Appendix G

Grades 6–8 Science

Typical Lessons

Ratings of Lesson Components

Overall Lesson Quality

Typical Lessons

The following lesson descriptions are based on a random sample of 6th–8th grade science lessons.

6th Grade: Food Chains

The primary activity during the period was an owl pellet dissection, but the lesson began with a ten-minute, whole-class discussion of multiple-choice questions from a standardized test-prep booklet called Test-Ready. Preceding this lesson had been a lecture in which guest presenters brought an owl and red-tailed hawk to show the students. Students had also spent one class period removing the largest bones from the fur. In future lessons, students were going to record findings in their lab books, pool their data within the class and with other classes, and analyze the number and diversity of skeletons found within all of the pellets.

The prep session for an upcoming standardized test was held because the teacher believed these students needed practice with this type of test and because going over test questions was a quick way for the teacher to cover lots of content. The dissection portion of the lesson was taught in part because it supported the standards, but the teacher noted he would have taught it anyway because it was fun.

During the first part of class, the teacher would ask a student to read a question aloud from the test-prep booklet, and then he would ask other members of the class to offer ideas related to the question. After a short discussion, the teacher would provide the reasoning behind the correct and incorrect answers. For the remainder of the class period, students worked in pairs picking up where they had left off the previous week dissecting owl pellets. This day's lesson provided an opportunity to pick through the fur more carefully for smaller bones and match them to a bone identification chart. During the dissection, the teacher circulated from group to group to help identify bones. This help came in the form of questions and statements such as, "That looks like a rat vertebrae, do you have a rat skull?" and "That's probably a _____."

6th Grade: Light

This day's lesson was a review for an upcoming chapter test on light. The teacher indicated that the review would cover material that the class had been studying for the last week and a half. The objective written on the board was, "Describe the importance of light in our everyday lives and review for Chapter 3 test on light."

At the start of the lesson, students were asked to write a half-page response on how their lives would be different without electric light, a question taken from the textbook. Students worked quietly and independently to do this, and then discussed responses as a class. The assignment was not collected.

After the initial writing activity, the lesson turned to a teacher-led review of information from the textbook. The teacher flipped through the textbook and asked questions from it. Students raised their hands to respond. Questions included: "What has the longest wavelength?" "If it has the longest wavelength, what do you know of the frequency?" "What is the smallest region of the electromagnetic spectrum?" "An object that can produce its own light is said to be what?" and so on. Toward the end of the lesson, students worked in groups to write five questions for a class review game of "Who Wants to Be a Millionaire?" The teacher also passed around a prism for students to look at. The class then broke into two teams and played "Who Wants to Be a Millionaire?" with the questions they had created.

6th Grade: Sedimentary Rock Formations

The students were just beginning a unit on rocks, after finishing one on flight. For the first five minutes the teacher led a discussion about the previous day's lesson, which had involved a paper airplane "fly-off". She then asked a student to share the library book he had brought in on the subject.

This lesson was taught as part of a unit on Earth's changes over time. The teacher had been to many workshops in her 20-year career, and had chosen pieces from several of them to create a study packet that she used instead of a textbook. This topic was in the state standards and the district course of study, and the teacher felt that it was important for students to know. The teacher indicated that while she usually preferred an active classroom, this group of students has had severe behavior problems, so she planned her lessons to be more structured for them.

To begin the lesson on Earth's changes, she asked students to brainstorm about the words "weather" and "weathering" and then transitioned to a discussion of the rocks that make up the Earth's crust. She then referred to the vocabulary words written on the board and focused on the term "sedimentary rock." She explained how the word "sediment" is embedded in the term, then explained the process of sedimentary rock formation. She showed a piece of sandstone and asked, "Guess what sandstone feels like?" Then she asked, "If you break something, what do you need to put it together? We don't have someone down there (in the ocean) squirting Elmer's." She explained how minerals in the water are "glued" together over thousands of years. Then she asked, "What else do you need? If you break a vase and Mom will be mad…" Students discussed the need to hold pieces together and apply pressure, and the teacher asked, "Where might the force come from?" Once the class had decided that the weight of water creates the necessary pressure, the teacher passed around the sandstone for students to examine. Next, she held up examples of different types of sedimentary rock, discussed their formation and where they could be found, and passed them around the room. Then students answered questions on a worksheet from the packet the teacher had created, as the teacher elaborated on the fill-in-the-blank questions. Finally, the teacher reviewed what had been learned that day, a student read vocabulary words from the worksheet, and the teacher gave the evening's assignment.

7th Grade: Ecology

This 7th grade class was just beginning a unit on ecology. Previously, the class had been studying evolution, geologic time scale, and fossils. Following the ecology unit, the class would move into a study of the growth and development of plants.

The teacher taught the concepts of ecology covered in the lesson because they were included in the state and city standards. The teacher used an old life science textbook she had acquired from a book depository downtown as a main resource to plan this lesson. This textbook included a glossary with many of the vocabulary words she posted on the front board during the lesson.

The teacher began the lesson by drawing students' attention to the new vocabulary words listed. She said, "You'll notice the vocabulary is here and the words in black are seven new words that I will speak to this week." She told students they would not have a quiz on their vocabulary words today but they needed to copy down the new words on the list. The teacher launched into the lesson by asking the class: "Ladies and gentlemen, number one, who will answer this? I have three words, biosphere, ecosystem, and environment; how many before yesterday had heard of them?" One student indicated familiarity with the terms. The teacher asked the question again. Another student replied, "I have heard of ecosystem." "What did you think it meant?" the teacher asked. The student didn't respond. The teacher next started a discussion of the biosphere.

This pattern of teacher/student interaction continued with vocabulary-based discussions of the five kingdoms; producers versus consumers; photosynthesis; and examples of living, dead, and non-living things that occurred in all ecosystems. Each time the teacher began a new topic, she wrote various vocabulary words and their definitions on poster paper attached to the front board. The teacher concluded the lesson by explaining the homework assignments: study the vocabulary for a possible quiz the next day, and write a paragraph using five words the teacher had written on the board—producer, consumer, chlorophyll, animals, plants.

7th Grade: Erosion

The teacher indicated that this 90-minute class was generally split between science and social studies. This lesson, however, focused almost exclusively on science. The class had just finished a chapter on weathering the previous week. The day's topic, erosion, was chosen because it came next in the school's syllabus for the course and because all the 7th grade science teachers had decided to stay together so that they could give a common quarterly exam.

The lesson began with students copying 14 vocabulary words off the board to do as homework. The teacher then did a brief oral review of the chapter on weather, asking the students questions like, "How many forms of weathering are there?" He related weathering to the new topic, erosion, by asking, "Does weathering take a long time or overnight?" When the students answered that it took a long time, the teacher stated, "Erosion is fast-paced weathering" and gave the Grand Canyon as an example of a place where erosion is happening quickly. Next, he had the students copy a title for their "lab report" from the board and then directed them to the page in their textbook where erosion was defined. He wrote the definition on the board and had the students copy it in their notebooks. The teacher then asked students to draw two diagrams in their notebooks. One was an overhead view of the stream channel he created on the stream table, the other was a blank space where they would redesign the stream channel. The teacher said, "Here's our question: What exactly does erosion do? What problems does it cause?" A student responded that erosion "carves through rocks." The teacher then proceeded with a demonstration using a stream table that had been set up with potting soil. At the conclusion of the demonstration, the teacher asked students to return to their seats to work in pairs to redesign the "river basin" to minimize erosion. With about 20 minutes to go in the lesson, the teacher wrote four questions on the board from the teacher's edition of the text and told students to answer them for homework.

7th Grade: Fossils and Radiocarbon Dating

Students in this 7th grade earth science class had been studying fossils and had already done some hands-on activities like making casts. The teacher indicated that this lesson would teach students about radiocarbon dating and would also give them practice in graphing skills. Part of the lesson (a review of the kinds of fossils) was taken from a "book" the students had made on fossils, an idea the teacher had gotten at a recent NSTA conference. The hands-on activity was modified from one in the textbook.

The lesson began with a lively discussion between the teacher and students summarizing what the students had learned so far about fossils. Standing in front of the class, the teacher opened one of the little booklets that students had been creating on fossils and reviewed the main topics. She started by asking the class, "What are the five ways fossils form? Name one and explain." She waited for them to answer, and almost all of the students eagerly raised their hands. She called on different students, each of whom came up with a part of the answer. One student was having difficulty explaining how molds and casts form, and the teacher gently helped him by providing a series of "fill in the blank" type questions. "The water left the minerals in the _____." Using this strategy she elicited from the students all five paths to fossilization that they had been studying.

The review led naturally to a mini-lecture about how scientists date fossils. The teacher then led the class through the process of creating a radiocarbon dating curve used to measure the age of a fossil, and each student created his or her own curve. This was followed by a hands-on activity in which students, working in pairs, dated "fossils" (with Carbon atoms represented by pennies in a plastic bag). Each "head" on a penny stood for a C14 atom, which students replaced with a paper clip, representing N14. Students then dated their "fossils" in thousands of years, using the standard curve they had created. Students who finished the task early were asked to create the corresponding standard N14 curve.

7th Grade: Liquids and Gases

This 7th grade class was working on the last section in a chapter on states of matter and energy transformations. Prior to this lesson, they learned about solids and did a mini-lab on cohesion and surface tension. In this lesson, the students focused on the specific characteristics of liquids in terms of density and buoyancy, and next they would move on to the properties of gases.

The teacher indicated that she taught this lesson largely because she believed it would be a focus area on the state test in February. She skipped over several chapters to get to this one because she wanted to be sure she had covered this material and because she had already taught the content in the skipped chapters to about half of these students the previous year.

The lesson began with a focus activity in which students read a paragraph about the buoyancy of submarines from a "section focus transparency" and spent a few minutes answering questions about it. The teacher then introduced the day's lesson by reminding students that they had been studying the states of matter and that today they would work on liquids and gases. She asked, "Does anyone remember about ice and liquid water, and why ice floats?" A student explained the concept, and the teacher asked, "What term did we use? It started with the letter D." A student replied "evaporation," and the teacher said, "D? Density—remember the discussion on density. What did I say about the density of an object in terms of whether or not it floats? More or less dense than water?" Once they had reviewed the density of water, they moved on to discuss the example of a submarine. The teacher asked, "What about this taking in water would make it sink?…What's your weight on the moon? It's going to feel different in water, because of a subject we're going to talk about today called buoyancy." The teacher continued her lecture on density and buoyancy, including a variety of student questions in her presentation. She then played an eight-minute audiocassette which summarized the book chapter. After the cassette had finished, the students spent the remaining 20 minutes of the class period filling out a worksheet on the behavior of liquids and gases.

7th Grade: Physical and Chemical Changes

This 7th grade class was in the middle of the Matter and Energy chapter of their textbook. They had just completed a study of atoms, molecules, and changes in matter. This day's lesson was a review of physical and chemical changes, as well as the branches of science. The following day the class would start learning about molecules and chemical symbols. The teacher reported that the district standards indicated where they have to be in the textbook by certain points in the school year and that she followed these standards and the textbook to develop her lessons. The teacher used the textbook as a guide and as a reference, but said that students did not actually read it too often because the wording was difficult for them. Also, the teacher said that the textbook was missing a lot of supplementary materials (e.g., worksheets), so she has to find things like that on her own, as she had done for this day's lesson.

The class began with students working to complete a worksheet on physical and chemical changes. They worked on this individually for several minutes, and then the teacher called on students to read their answers aloud. The worksheet had a list of 23 changes, and the students had to mark each with a "P" or "C." For example: etching glass with acid; fertilizing a lawn; crushing ice in a blender; and slicing a block of cheese. If an answer was called out incorrectly, the teacher or another student corrected it, with little explanation. For example, a student answered that baking bread was a physical change. The teacher quickly said that it was a chemical change because "when you bake bread it rises, so it is different."

Next, the class went over the previous night's homework, which was a worksheet in which they had to categorize types of science as life, earth, or physical science (e.g., cosmology, biology, meteorology, ornithology, and physics). The teacher asked students for their answers, and students called out answers to the various questions. After the teacher collected the homework, she gave each pair of students a newspaper and asked them to find one article that dealt with life science and one that dealt with physical science. As students worked on the assignment, the teacher walked around the room answering questions and asking students to pick their trash up off of the floor. The class ended with the teacher asking students to fold up their newspapers and to put their names on the back of the articles.

8th Grade: Inheritance of Traits

This 8th grade science lesson focused on the inheritance of traits using an imaginary scenario of marshmallow creature reproduction. The related concepts of meiosis and mitosis were part of the state and district standards and appeared in the textbook designated for the class. The marshmallow activity seemed to the teacher like a fun way to give the students concrete experiences with these concepts, and she believed hands-on activities to be important in concept development. The activity also provided an opportunity to integrate science with mathematics through the Punnett Square component and to tie genetics to the similarities and differences that exist among individual human beings.

The lesson began with students responding independently to two "Questions of the Day" asking them how many chromosomes there are in a human daughter cell after mitosis and to explain the stages of the cell cycle. While students wrote their responses, the teacher passed back papers and helped some students with their answers. The teacher then introduced the primary activity for the day, which involved the sexual reproduction of imaginary marshmallow creatures. Students were to use toothpicks and marshmallows to create baby creatures based on the inheritable traits of the parent creatures. In groups of about four, students randomly selected strips of paper representing chromosomes of the parents, determined the phenotype of their baby, and constructed a physical model of it. When the babies were completed, the teacher asked for a reporter from each group to describe the baby their group had constructed. The teacher provided a brief introduction to Punnett Squares on the chalkboard, and in the final two minutes of class, students responded independently to worksheet questions related to the marshmallow babies.

8th Grade: Periodic Table

This 8th grade lesson focused on the periodic table. The state standards call for an integrated approach to the teaching of physics and chemistry. This teacher, however, strictly followed the textbook, which started with physics and ended with chemistry. This study of the periodic table was near the beginning of the second chemistry unit, which dealt with the structure of matter and chemical properties.

The teacher began the lesson with a warm-up activity, asking students to list the six steps of the scientific method. The teacher also offered two bonus questions: "What was the caliber of the gun used in the San Diego school shooting?" and "How many days of school are left?" A student quipped, "I'm going to put down too damn many." The teacher told him that he could do that but that he might not get credit for that answer. Many students were talking throughout this part of the lesson.

After the warm-up activity, the teacher showed a video entitled "The Periodic Table," asking students to take notes. Besides presenting the periodic table and showing pictures of different elements, the video discussed the structure of the atom, including the definition of isotopes and the relationship between electron levels and the periodic table. After the video, the teacher passed out a copy of the periodic table and asked students to take notes from a lecture to be presented by one of the students from the class. The student presented the information from one cell of the periodic table (atomic number, symbol, and atomic mass). The teacher asked the student presenter, "What does atomic number mean?" The student did not know, so the teacher asked the student to sit back down. The teacher said, "You didn't do much preparation time. I'm kind of disappointed."

Next the teacher asked several questions about elements in the periodic table. The table that the students were reviewing differed somewhat from the one the teacher had, which caused some confusion. Finally, the teacher asked students to use their books to explain how the groups in the periodic table were different from each other. Nearly half the students in the class did not have their book, and so he had them copy definitions from a dictionary as part of the review for the final exam, which was two months away.

8th Grade: Projectile Motion

This 8th grade lesson was in a unit on motion, forces, and energy and dealt specifically with projectile motion. Prior to this lesson, the students had read the section of the book on projectile motion, gone over questions from the book, and outlined the material. This lesson on projectile motion was taught for three main reasons. First, the teacher indicated that the topic was in the state standards and that she followed the standards. Second, the teacher was piloting a new textbook for the district, and thus was working her way through the textbook very methodically. Third, the teacher thought the students needed practice with their measurement skills.

This lesson began with the teacher reviewing lab procedures and using the overhead projector to remind students how to properly use a ruler and a protractor. The teacher demonstrated measuring one distance and one angle before asking students to open their textbooks to the lab activity. The teacher asked students to read the procedures twice (the lab was to use a spoon to catapult marshmallows, launching at various angles and measuring how far they went). When students finished reading, she reminded them to measure their distance from the catapult to where the marshmallow hit the ground, not to where it rolled. She then assigned students to groups of three and had one person from each group collect the materials needed for the lab.

Next, the students went outside to the quad to conduct the experiment. Students experienced some difficulty in correctly completing the activity, making errors in measuring both distances and angles (e.g., when they launched a marshmallow that went over a 2 foot wall, they draped the measuring tape over the wall instead of just measuring the horizontal distance; the students were not using the protractor correctly as they did not understand how to line up the base of their catapult with the crosshairs at the base of the protractor). Some groups were not really doing the lab and were just trying to launch their marshmallow at certain targets ("Let's try to get it over the bush.")

Near the end of the period, the teacher called the students back into the classroom and had them work individually on writing their lab reports. Most students spent the time writing out the lab procedure and copying a data table from the textbook and then filling it in. As the students worked, the teacher circulated through the room asking questions.

8th Grade: Water Cycle

Students in this 8th grade class had been working on a unit on weather for the past week. The class alternated between units on earth science and units on life science. This lesson was taught because the teacher enjoyed the topic of weather and felt the concepts she covered were important ones that build upon one another. In addition, the content was included in the course of study the teacher followed and would likely appear on the end-of-grade exam. The teacher took her lesson objectives from the designated textbook and used worksheets from its associated resources. Wanting to include content on the atmosphere's composition and importance (which was not specifically covered in the textbook), the teacher opted to also make use of worksheets from an older textbook.

The lesson began as students entered the classroom. The teacher reminded students to update their temperature chart and do their temperature conversions for the daily weather chart that was posted on the front board. After calling roll, the teacher directed students to take out their worksheet on the content of the atmosphere. The teacher began the review by asking questions such as: "What is the atmosphere?" "What is it composed of?" "What is one importance of our atmosphere?" She then proceeded to go over the answers to the worksheet by calling on different students to provide the answer for each of the questions. The teacher next moved to a handout on the water cycle. On the overhead projector, the teacher had a diagram of the water cycle with various processes listed. Students were asked to draw their own diagram and write a paragraph explaining the cycle. As a check for the class, the teacher asked students to go to the board to write the various processes of the water cycle, such as transpiration and condensation, and then define the terms. The teacher next placed notes on the overhead entitled, "What is Weather?" Students copied the notes while the teacher discussed various points. Near the end of the lesson, the teacher reminded students to fill out the atmospheric gases handout, to work on their independent library research assignment, and to study their notes.

Ratings of Lesson Components

The design of middle school science lessons is rated most highly for the contribution of available resources to accomplishing the purpose of the instruction and for reflecting careful planning and organization. Lessons are rated somewhat less highly in their attention to student backgrounds and prior experience and in their encouragement of collaboration and investigation. On average, the lessons are weakest at providing adequate time and structure for sense-making or wrap-up. The relatively low ratings in these areas may account for the low synthesis ratings of more than two-thirds of middle school science lessons and high ratings of less than ten percent.

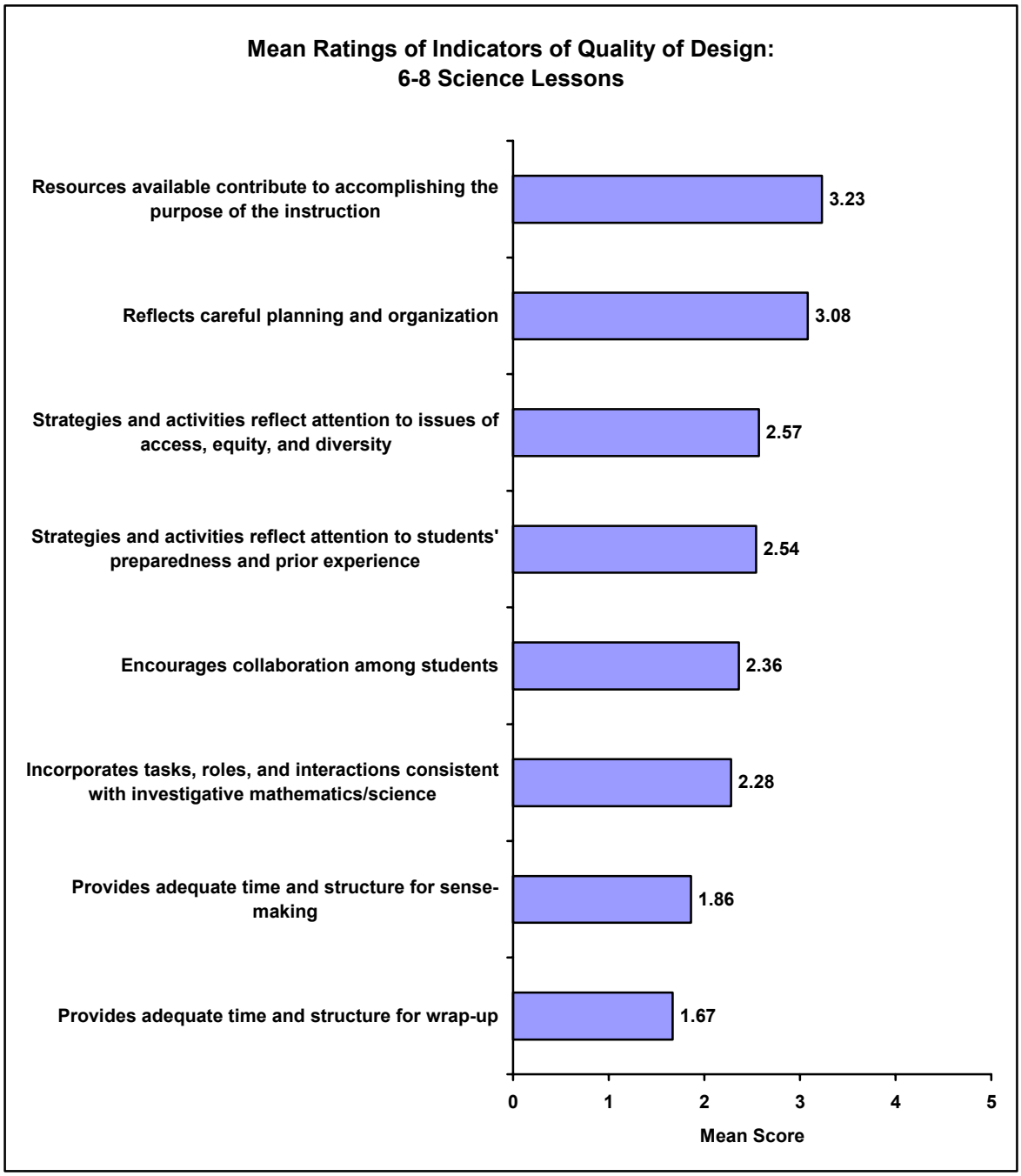
Mean Ratings of Indicators of Quality of Design:
6-8 Science Lessons
Resources available contribute to accomplishing the purpose of the instruction
3.23
Reflects careful planning and organization
3.08
Strategies and activities reflect attention to issues of access, equity, and diversity
2.57
Strategies and activities reflect attention to students' preparedness and prior experience
2.54
Encourages collaboration among students
2.36
Incorporates tasks, roles, and interactions consistent with investigative mathematics/science
2.28
Provides adequate time and structure for sense-making
1.86
Provides adequate time and structure for wrap-up
1.67
0
1
2
3
4
5
Mean Score

Figure G-1

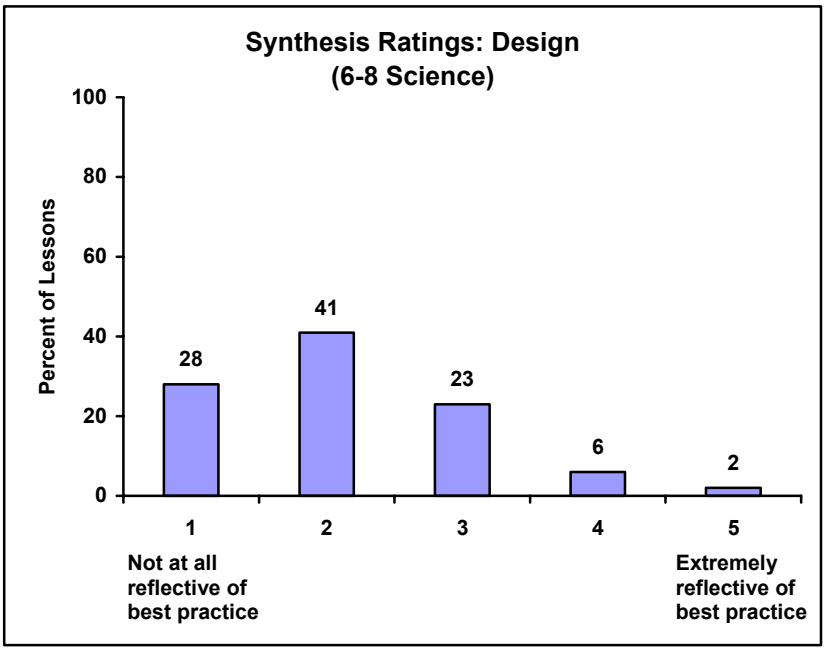

Figure G-2

The implementation of middle school science lessons receives the highest implementation ratings, on average, for teacher confidence and classroom management ability. Ratings are lowest for teachers' ability to adjust instruction according to student understanding, and to ask questions that enhance student learning. Overall, only eight percent of middle school science lessons are given high synthesis ratings for implementation and 16 percent receive medium ratings. Low ratings are given to 76 percent of lessons.

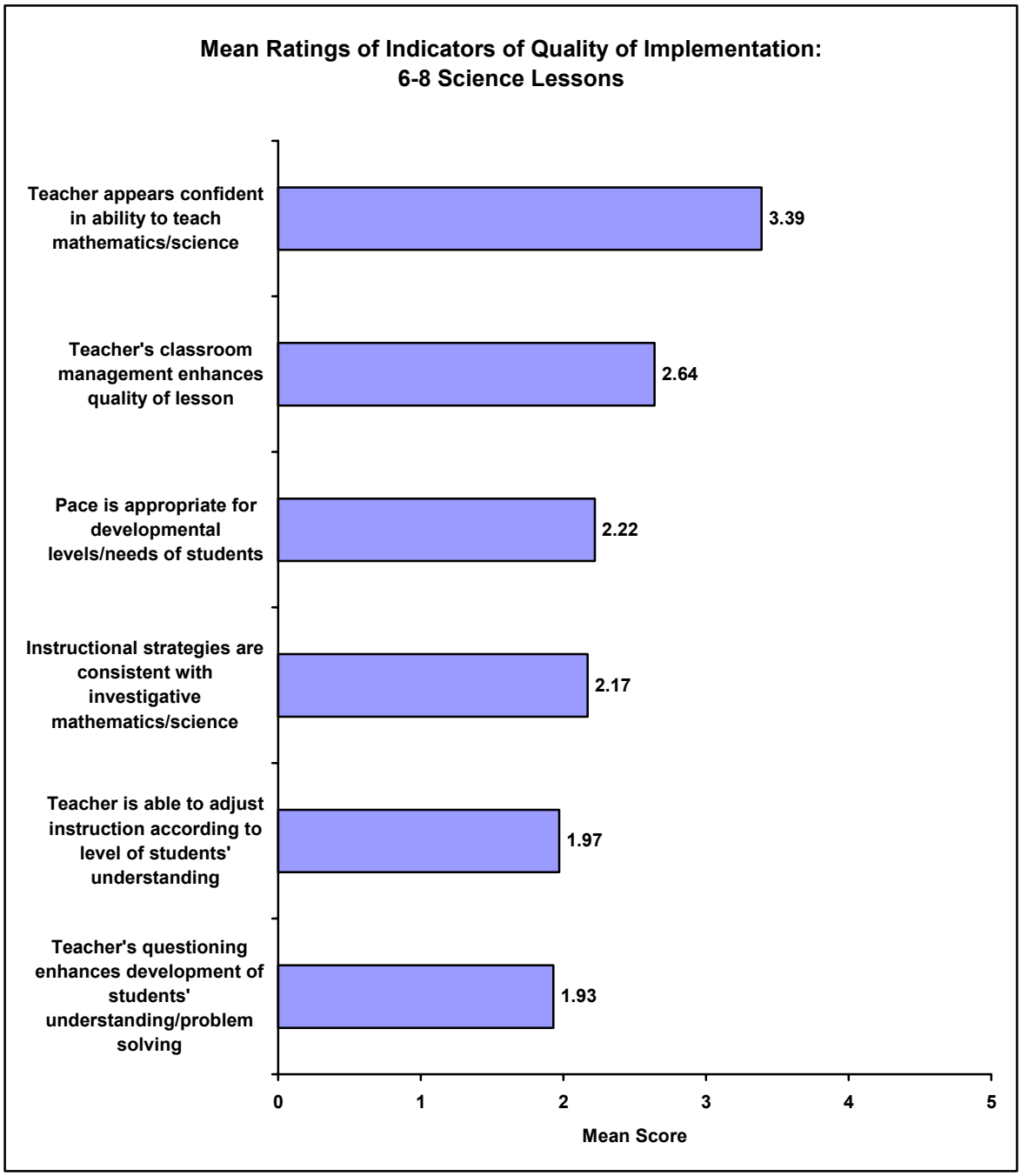
Mean Ratings of Indicators of Quality of Implementation:
6-8 Science Lessons
Teacher appears confident in ability to teach mathematics/science
3.39
Teacher's classroom management enhances quality of lesson
2.64
Pace is appropriate for developmental levels/needs of students
2.22
Instructional strategies are consistent with investigative mathematics/science
2.17
Teacher is able to adjust instruction according to level of students' understanding
1.97
Teacher's questioning enhances development of students' understanding/problem solving
1.93
0
1
2
3
4
5
Mean Score

Figure G-3

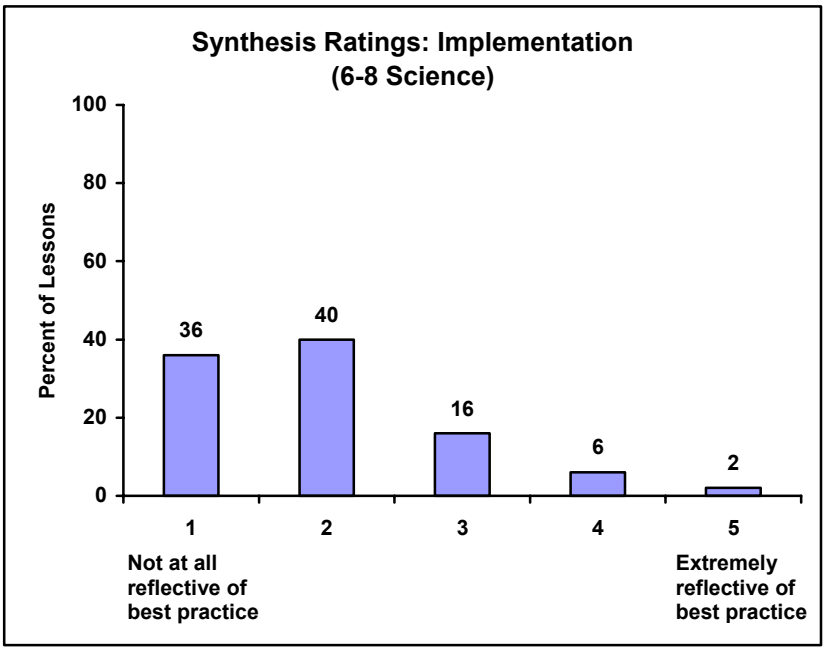

Figure G-4

The content of middle school science lessons is generally rated highly for being accurate, significant, and developmentally appropriate. Lessons are less strong in terms of including connections to other disciplines or elements of abstraction. The lowest ratings are given for the portrayal of science as a dynamic body of knowledge, intellectual engagement of students, and appropriate sense-making. These weaknesses are reflected in the synthesis ratings; only 8 percent of lessons receive a high synthesis rating for content, whereas 28 percent receive a medium rating and 64 percent receive a low rating.

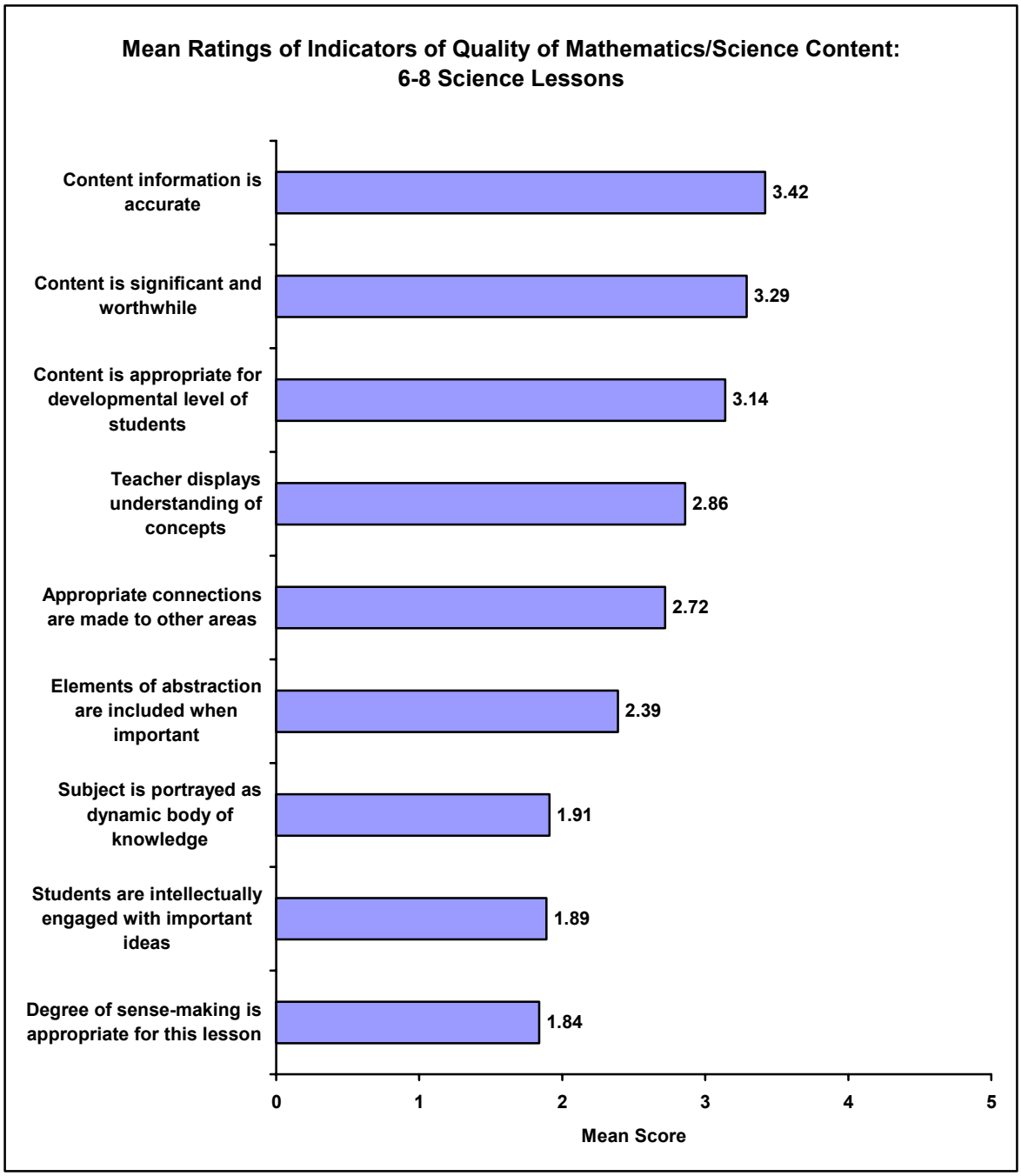
Mean Ratings of Indicators of Quality of Mathematics/Science Content:
6-8 Science Lessons
Content information is accurate
3.42
Content is significant and worthwhile
3.29
Content is appropriate for developmental level of students
3.14
Teacher displays understanding of concepts
2.86
Appropriate connections are made to other areas
2.72
Elements of abstraction are included when important
2.39
Subject is portrayed as dynamic body of knowledge
1.91
Students are intellectually engaged with important ideas
1.89
Degree of sense-making is appropriate for this lesson
1.84
0
1
2
3
4
5
Mean Score

Figure G-5

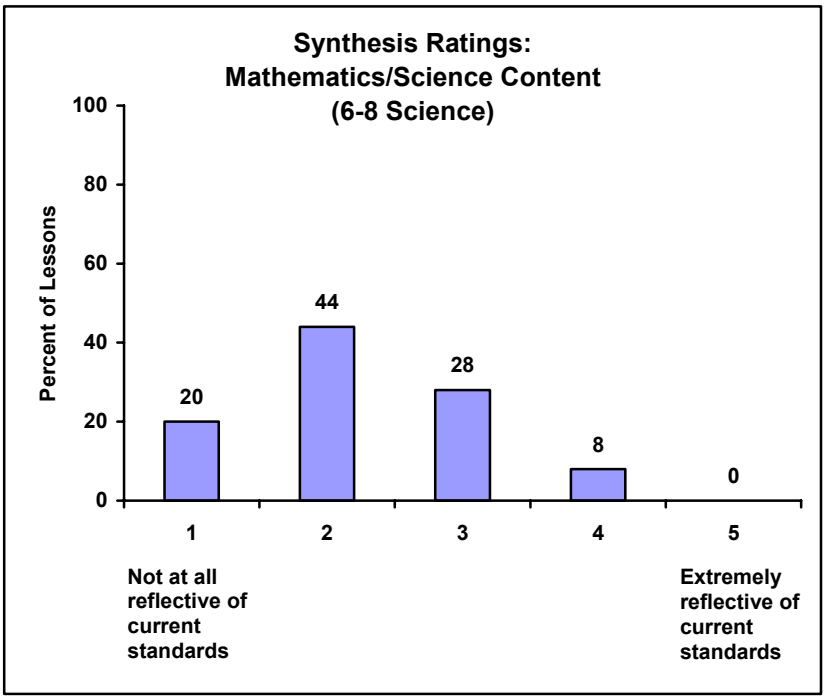

Figure G-6

The culture of middle school science lessons is rated highest on average for being respectful of students' ideas, questions, and contributions, and for encouraging active participation. The lessons are weaker with regard to encouraging student ideas and questions, and the lowest ratings are given for intellectual rigor. The synthesis ratings for classroom culture reflect these indicators with 13 percent receiving a high rating, 20 percent receiving a medium rating, and 67 percent receiving a low rating.

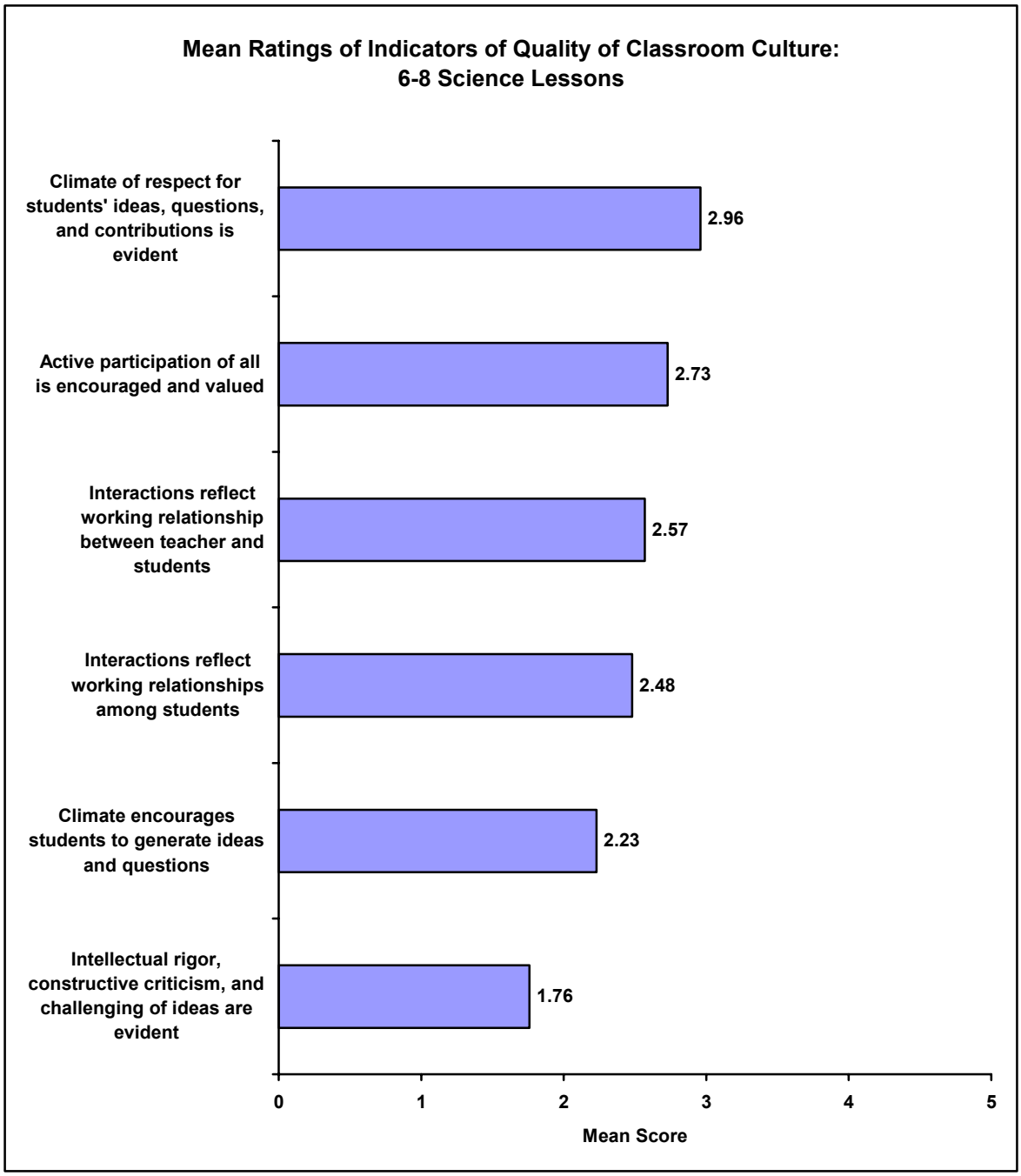
Mean Ratings of Indicators of Quality of Classroom Culture:
6-8 Science Lessons
Climate of respect for students' ideas, questions, and contributions is evident
2.96
Active participation of all is encouraged and valued
2.73
Interactions reflect working relationship between teacher and students
2.57
Interactions reflect working relationships among students
2.48
Climate encourages students to generate ideas and questions
2.23
Intellectual rigor, constructive criticism, and challenging of ideas are evident
1.76
0
1
2
3
4
5
Mean Score

Figure G-7

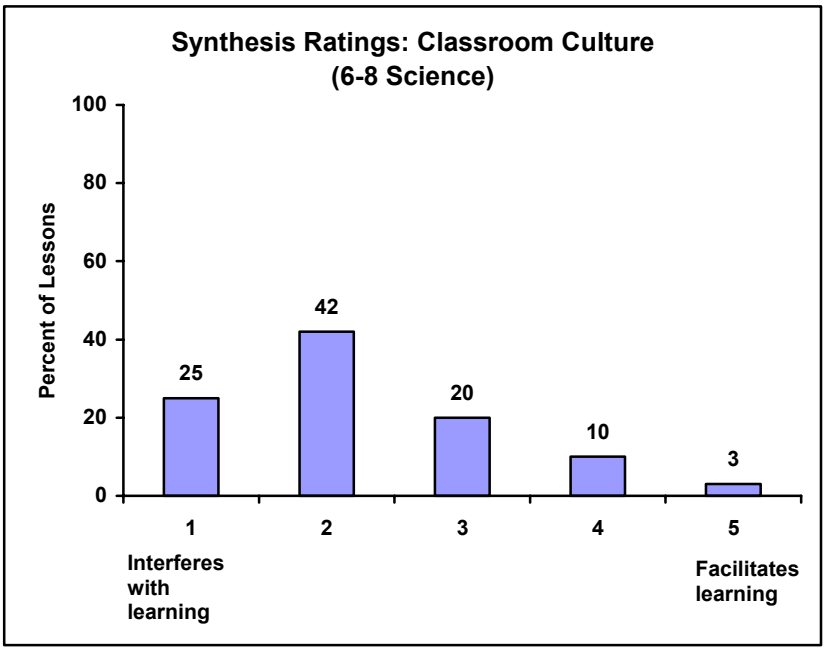
Synthesis Ratings: Classroom Culture
(6-8 Science)
Percent of Lessons
100
80
60
40
20
0
25
42
20
10
3
1
2
3
4
5
Interferes with learning
Facilitates learning

Figure G-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. Just under a quarter of the lessons are judged to have a positive effect on student content knowledge, ability to generalize skills and concepts, and interest in science. In about one-third of lessons students' interest in science is judged to be negatively affected. (See Table G-1.)

Table G-1
Likely Impact of the Lesson: 6–8 Science

	Percent of Lessons		
	Negative Effect	Mixed or Neutral Effect	Positive Effect
Students' understanding of important mathematics/science concepts	19	57	24
Students' ability to apply or generalize skills and concepts to other areas of mathematics/science, other disciplines, and/or real-life situations	11	65	23
Students' interest in and/or appreciation for the discipline	33	45	22
Students' capacity to carry out their own inquiries	17	67	16
Students' understanding of mathematics/science as a dynamic body of knowledge generated and enriched by investigation	28	58	14
Students' self-confidence in doing mathematics/science	22	65	13

Figure G-9 shows the percentage of 6th–8th 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.) Seventy-eight percent of middle school science lessons are rated as low in quality on the capsule rating, 16 percent are rated as medium in quality, and 7 percent are rated as high in quality.

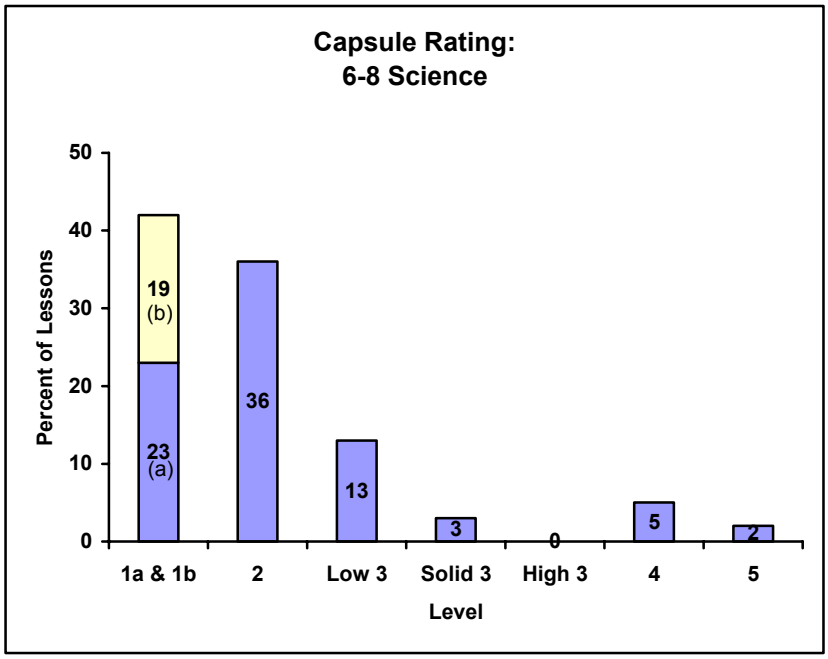

Figure G-9

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

Sample Low Quality Lesson: Passive "Learning"

This 6th grade class was starting the last section of a unit on matter. Prior to this lesson they had studied the atom and characteristics of elements, and now they were beginning to study compounds.

The teacher conducted a review of the earlier material by asking a series of questions: "Can anybody tell me what a compound is? What is a mixture? Can anyone give an example? How about a non-uniform mixture?" Students raised their hands to answer the questions, and gave examples of each term (e.g., sand and water for a mixture, water for a compound, blood for a non-uniform mixture).

The teacher then began going over a worksheet the students had completed for homework, stating that "if you didn't get it correct, you need to erase it. We're going to fill it in together." He read through the worksheet aloud and asked for answers, which the students called out. The teacher confirmed whether the answers were correct, and the students corrected their papers. Several students did not have their worksheets in front of them, and when the teacher questioned one, he replied that he couldn't find it. The teacher accepted this answer and simply went on with the lesson, calling only on students who volunteered.

When they had finished with the worksheet, the teacher instructed students to put it in their notebook. Students asked whether it should be placed in the homework section or the classwork section, and the teacher told them it was homework.

Before the teacher moved on, a student asked, "In H_2O, what's the 2?", and the teacher opened the question up to the class, asking, "Does anybody know?" Another student replied, "It's two elements." The first student asked, "So why isn't it H_2O_1?", and the teacher said "It's understood."

The teacher then introduced the next worksheet. He drew a diagram of an atom and asked questions such as: "Can anyone tell me the negative charged part? How about the positive charged part? What about the part with no charge? What about the part right there located in the center of the atom?" Students raised their hands to answer these questions. The teacher then passed out the review sheet, clarifying that it was part of classwork, which counts for 15 percent of the final grade. A student asked, "Are we working together?" and the teacher replied, "No, I want you working on your own so you can prepare for the test next week."

Students worked individually on the worksheets for the remainder of the class period, with the teacher circulating to help. As students finished the worksheet, they either took out books to read or put their heads down on their desks to sleep.

This lesson was very passive in nature. The teacher's heavy reliance on worksheets with low-level questions, and the lack of engagement of most students throughout the lesson, made it unlikely that this lesson would enhance students' understanding of compounds.

Sample Low Quality Lesson: "Activity for Activity's Sake"

The students in this 6th grade class have been studying weights and measurement in mathematics and Roman architecture in social studies. To integrate these topics with physics, the teacher decided to have a bridge building competition in which the students acted as groups of engineers. The lesson began with a student reading the bridge challenge to the class, after which the teacher reviewed the terms compression and tension. The teacher then explained the procedures for the competition and listed the materials that each group would receive (35 straws, 10 rubber bands, 1 foot masking tape, and 10 paper clips). Next, the students arranged themselves in groups of 3–6 to build the bridges, and the teacher handed out materials. The teacher stated that the groups that worked diligently together would receive extra materials. The students built different components of the bridge by cutting or inserting straws or assembling pre-made structures into the bridge. Once the groups were finished, the teacher put the bridge across a span of 1 foot and asked students to gather around. The students placed the weights on the bridges to test their strength, but no standard weight was used for all of the groups. The students went to lunch immediately after these trials.

During the bridge building and competition most of the students were engaged in the process of constructing or observing. The students worked well together, and the teacher recognized the student work by providing the groups with more materials for the bridge. However, none of the groups discussed the type of bridge they should build, nor did any design a bridge before building it. Although the students came up with some interesting ways to provide support for the bridge, all groups used a similar span design. No time was provided for reflection on the physics or engineering concepts behind their designs, nor was there any discussion of why the different bridges supported different amounts of weight. The students seemed to enjoy the activity, but no clear connection was made to either the mathematics or social studies content that the lesson was intended to integrate. The lesson was essentially an activity for activity's sake, with no science content save for a brief introduction by the teacher on compression and tension.

The bridge project was grade appropriate, but the science content was limited. Although some students may have gained some confidence in their ability to do science, they neither furthered their understanding of tension and compression, nor learned about the role of controls and experimentation in science.

Sample Medium Quality Lesson: Beginning Stages of Effective Instruction

This lesson came in the latter part of a unit on plant growth and development and was divided into two major sections. For the first part of the class, students worked on finishing a lab activity on plant development; the second part of the class consisted mainly of a lecture on the structure and functions of leaves.

The class began by students finishing a two-week lab activity in which they grew different types of seeds in a beaker (with wet paper towels) and made daily observations about the plants' growth and development (root systems, stems, and leaves). As this was the final day, students took their plants from the beakers and made final measurements of the root system, stem, and leaves. The students were quite engaged in the activity, as evidenced by the questions they asked of the teacher and their conversations with classmates. For example, one group was excited to discover a type of nodule on one of their plants and asked the teacher what it was. The teacher told them what it was called and what function it served.

The students recorded their observations and answered questions on a lab worksheet (e.g., "Do all seeds planted at the same time germinate at the same time?" "Compare the growth rate of different seedlings.") which called for the students to use their data to support their answers. This was the weakest aspect of the lesson as the teacher ended up doing most of the intellectual work. By leading them through the questions, the teacher didn't give students much of a chance to draw conclusions from their data.

Next, the teacher distributed a worksheet with a diagram of a leaf cross-section and had students take out paper for notes. The teacher lectured about the parts and functions of a leaf, and the students took notes and labeled the parts of the leaf on their worksheet. The lecture was interesting, as the teacher drew upon several videodisc images to illustrate parts of the leaf, and his examples used plants commonly found in the local area. The teacher also mixed in questions that drew upon students' prior knowledge about plant parts and functions, though these tended to be factual/recall types of questions (e.g., "What is the outermost layer of a cell?" "What do we call this?").

The lesson engaged the students in important science content and processes, in both the lab and lecture portions. However, the teacher's short-circuiting of the data analysis from the lab activity and the predominant use of recall-type questions in the lecture tended to limit the effectiveness of an otherwise well-designed and well-implemented lesson.

Sample High Quality Lesson: Traditional Instruction

This 8th grade lesson focused on probability, genetics, and the Punnett square. It came near the end of a multiple-week unit on cell structure, function, and processes that included "mitosis, meiosis, and a little bit on genetics." The lesson followed a hands-on activity in which two imaginary marshmallow creatures reproduced sexually, and students were asked to construct marshmallow babies based on the genetics of the parents. Today's lesson began with students writing answers to two "Questions of the Day" pertaining to the marshmallow activity: "Describe two phenotypes that your marshmallow baby had (what did it look like?)" and "How many 'daughter' cells are produced from 1 human cell during mitosis and how many chromosomes do the 'daughter' cells have?" These questions were posted on the board prior to students' arrival. When students were finished answering the questions, the teacher led a whole-class discussion about them and then transitioned into a brief interactive lecture about meiosis, X-chromosomes, and Y-chromosomes. During this lecture, the teacher involved students by asking them questions about their parents, elaborating on one student's reference to a movie, and asking students what sex chromosome (X or Y) they'd received from their fathers.

Following the lecture, the teacher supplied each student with a one-page passage about probability and genetics and a related worksheet, both from their textbook. The worksheet required students to complete Punnett squares for heterozygous matings and to infer the genotypes of the parents given specified offspring genotypes. In addition, there was a matching section related to vocabulary from the reading selection. The teacher gave students the option of reading the selection as a whole class, but they chose to read independently instead. Most students had just begun the worksheet when the teacher asked who was confused about the Punnett squares on the worksheet. When many students raised their hands, the teacher led a whole-class, interactive tutorial about how Punnett squares work. Students then returned to the worksheets for a few more minutes. During the period of independent work the teacher circulated to ask questions, provide encouragement, and offer assistance. Once students had finished the worksheet they discussed it as a class, with students volunteering their answers and the teacher writing them on an overhead. Finally, the teacher distributed blank Punnett squares and announced two crosses for students to complete. Students again worked alone, and when they were finished the teacher called on volunteers to share their answers with the class.

This lesson included a variety of instructional strategies that all appeared to be appropriate for the students in the class. The teacher asked questions that engaged the students, and she probed further at appropriate times. She also changed her instruction when it was clear that students were not following. The intellectual rigor during the entire period was high, and the level of difficulty seemed to require most students to stretch, but never to a point of frustration. In addition, the content was worthwhile, had relevance to students' real world, and included a cross-disciplinary connection to mathematics. Although the lesson was fast-paced, students remained engaged and motivated. Overall, this lesson seemed very well suited to the students in the room and was likely to have helped deepen their understanding of genetics concepts.

Sample High Quality Lesson: Reform-Oriented Instruction

This 7th grade class was studying a unit on human anatomy that included the structure and function of body systems. The focus of today's lesson was an introduction to the digestive system. The teacher began the lesson by asking students if they knew "which organ performed 500 different functions for their bodies?" This got the students' attention and the class moved into the study. After materials were dispensed, a student was asked to read aloud from the text describing the organs of the digestive system. The class was then asked to look at the expanded diagram of the digestive system, find specific structures, and color them in.

As each structure was colored, the teacher led a discussion linking the form of each structure in the digestive system to its function. The teacher used an interactive, conversational style in which he would ask a question and the class would put together the concept in their responses. To enhance the discussion, he used both interesting examples and models that he had built before class. For example, a corrugated plastic hose was used to model the cartilaginous support in the trachea, and a bicycle inner tube was placed against the trachea to represent the position of the esophagus. To illustrate enzymatic digestion, the teacher cut a piece of paper into tiny pieces. He then visually demonstrated how the epiglottis folds back so food can go down the esophagus and not the trachea. The class period ended with students chewing soda crackers, holding them on their tongue until they could taste sugar in order to reinforce the idea that starch is converted to sugar by enzymes of the digestive system. Students were then reminded of their assignment: to write an essay entitled "As the Stomach Churns" which would describe what happens to food in the stomach.

This lesson was well planned, with every minute allocated to instruction. The teacher used multiple pedagogical strategies to introduce the digestive system and to conceptually link structure with function. The teacher emphasized the student reading of the textbook for content, but amplified the student understanding with many activities and concrete models. His method of alternating discussion to explain, coloring to reinforce the form of the system, and models to describe the function was an effective way of helping students understand the digestive system.