) on the front board. Then she asked students to tell her which items were shared by both plants and animals, and she wrote these in the center of the two circles she moved to overlap. She ended the lesson by explaining the concept of a Venn diagram.

### **3<sup>rd</sup> Grade: Alka Seltzer Experiment**

The activity in this 3<sup>rd</sup> grade lesson was modified from one the teacher encountered in a professional development workshop. The content was included in the 3<sup>rd</sup> grade curriculum as part of a unit on gases by common decision of the teachers at that grade level.

The lesson began with a whole-class review of an experiment with Alka Seltzer and water in a bottle topped by a balloon that the class had done previously, including a review of the predictions they had made and what they had actually observed. The lesson then proceeded with an introduction to a variant of this experiment, using capped film canisters instead of the bottle and balloon. First, the children made predictions of what might happen, “It will blow the lid off, because there is so much pressure, it will blow the lid off.” In response, the teacher asked, “Will it always happen?” The student answered, “Maybe not. Because you put in a little piece [of Alka Seltzer].” The teacher then had a student do a demonstration of Alka Seltzer and water in a canister, and the children reacted with glee at the “pop” of the lid. After a thorough briefing on safety issues, the class adjourned to the school playground to experiment. Working in pairs, the children lined up on the basketball court and tried out different sizes of pieces of Alka Seltzer tablets along with different numbers of drops of water. The teacher walked among the children asking them questions about their observations. The teacher asked students why they thought that the lids were popping off, or in some cases, not popping off. After fifteen minutes of experimenting, during which all of the students had a chance to pop their canisters several times, the class reassembled in the classroom. The children then had a chance to talk about what they had observed, and to consider how it related to the idea of a solid and liquid producing a gas that they had discussed before the experiment. The lesson was brought to closure by having the students either write and draw what they had done and observed, or draw a cartoon depicting the events.

### **3<sup>rd</sup> Grade: Animal Survival Needs**

This 3<sup>rd</sup> grade class had just finished a chapter on animal classification and was beginning to study what animals need to survive. Prior to this lesson they had read through the chapter. This lesson was designed to generate notes on the material as a class, and was taught because it is in the district curriculum and the teacher expected the content to show up on the state test. It was organized as a reading comprehension activity, with the students reading aloud and deciding together what the important points were, because the teacher had noticed that the students were struggling with the high reading level of the textbook.

The lesson began with the teacher asking students to open their books and look up the definitions for “environment” and “savanna,” which they called out in unison and she copied onto chart paper at the front of the room. She then called on a student to read aloud from the first paragraph in the chapter, after which she asked them to find the important facts in the paragraph. After the students had identified what they considered to be the key points, the teacher wrote them on the chart paper. She then called on another student to read aloud, and the rest followed along silently. This continued for the rest of the lesson, with the teacher calling on a different student to read each time and asking students to identify key phrases or facts. She occasionally asked questions about the material in the chapter, such as: “Does that (the category of animals) include us? What kind of animals are we?”, “How long can we go without eating?” and “Do you think animals could have more than one shelter?” To this last question a student responded, “No, because they lay their eggs in one nest and need to take care of them.” The teacher praised this answer then went on to ask, “What if the eggs don’t hatch? What if it’s a bad nest—can they go to another?” Most of her questions, however, were variations of “What’s important in this paragraph?” or “Who sees something really important that we need to put on our wall?”

Toward the end of the lesson, the teacher pointed out a picture in the book and said, “These animals are all the way in Africa, and they need ...?” Students replied together with a shout, “Food, water, shelter!” The teacher then asked “What about Washington?... Pakistan?... Anywhere I call out?” and students gave the same (shouted) answer. They then finished the reading, and the lesson ended with the teacher instructing the students to put their books away and prepare for the next subject.

### **3<sup>rd</sup> Grade: How Wind Changes the Land**

This was a beginning lesson in an earth science unit in the 3<sup>rd</sup> grade class. The teacher reported that earth science topics are included in the district standards, but she has flexibility with the order in which topics are covered. This earth science unit was chosen in part based on student interest. They had recently attended a symphony performance at which “space” was the theme and were very interested by the concept. The teacher is focusing on earth science as a prerequisite to talking about space.

Today’s lesson was based on reading the students did in the text as homework the night before. At the start of the class, the teacher asked questions about the reading and recorded their responses in the form of an outline on the chalkboard. Students answered questions but did not take notes. The teacher then called on students to read aloud a page in the textbook and periodically asked questions about the content. She tied in spelling with a quick game of Hangman to spell the word “erosion.” Then the class began a discussion of sand dunes, including an explanation of how wind causes sand dunes to move. The teacher began by drawing diagrams of sand dunes on the chalkboard, then gave a demonstration in which she blew on a pile of glitter to simulate sand dune movement, and finally used a group of students to represent grains of sand. For this last demonstration, the students stood in a line with the teacher at the front, and students moved to the back of the line as the teacher blew on them. They repeated this process several times, after which the teacher asked them to explain the process. The teacher then made a closing statement on how sand dunes move and class ended.

### **3<sup>rd</sup> Grade: Properties of Matter**

This 3<sup>rd</sup> grade lesson occurred towards the end of a unit of study on the properties of matter, with the purpose of reviewing the basic ideas and definitions of terms for the unit test. Prior to this lesson, students had read and answered questions about matter from the textbook and had observed water as a solid, liquid, and a gas. The content of this lesson included several facts and definitions about the physical properties of matter, specifically changes in the states of matter.

The teacher began the class by having the students open their textbooks to the chapter on the properties of matter, while she handed them a review worksheet from a workbook. She then guided the class through the completion of the worksheet by referring the class to a particular question on the worksheet, telling them to turn to a specific page in their textbook and look for the answer, asking one student volunteer to read the answer from the book, and then writing the answer on an overhead transparency copy of their worksheet. The topics on the worksheet included three physical properties of matter, three states of matter, changes in states of matter, the idea that matter is made up of atoms, and measuring matter as volume and mass.

After the completion of the worksheet, the teacher reread the questions and answers to summarize the content in the lesson. The students were instructed to keep their worksheets for tomorrow's lesson as this lesson came to a close.

## **4<sup>th</sup> Grade: Introduction to Flight**

This day's lesson was an introduction to a unit on flight. The teacher's stated purpose for the lesson was "to introduce [students] to the concept of how air acts and how it reacts; air pressure and how air is a force and we breathe it; to get them to understand some basic things about air." The lesson was taught as an introduction to the next unit in the textbook. The teacher indicated that he closely followed the text as a guide for topics to be taught. In addition, the teacher said that he covered all topics in the state standards and that this topic was a part of those standards.

This lesson began with the teacher asking students to take out a sheet of paper and then sit still with their eyes closed and imagine themselves as birds. The teacher asked students what they felt, and someone answered, "air." The teacher then introduced a series of teacher-led demos (using student volunteers) to illustrate concepts associated with air. Demonstrations included dropping a piece of paper in the wastebasket, indicating the presence of air keeping it from dropping straight in; placing a cup in a tub of water to show the release of air bubbles when tilted; blowing up a balloon to show that air fills space; and blowing a piece of paper to see it stand straight out.

The teacher then introduced various terms, including matter, air pressure, force, gas, atmosphere, and oxygen. These were quickly referred to, and as homework, students were to copy the definitions from the back of their textbooks.

## **4<sup>th</sup> Grade: Vertebrates and Invertebrates**

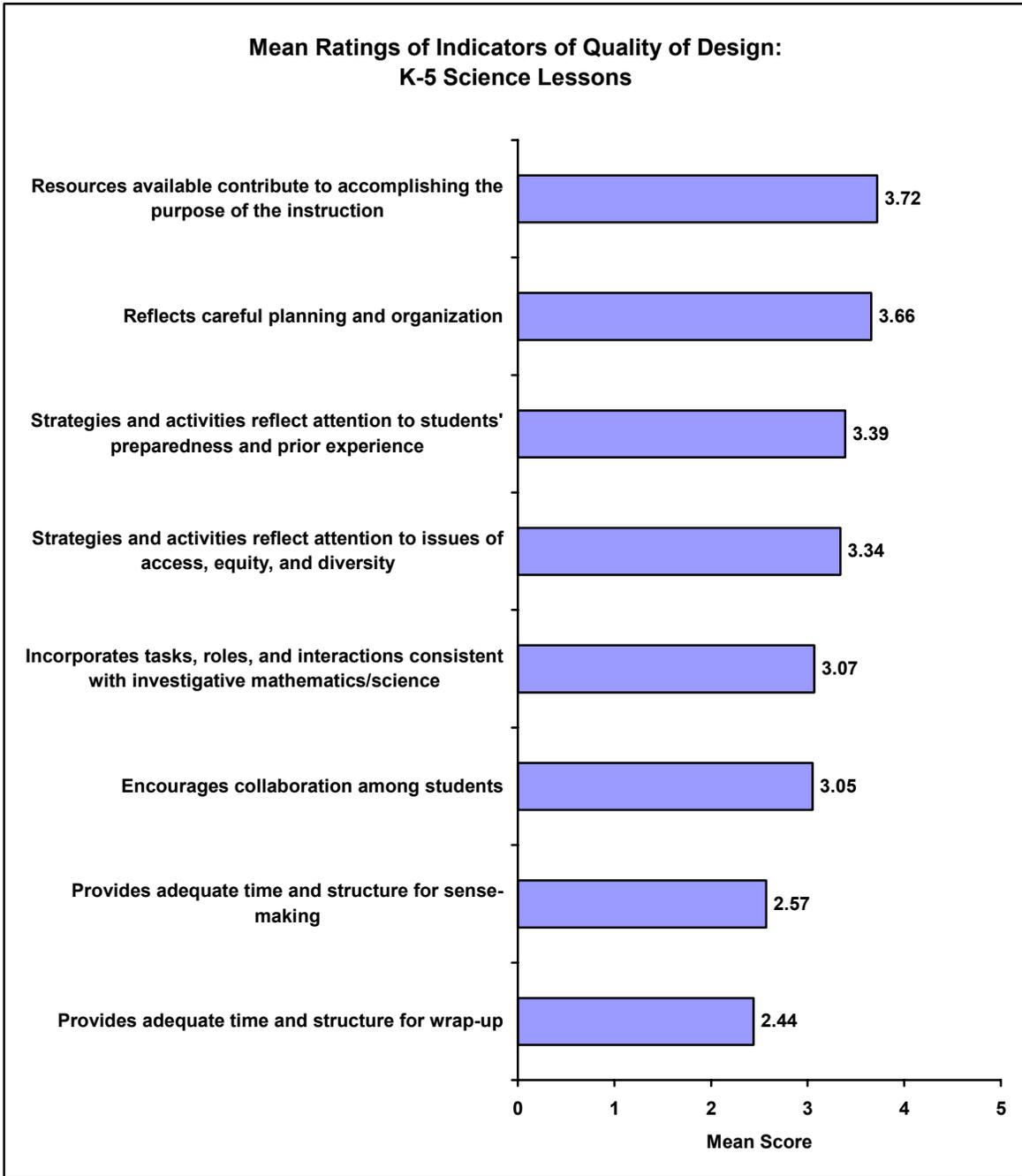
Students in this 4<sup>th</sup> grade class have been working on an animal unit for the past nine weeks. Prior to the lesson, students had learned about ecosystems, food chains, and most recently, habitats. The class was working through a series of lessons on animal classification, which would be followed by lessons on heredity and adaptation.

This lesson on vertebrates and invertebrates within the context of animal classification was taught because the teacher was required to do so. The topic was in the district designated scope and sequence, which told the teacher what to teach and when to teach it. The topic was also to be on the upcoming, district, nine-week test, and the district would use the exam to make an assessment of whether the teacher was keeping pace with the content as she was required to do.

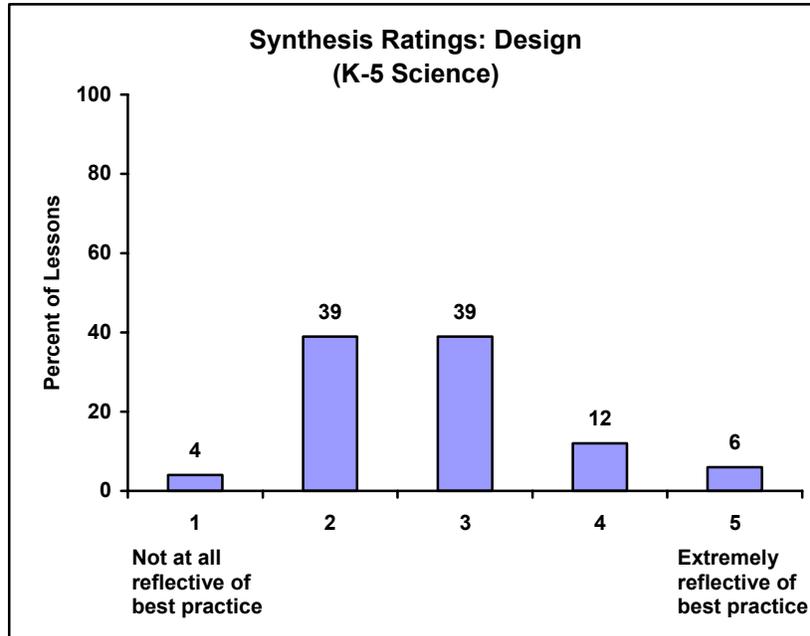
The lesson began with a brief review of why classification is important and the main characteristics of vertebrates and then invertebrates. Next, the class played a game where they identified animals from each of these two groupings. The teacher then introduced a Venn diagram drawn on the board and had each student copy it onto a sheet of paper. The teacher probed students so she could fill in the diagram on the board, first filling in the center where two circles overlapped with characteristics shared by both vertebrates and invertebrates. Students then worked on their own to think of characteristics specific to each of the groups. The teacher wrote these ideas on the diagram as well. Half way through the hour-long lesson, the class stopped for a 30-minute pre-scheduled library visit where they worked on CD-ROMs or read a book (work that was unrelated to the lesson). During the second half of the lesson, students first looked in their textbooks at two pages that outlined simple facts about vertebrates and invertebrates. The students were told to read the pages and add more information to their diagram for homework. The teacher then handed out an “animal study” worksheet and a picture of an animal to each student and asked them to answer all of the questions on the sheet about their given animal. Students worked on this individually for several minutes. The teacher circulated to answer questions. The final few minutes of the lesson were spent revisiting why classification is important.

## **Ratings of Lesson Components**

The designs of elementary science lessons are, on average, most highly rated for utilizing the resources available to accomplish the purpose of the lesson and for reflecting careful planning and organization. The lessons also tend to reflect attention to students, either in terms of their prior knowledge and experience or their background. However, elementary science lessons are weakest in regard to providing students with the time and structure needed for sense-making and wrap-up. The relatively low ratings in these two areas may explain why over twice as many elementary lessons receive low synthesis ratings for their design than high ratings (43 percent and 18 percent, respectively).

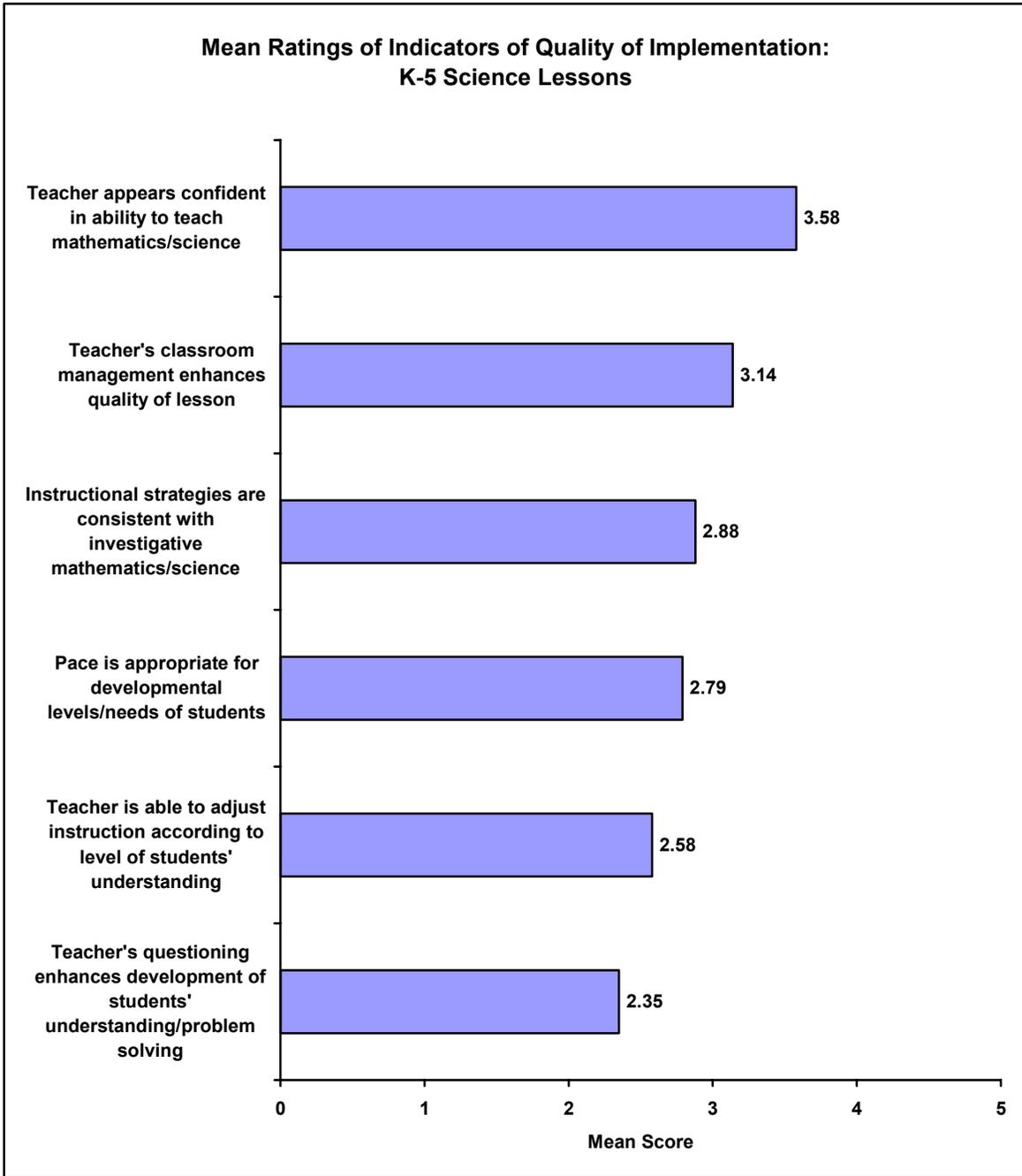


*Figure F-1*

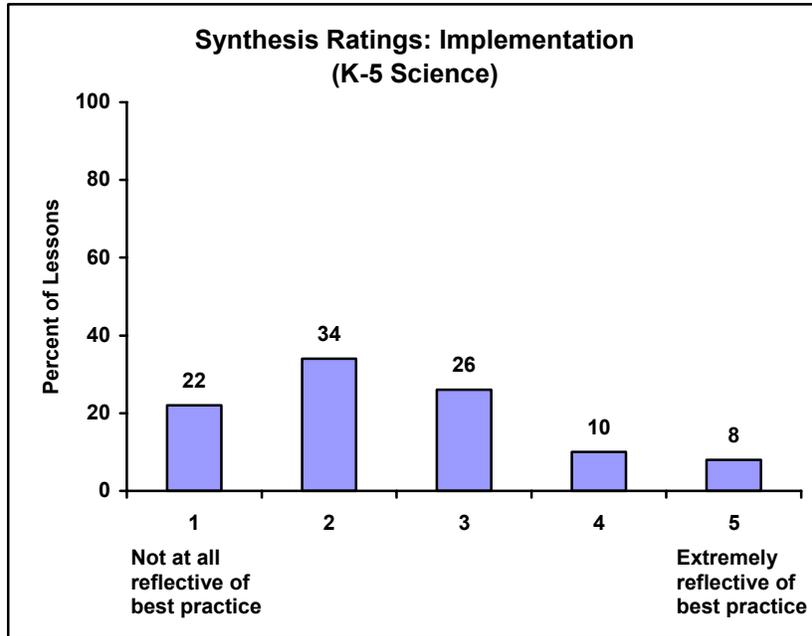


*Figure F-2*

The implementation of elementary science lessons is rated most highly for teachers' confidence in their ability to teach science. Lessons are relatively strong in regard to teachers' classroom management as well. However, lessons are weaker when it comes to using instructional strategies consistent with investigative science and moving at an appropriate pace (either too quickly or too slowly). Teachers' ability to adjust their instruction according to student understanding and to ask questions that enhance student understanding are the weakest elements of elementary science lessons. These low ratings are reflected in the implementation synthesis ratings. Fifty-six percent of lessons receive a low rating for implementation while only 18 percent receive a high rating.

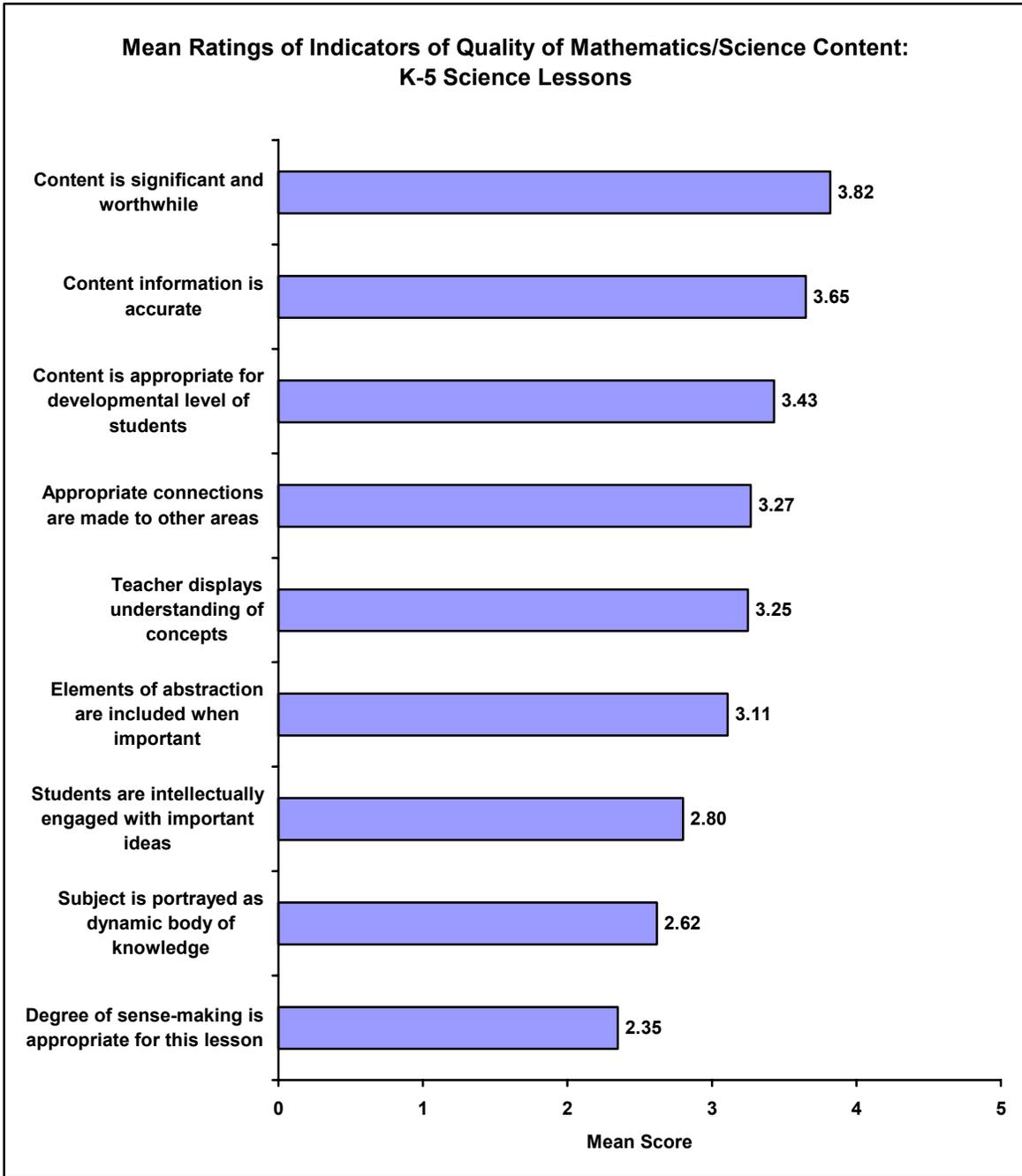


*Figure F-3*

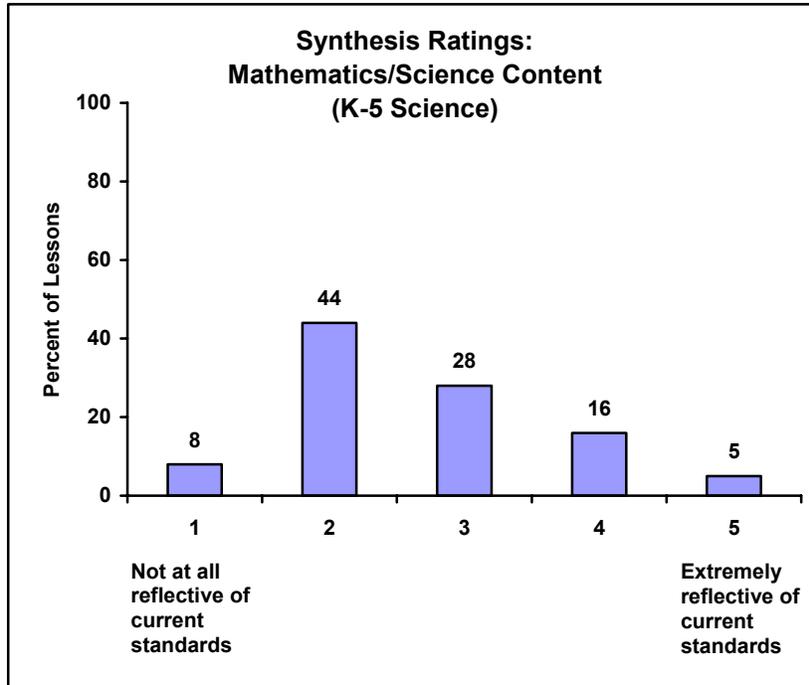


*Figure F-4*

The content of elementary science lessons is, on average, rated highest for focusing on significant and worthwhile content at a level appropriate for the students in the class. Further, lessons are strong in teacher understanding of the content. However, lessons are weak in engaging students with the content in a meaningful way and in providing opportunities for students to make sense of the content. Twenty-one percent of lessons receive a high synthesis rating for content, 28 percent receive a medium rating, and 52 percent receive a low rating.

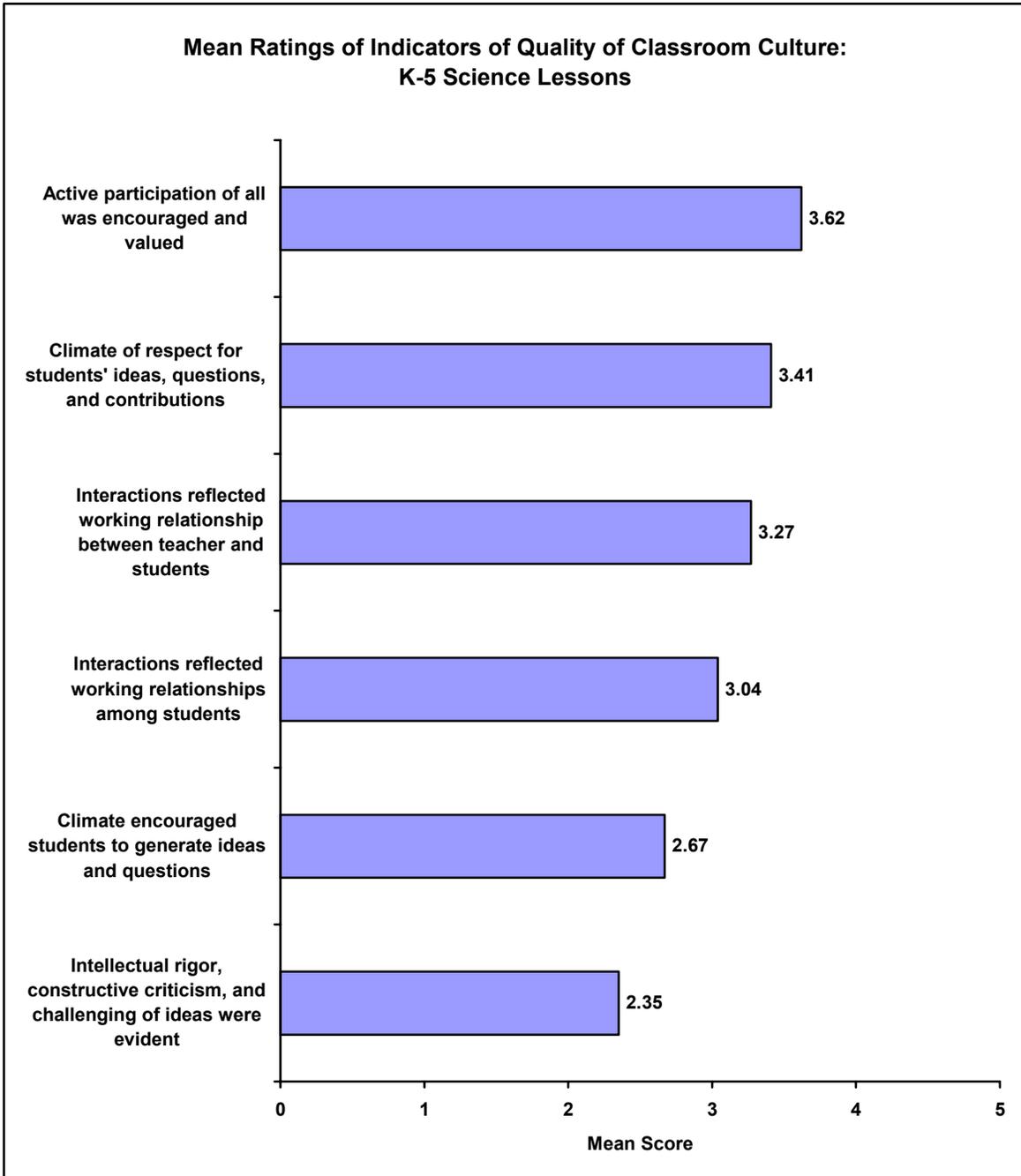


*Figure F-5*

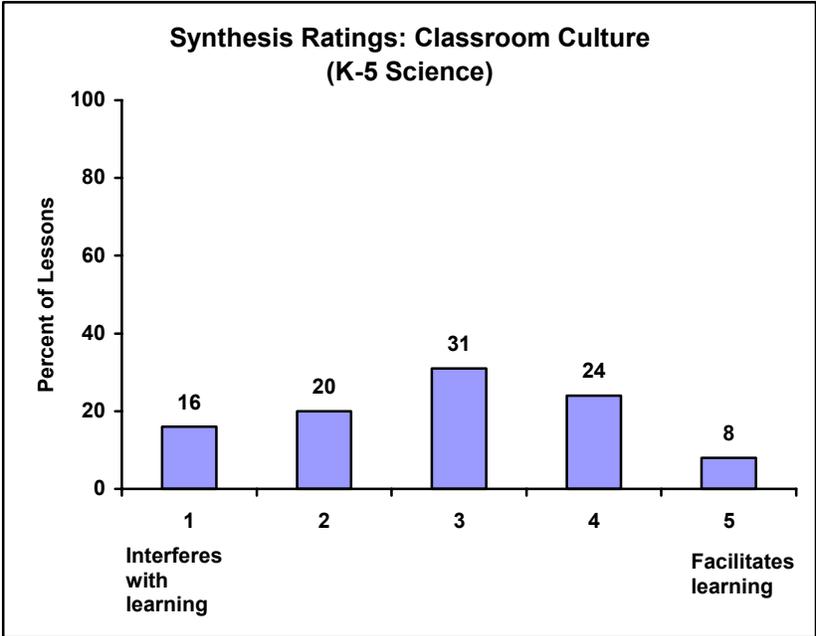


*Figure F-6*

The strongest aspect of classroom culture is the encouragement of active participation of all students. Although lessons are rated relatively highly for having a climate of respect for students’ ideas, questions, and contributions, lessons are weak in encouraging students to generate ideas and questions. Further, lessons are weakest in their level of intellectual rigor. The synthesis ratings for classroom culture reflect these indicators with about one-third of lessons receiving a high rating, one-third receiving a medium rating, and one-third receiving a low rating.



*Figure F-7*



*Figure F-8*



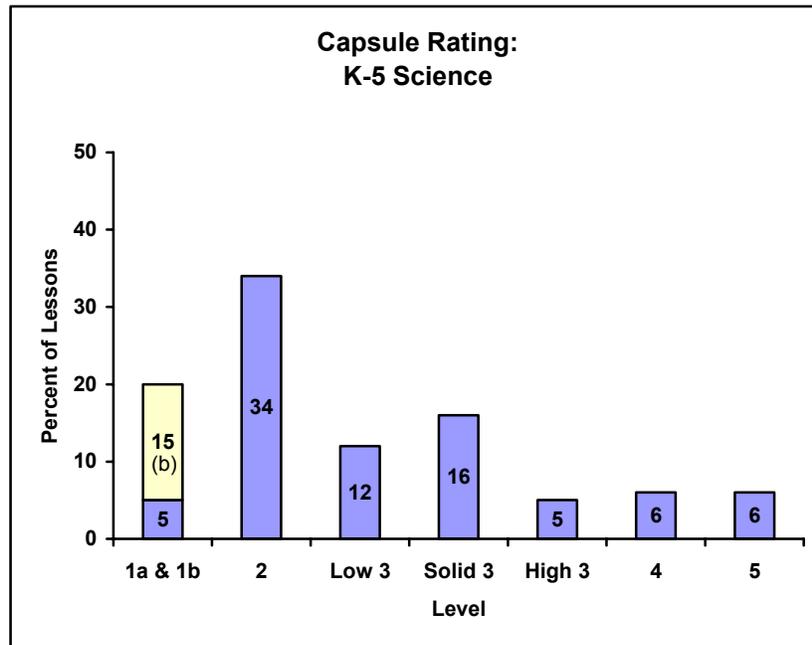
## Overall Lesson Quality

Following the ratings of the individual components of the lesson, the researcher was asked to consider the likely impacts of the lesson as a whole. Roughly one-third of lessons have positive impacts on students' understanding of important science concepts, ability to do science, or ability to apply the skills and concepts they are learning to other disciplines or real-life situations. (See Table F-1.)

**Table F-1**  
**Likely Impact of the Lesson: K–5 Science**

	Percent of Lessons		
	Negative Effect	Mixed or Neutral Effect	Positive Effect
Students' interest in and/or appreciation for the discipline	14	42	43
Students' understanding of important mathematics/science concepts	15	51	34
Students' capacity to carry out their own inquiries	13	53	34
Students' understanding of mathematics/science as a dynamic body of knowledge generated and enriched by investigation	18	49	33
Students' ability to apply or generalize skills and concepts to other areas of mathematics/science, other disciplines, and/or real-life situations	9	58	32
Students' self-confidence in doing mathematics/science	13	57	31

Figure F-9 shows the percentage of K–5<sup>th</sup> grade science lessons in the nation rated at each of a number of levels. (See page 9 of the Observation and Analytic Protocol in Appendix A for a description of these levels.) Fifty-four percent of elementary science lessons are rated as low in quality on the capsule rating, 28 percent are rated as medium in quality, and 17 percent are rated as high in quality.



*Figure F-9*

The following illustrate lesson descriptions that were rated low, medium, and high in quality.

## Sample Low Quality Lesson: Passive “Learning”

This was the fourth lesson in a unit on ocean and pond habitats. Prior to this lesson, these 2<sup>nd</sup> grade students had studied what organisms live in ponds and how they are adapted to their freshwater environment. The focus of this lesson was for students to understand the concept that certain mammals can and do live in sea water. The characteristics of mammals was review for the students, while recognizing and understanding how mammals survive in the ocean was new.

The teacher began the lesson by showing the students a videotaped program on whales, during which she allowed students to talk and play, making it difficult for many to concentrate on the program. After the video, the teacher led the whole class in a discussion, which began with the students listing animals that live in the ocean, such as fish, turtles, and lobsters. Then the lesson jumped to the teacher listing the characteristics of mammals on the board, such as fur, live births, and warm-blooded.

Next, the teacher passed out a worksheet that included pictures of mammals that live in the ocean. She proceeded to read information off of the worksheet to the class, then had the class read the same information again out loud with her. The information from the worksheet included: “Mammals on land breathe with lungs. Mammals in the ocean breathe with lungs too. They can stay underwater for a long time, but they must still come to the surface to breathe.”

Following the reading, the teacher led the class through the pictures, asking if each animal relied on fat or fur to keep warm. She then told the students to put a box around the sea otter because it relied on fur to keep warm and to put an X on the whale because it was the largest mammal. Throughout the implementation of this lesson, the teacher stopped every few minutes to discipline a child or two by pointing out what rule they were breaking and giving them a mark on her clipboard.

The teacher’s questioning was narrow in scope, and she usually led students to one specific answer. For example, as the teacher was asking the class to tell her if each animal pictured on the worksheet used fat or fur to keep warm, she said, “OK, what about the sea otter?” and a student answered, “Fur.” The teacher then asked, “What about the sea lion?” and the same student responded “Thick fur.” The teacher asked, “OK, what else could he have? If it’s not thick fur, it’s what?”, and the student replied, “Fat fur.” The teacher then said, “No, no. Just fat. OK, let’s move down to the whale and the dolphin.” Not only did the teacher’s search for one specific answer discourage students from volunteering their own thoughts, but in this case it also may have created a misconception that mammals have either fur or fat, not both.

The teacher ended the lesson by telling the class that they could color their worksheet while she read a book on dolphins and whales. After reading a few pages, the teacher recognized that many of the students were not working, so she pulled them together by having the class stand up and sing a song.

Throughout this lesson the teacher did most of the thinking for the students, short-circuiting any opportunity for the students to become intellectually involved with the content. The students were very passive intellectually, with some acting out physically (such as by crawling on the floor and poking other students), which resulted in their being disciplined in front of the whole class. Due to the vagueness of intended purpose and the deficiencies in the implementation, this lesson is unlikely to have helped students deepen their understanding of important science content.

## Sample Low Quality Lesson: “Activity for Activity’s Sake”

The objective of this 3<sup>rd</sup> grade lesson was to introduce students to food webs. The students had been studying ecosystems, and were now beginning to study how animals interact. They had recently finished an activity on food chains and their “index card food chains” with pictures of organisms hung on the wall. The lesson began with the teacher asking the students to read aloud the step-by-step instructions for making a paper model of a food web. She told them, “On Tuesday we made food chains; today we are going to make a food web, although we have not read about food webs yet.” She drew different food chains on the board, each in a different color, then had the whole class follow in lock-step the directions in the book on how to label pieces of index cards with the names of six organisms and paste them in a circle on construction paper. The questions she asked of the class were mostly rhetorical, with very little wait time. When she asked, “Is everybody listening?” and “Do you see what you are going to do today?” a few children answered, “yes,” unenthusiastically. Finally, she led the whole class as they connected some of the organisms into a food chain on the board using one color crayon and depicted another food chain by using another color. All of the students copied the food chains drawn by the teacher. There was no time for discussion or closure, but the teacher told the children that they might add another food chain to the web later in the week, when they would read about food webs in their textbook.

In the teacher’s modification of the textbook’s design, all but the “hands-on” activity was deleted, and that activity was reduced to following a set of instructions. With almost no conceptual foundation and very little discussion, the lesson design had the children spend nearly the entire class period writing the names of organisms on little pieces of paper and pasting them in a circle. Throughout the class period, the teacher had the children work individually doing exactly the same activities, even though they demonstrated vastly different levels of ability. Thus, many children were restless and bored, waiting for the next step, while the slower students painstakingly wrote the names and pasted them on the paper. The activity was designed so that the only important conceptual work, considering the connections in the food webs, was done during the last five minutes of the class and was entirely teacher-directed.

The teacher’s main classroom management strategy was to chastise the class repeatedly, “pockets on your seat, eyes up, lips zipped.” She allocated “points” for each table behaving as she had requested and recorded these table points on the board. “Show me that you want points by sitting on your seats correctly and zipping your lips.” Thus all of the rewards for the activity were external and unrelated to science. By the time the class reached the “meat” of the lesson, constructing food webs using the organisms they had pasted on the construction paper, they had run out of time. The teacher did not see this as a problem, however, and told the children, “Good class, we are onto the last activity and we only have five minutes left.” The only individual contribution that students could make to their food webs was to decide which color crayon to use to connect the organisms.

## Sample Medium Quality Lesson: Beginning Stages of Effective Instruction

According to the teacher, the purpose of this 2<sup>nd</sup> grade lesson was for students to identify and be able to name the basic characteristics of an insect. Students had previously considered characteristics of other types of animals within the Animal kingdom. This day's lesson on insects came near the end of the animal unit. After this lesson, the class would make a collage and play a classification game to conclude the animal unit.

The lesson began with students sitting together on the floor participating in a whole-class discussion. The teacher quickly reviewed characteristics of animals other than insects that had been covered previously (mammals have fur, fish have scales, etc.). Five animal types and their characteristics were listed on a flip chart. During the observed lesson, the teacher added insects to the chart. The teacher related some facts about insects and asked students to share with the class any experiences they had had with insects. During the whole-class discussion, she asked things like, "How does it feel when you step on insects with your bare feet?" Students responded with things like "they crunch" and "their insides squish out." By the end of a 20-minute discussion, the teacher had added four characteristics to the flip-chart: "insects have three body parts (head, thorax, and abdomen), 6 legs, hard shell, and eggs (soft)."

Following the discussion, students were instructed to create an imaginary insect using colored construction paper, and they were reminded that whatever they created needed to have 3 body parts and 6 legs. Concurrent with this arts-and-crafts activity, which students conducted individually at their desks, there was a silent video playing in the background showing close-up images of insects. Students also had access to a wide array of books about insects, which they used for reference and to spark their imaginations about insect diversity. The teacher circulated around the room during this portion of the lesson asking individual students some factual-recall-type questions such as, "What are the names of the body parts of your insect?" None of the questioning was truly higher-order. She also informed some individuals that they had mistakenly attached legs to an abdomen. In these cases, she instructed the students to correct their mistakes by tearing off legs and re-attaching them to the thorax. The creation of imaginary insects lasted 40 minutes at which point most students had completed the task and it was time for lunch.

The lesson design reflected attention to various learning styles and student interests. Some students were clearly quite captivated by the video, others enjoyed perusing the reference books, and still others dedicated their entire attention to the creation of the imaginary creatures. The resources (the video, reference books, and craft materials) were plentiful, varied, and of high quality.

The teacher was competent in guiding the whole-class discussion and clearly had prepared her students well to use hands-on materials appropriately. The lesson included very little in the way of investigation, however, and lacked time or structure for sense-making or wrap-up. There was some inaccurate content (including the teacher's saying that spiders are insects that disobey the general rule of having six legs). Overall, the teacher was nurturing and demonstrated concern for her students' learning, but didn't challenge the students to think very deeply. The lesson was strong as an arts-and-crafts lesson, but in the final analysis, deficiencies in both design and content limited the lesson's likelihood to enhance students' knowledge about insects.

## Sample High Quality Lesson: Traditional Instruction

This 5<sup>th</sup> grade lesson focused on the skeletal system as part of a unit on the human body. As class started, the teacher stood at the side of the room waiting for students to come in from recess and take their seats. Students seemed excited to see the life-size skeletal model. The teacher introduced “Mr. Bones” and the skeletal system using the student booklet, which was developed by the teacher, as a discussion outline. She talked freely about specific bones of the body, capturing students’ attention by telling stories and asking probing questions.

Throughout the class discussion, the teacher used a questioning pattern that seemed to work well. She would ask students a question, wait for them to raise their hands, call on one student, let the student give an answer, emphasize the information by restating it, add more information, then repeat the process with another question. For example, the teacher said, “The adult body has 206 bones. How many bones does a baby have?” Several students raised their hand and the teacher called on one of them who responded, “Over 300.” The teacher said, “That’s right. Why does the number of bones change as we get older?” No one could articulate the correct answer so the teacher continued explaining how some of the bones “fuse or knit together as we get older.” She continued, “What about the skull? It looks like one bone, but it isn’t. Why is that?”... “You’re right. This helps allow for growth.” Throughout the discussion, students demonstrated their intellectual engagement by raising their own questions based on family experiences or their own interest in the subject matter, such as, “Can you die if you break your neck?” “My dad blew a disc. What does that mean?” “How much weight can your spinal cord hold?” and “What allows people to pop their knuckles?” The teacher encouraged such questions about the human body and was very confident and thorough in her answers.

The lesson design was enriched by a brief demonstration in which a stack of papers was used to hold up two textbooks. The books could not balance when the papers were standing on end, but they could when the papers were rolled up. This helped students see that circular bones are stronger than flat bones.

The teacher captured students’ attention by her stories and personal experiences. She told of her husband’s broken collar bone from a bike accident, actor Christopher Reeve being paralyzed by a spinal cord injury, her father having arthritis in his neck and not being able to turn his head, teachers at school with carpal tunnel syndrome, how baseball catchers wear chest gear to protect their sternum, and how you can simulate having arthritis by wearing heavy gloves and trying buttons and zippers. Students shared similar stories about the mailman with carpal tunnel syndrome and a mother with TMJ.

The teacher demonstrated her experience and effectiveness in teaching, as well as her wealth of knowledge about science. She encouraged student questions about the human body and was very comfortable in her answers to a variety of questions. The teacher had a knack for inspiring students to listen, think deeply, and ask further questions related to the topic. Her classroom management style appeared to be based on caring and respect. She showed high expectations for on-task participation and attention, encouraged the sharing of ideas, and listened intently. Sense-making and wrap-up were facilitated by a review of “what you know” at the end of the discussion.

This was a fairly traditional, teacher-directed lesson. Due to the teacher’s high level of content knowledge, her ability to relate science concepts to familiar circumstances, and the creation of a positive learning environment, it is highly likely that student understanding of the skeletal system was enriched by this lesson.

## Sample High Quality Lesson: Reform-Oriented Instruction

This was a beginning lesson on wind, designed to tie in with earlier units on weather. This kindergarten class had been doing a morning weather report including weather charts and graphs and would work wind into that routine.

As students moved into the classroom from lunch, they quickly took their seats on a carpet in the center of the room. The teacher got down on the floor with them to begin the lesson. After reviewing air by “catching” air in a bag, the teacher started a discussion on what wind is. Toward the end of the discussion, the teacher let students know that they would be doing an experiment with wind that they would create in the classroom with a fan. She told them that they would predict whether objects would blow in the wind and quickly reviewed “predictions.” Students were familiar with the term; some explained it as a “guess.” The teacher clearly outlined expectations for the students now and during the entire lesson, making them comfortable and therefore willing to talk and participate.

Students were divided into two groups, one to be led by the teacher, and the other by a paraprofessional. Once in groups, each student chose an object that had been provided and was asked to predict whether or not it would blow in the wind. As they made their predictions, students placed their objects on a teacher-prepared chart with two columns. One column was labeled “The Wind Will Blow” and the other “The Wind Will Not Blow.” Objects included items such as cotton balls, yarn, lace, scissors, clothespins, and a cassette tape.

Once predictions were made, students moved back to the whole group. The teacher facilitated transitions with effective classroom management techniques; for example, soon after students started moving, the teacher sat on the floor and said, “Give me 5” and held up her hand, indicating that all students were to be sitting quietly, holding up their hands.

Once settled in the whole group, students tested their predictions one at a time by placing their objects on a table in front of a fan. Students were asked to give their thoughts on why each object did or did not move, and the class chart was updated to reflect the results. When students’ predictions turned out to be inaccurate, the teacher explained that was okay and that they need to predict, experiment, and change predictions “just as scientists do.”

During this time, the teacher was able to weave in content that had previously been taught, both science content and language arts content. For example, an object in today’s lesson was yarn, and the teacher took the opportunity to review the letter “y” that they had just learned. The teacher also skillfully handled misconceptions; for example, when reviewing where air is a student said, “space.” The teacher reminded them of the space unit that they had done and led them to remember why people in space need oxygen tanks.

Then the discussion turned into one of *why* certain objects blew. The teacher’s questioning strategies helped students realize that lighter objects were blown more easily. Her strategies also helped students move beyond misconceptions, such as that “hardness” determines what objects will be blown by the wind. For example, the teacher asked, “Why do you think those blew?” and a student responded, “Because they’re not real hard.” The teacher followed by asking, “But what about the clothespin? That’s hard,” and the student responded, “But it’s not so heavy.” This dialogue continued until students moved beyond misconceptions and formed solid ideas.

The lesson was designed to be investigative and was well executed in an extremely positive and supportive environment.