Using the Project 2061 Curriculum Analysis to Rate a Middle School Science Curriculum Unit: ARIES: Exploring Motion and Forces.
SCALE-uP Report No. 10.

Scaling-up Curriculum for Achievement, Learning, and Equity Project

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Executive Summary

This report presents the results of a curriculum analysis for a middle school physical science curriculum unit, Exploring Motion and Forces: Speed, Acceleration, and Friction (Harvard-Smithsonian Center for Astrophysics, 2001). A team of curriculum analysts used the Project 2061 Curriculum Analysis procedure (AAAS, 2001b) to guide the work. The analysis work is part of the Scaling up Curriculum for Achievement, Learning, and Equity Project (SCALE-uP), a research study in which middle school science curriculum units, such as Motion and Forces are being implemented in a large suburban school district to examine the effects of highly rated curriculum units on student achievement.

The Project 2061 Curriculum Analysis provides a comprehensive, research-based tool for determining the quality of instructional materials. We have used the Project 2061 Curriculum Analysis to systematically examine, rate, and report on the alignment and instructional qualities of Motion and Forces. The unit was developed for the ARIES curriculum program by the Science Education Department at the Harvard-Smithsonian Center for Astrophysics. It is a six-week physical science curriculum unit designed for grades 5-8.

The Curriculum Analysis of Motion and Forces was completed by an evaluation team, which included a scientist, a science educator, a middle school science teacher and a member of the SCALE-uP research team. Project 2061 was not involved in the analysis but the SCALE-uP staff attempted to follow the Curriculum Analysis procedure as closely as possible. Several of the SCALE-uP staff members have had experience with the process.
The Curriculum Analysis consists of two distinct phases: the Content Analysis and the Instructional Analysis. The Content Analysis requires reviewers to determine whether the unit’s content aligns with specific learning goals. The Instructional Analysis determines how well the material’s instructional strategies support student learning of the selected learning goal.

The results of the Content Analysis found Motion and Forces to align with the following four target ideas: 1) changes in speed or direction are caused by forces; 2) the greater the force is, the greater the change in motion will be; 3) the more massive an object is, the less effect a given force will have; and, 4) an object at rest stays that way unless acted on by a force, an object in motion will continue to move unabated unless acted on by a force (AAAS, 1993, p. 89-90).

Overall, the Content Analysis revealed that Motion and Forces does not make explicit connections among these target ideas, although there are some connections made between the target ideas and the related and prerequisite ideas. While the analysis reports that Motion and Forces does not provide an evidence-based argument for these target ideas, it states that students are provided with numerous opportunities to observe phenomena that are specifically related to the target ideas. The material, however, does not explicitly link these observations to students’ own conclusions about the target ideas or about the laws of motion. This unit, in general, does not go beyond ideas that are needed for scientific literacy related to these target ideas at this grade level. In addition, the unit does not contain a large number of errors or misleading statements.

The Instructional Analysis for Motion and Forces reveals relative strengths in the areas of lesson/activity purpose, providing a variety of vivid experiences, helping the teacher to identify students’ ideas, developing scientific ideas, and encouraging students to explain their ideas. The process revealed relative weaknesses, however, in the areas of conveying unit purpose, taking account of student ideas, guiding student thinking, demonstrating use/practice of scientific knowledge, and assessing progress.

This technical report, “Using the Project 2061 Curriculum Analysis to Rate a Middle School Science Curriculum Unit: ARIES: Exploring Motion and Forces” presents the results of the curriculum analysis conducted for the SCALE-uP research study.
The need to do a curriculum analysis of Motion and Forces (Harvard-Smithsonian Center for Astrophysics, 2001) was precipitated by a NSF/IERI research grant entitled, Scaling Up Highly Rated Science Curricula in Diverse Student Populations: Using Evidence to Close Achievement Gaps (Lynch, Kuipers, Pyke, & Szesze, 2002). A goal of this research was to locate “reform” or “standards-based” middle school science curriculum units, and scale them up in a large, diverse, public school system, over six years. It was understood that the units would likely have in common a well-defined set of instructional attributes that would lead to superior outcomes when compared to “standard” curriculum materials already in use in the school system. However, this study also seeks to learn if the scaled-up units might result in better outcomes for various subpopulations of students (defined by gender, socioeconomic status, ethnicity, and status as a learner of English or as having an identified disability). In the preliminary phases of our study, we implemented an eighth grade curriculum unit, Chemistry That Applies (State of Michigan, 1993). Students in five highly diverse middle schools had statistically significant higher outcome scores than their counterparts in five comparison schools who studied the same concepts with the standard curriculum materials (Lynch, Kuipers, Pyke, Szesze, 2003).

Chemistry That Applies (CTA) had received a high rating according to the Project 2061 Curriculum Analysis (AAAS, 2001b), and was one of the few existing middle school science curriculum units to have done so. The process of rating a curriculum unit requires that it focuses on particular standards/benchmarks and that it has instructional characteristics well defined by the analysis procedure (Kesidou & Roseman, 2003). Thus, as Scaling up Curriculum for Achievement, Learning, and Equity Project (SCALE-uP) research proceeded, we sought to identify two additional curriculum units that also would earn a high rating on the Project 2061 criteria, (one for sixth grade science and one for seventh). These new units had to align with the local school district’s curriculum framework, be cost and time efficient, and have the potential for rating highly on the Project 2061 Curriculum Analysis. We examined a number of “reform-oriented” middle school science curriculum units. Many of these had their provenance with NSF’s curriculum development efforts. In the final analysis, the research/science education staffs at the local district and university were able to find only two curriculum units that seemed suitable: ARIES: Exploring Motion and Forces (Harvard-Smithsonian Center for Astrophysics, 2001) and Great Explorations in Math and Science: (GEMS) The Real Reasons for Seasons (Lawrence Hall of Science, GEMS, 2000). It was our hope that both units would receive high ratings on the Project 2061 Curriculum Analysis. The intent of this report is to present the results of the analysis for the ARIES unit, Motion and Forces.

The Curriculum Unit


Exploring Motion and Forces: Speed, Acceleration, and Friction (Harvard-Smithsonian Center for Astrophysics, 2001) was developed for the ARIES curriculum program by the Science Education Department at the Harvard-Smithsonian Center for Astrophysics. It is a six-week physical science curriculum unit designed for grades 5-8. It has 18 “Explorations” divided into
four parts. The Explorations are inquiry-centered and activity-based, with an emphasis on students’ direct experience with phenomena. The curriculum material itself consists of a Teacher Manual (TM) and a student Science Journal (SJ). There is no traditional student textbook. Educators may buy all of the necessary materials in a prepared kit, or they may make up their own sets of student lab materials.

Overview of the Project 2061 Curriculum Analysis

The Curriculum Analysis was developed by the American Association for the Advancement of Science (AAAS), Project 2061. The analysis consists of two distinct phases. The first phase, called the Content Analysis requires reviewers to look closely at curriculum material to determine whether its content aligns with specific learning goals. The content should address the substance of the goal (such as a benchmark, standard, or local school district’s indicators) rather than be a superficial topic match (Kesidou & Roseman, 2002). If there is a good content match, then the Curriculum Analysis can enter the second phase, called the Instructional Analysis (see Appendix B), which determines how well the material’s instructional strategies support student learning of the selected learning goal. Finally, both the Content and Instructional Analyses are finalized in a report (this document, for Motion and Forces), which includes the development of a criterion-by-criterion profile that shows how the learning goal is met by the unit’s instructional attributes (Kesidou & Roseman, 2002). The resulting profile allows for comparison of various curriculum units rated by the Project 2061 Curriculum Analysis. (It should be noted that the Project 2061 Curriculum Analysis does not include the universe of all desirable characteristics of curriculum materials, but rather a number of attributes with rationales supported by research literature. See Kesidou & Roseman, 2002, Holliday, 2003, and Kesidou & Roseman, 2003 for a more extensive discussion.)

The Rating Process for Motion and Forces

The Curriculum Analysis for the ARIES unit, Exploring Motion and Forces, was done during the spring of 2003. Project 2061 was not involved with this analysis. However, the SCALE-uP staff attempted to follow the Project 2061 Curriculum Analysis procedures as closely as possible. Curtis Pyke, Assistant Professor of Secondary Education at George Washington University (GWU), has been trained by Project 2061 and participated in the Project 2061 middle school algebra textbook analysis. Sharon Lynch, Professor of Secondary Education at GWU, was on the Project 2061 High School Biology Textbook Advisory Board and has used a modified version of the Curriculum Analysis in her classes at GWU for six consecutive years (Lynch, 1997; Lynch, Pyke, & Jansen, 2003). Although the SCALE-uP staff attempted to be as faithful to the Project 2061 Curriculum Analysis as possible, the Motion and Forces analysis should not be construed as sponsored by Project 2061.

First, most of the groundwork for the Content Analysis (the location of various “sittings” of evidence within the curriculum unit for the target benchmark) was completed by the GWU SCALE-uP research staff. Then an outside evaluation team of science/science education specialists traveled to the GWU campus to analyze Motion and Forces, using the Project 2061 procedures (see Appendix A for a list of team members).

The Instructional Analysis took place from May 14th-17th, 2003. The evaluation team worked on the Instructional Analysis for about eight hours/day, for four consecutive days. The first day was mostly devoted to familiarizing the reviewers with the goals of the research grant...
and teaching them the Curriculum Analysis process. They also studied the Motion and Forces curriculum material, and reviewed a map of middle school benchmark (learning goals) for forces and motion. In the next two days, the four-person evaluation team broke into two pairs of partners who worked methodically through the Project 2061 Instructional Analysis Categories (Appendix B), pausing at intervals to discuss and reconcile their results. The team used the final day primarily for writing its results of the Motion and Forces Instructional Analysis. Finally, the GWU research team proofread and edited the evaluation team’s work, and added supplementary information to create this final report. This report presents a description of the Content Analysis process as well as the criterion-by-criterion profile of the Instructional Analysis for Motion and Forces.

Content Analysis

The goal of the Content Analysis (of the Project 2061 Curriculum Analysis) is to identify the benchmark or standard (or a discrete set of targeted benchmarks/standards) aligned with the curriculum unit. It has three steps: 1) benchmark selection, 2) the sighting phase (determining the location or “sighting” of activities in the curriculum material that address specific benchmarks/standards and 3) determining quality of alignment (which involves five components: alignment, building a case, coherence, beyond literacy, and accuracy) (AAAS Project 2061, 1999). Each step is described in detail below.

Benchmark Selection

The Content Analysis followed the procedures used by Project 2061 in the Middle Grades Science Textbooks (AAAS, 1999). The Project 2061 Content Analysis focuses on a set of ideas that comprise either an entire Project 2061 benchmark, selected parts of related benchmarks, or statements from the supporting text in Benchmarks for Science Literacy (1993). These benchmarks or standards can be considered as either a single “target idea” or an “idea set”, composed of related science concepts that students need to understand to learn a target idea/idea set.

In order to select the target benchmark, it is possible to use various strategies, depending on the purpose of the Curriculum Analysis and the particular curriculum material being analyzed: a) select a priori an idea set that is so important that a case can be made that it ought to be covered in curricular materials, b) select an idea set that the curriculum material explicitly specifies as the learning goal or c) select an idea set through a process that carefully considers the likely set of ideas that the unit might address. For the SCALE-uP research, we used the latter. The GWU research team worked in a group to establish an idea set resulting from an attempt to consider all possible benchmarks addressed in Motion and Forces. The product was a map of target ideas that appeared to be the unit’s learning goal. This was accomplished by starting with the Project 2061 strand map found in Atlas of Science Literacy (AAAS, 2001a, p. 63) as the initial resource, and developing a more detailed and focused map for Motion and Forces, Figure 1.

Figure 1 was reviewed, modified and finally approved by the evaluation team of scientists and science educators. The team agreed that the map represents the ideas most essential for mastery of forces and motion concepts by the end of middle school. There was a minor modification to the idea set prior to initiation of the Instructional Analysis. One of the target ideas (4F, 6-8, #4, AAAS, 1993) was removed from the idea set after it was determined that Motion and Forces did
not specifically cover *unbalanced forces* (perhaps a more advanced idea). The map in Figure 1 shows the four target ideas (which make up the idea set), prerequisite ideas, related ideas and less and more advanced ideas. The map is presented by grade bands (K-2, 3-5, 6-8, and 9-12) and arranged logically such that a connection between benchmarks means that one “‘contributes to achieving’” the other (AAAS, 2001a, p. 7).

Note that target ideas 1 through 3 are all part of the same benchmark (4F, 3-5, #1) (AAAS, 1993, p. 89). This benchmark was separated into three target ideas because they are distinguishably separate ideas. It seems possible to understand distinct pieces of the benchmark, although not understanding others. The entire benchmark reads:

> Changes in speed or direction are caused by forces. The more massive an object is, the less effect a given force will have. The greater the force is the greater the change in motion will be (AAAS, 1993, p. 89).

Target idea 4 is taken from a statement in *Benchmarks for Science Literacy* (AAAS, 1993).

> An object at rest stays that way unless acted on by a force. An object in motion will continue to move unabated unless acted on by a force (p. 90).

After these four target ideas were selected to make up the idea set, it was then possible to move on to the sighting phase.

*The Sighting Phase*

Once the idea set was selected and well defined by the map (Figure 1), the next step was to locate areas within *Motion and Forces* that corresponded reasonably well to the idea set. This was accomplished by a meticulous, page-by-page survey of the unit’s activities, investigations, reading selections, and other learning opportunities that address the target ideas within the idea set. This process is referred to as “sighting”, and includes the specification of page number and quotes that link to a map idea. Two SCALE-uP research assistants developed a complete set of sightings. Appendix C presents these sightings, showing how the unit explicitly addresses each target idea.

*Quality of Alignment*

Quality of alignment explores and describes (a) how the curriculum materials align to each target idea (b) the evidence provided by the material that builds a case for the ideas, (c) the connections the material makes among ideas in the idea set and to other ideas, (c) level of sophistication (that is, to determine if the coverage is appropriately aligned with the literacy expectations of the target grade level) and (e) the accuracy of the materials related to the ideas. Each of these aspects is described in the following sections.

*Alignment*
The alignment part of the content analysis requires evaluators to determine if the curriculum material’s content aligns with the specific target ideas that have been selected for the analysis. The following is a summary of how Motion and Forces aligns with each target idea.
Motion and Forces: Curriculum Analysis

Figure 1. Strand map of force and motion ideas. Boxes numbered 1-4 represent the entire idea set.
Target idea 1. Changes in speed or direction are caused by forces.

There is content alignment with this idea. The unit builds from concrete notions of forces as pushes or pulls acting on objects (4F, K-2, #2 and Figure 1). In several Explorations (2, 3, 4, 13, & 17), the learning objectives are stated as, “a force (a push or pull) is required for an object to start moving.” In all of these Explorations, students are asked to consider what causes objects to start moving, different rates of motion (speed), and how objects move when different forces are used (direction). There are several activities used to show how pushes or pulls are examples of forces. Students slide several objects across a horizontal surface and throw a coin up in the air to observe examples of forces changing the speed and direction of objects. Students are asked questions such as:

Why do you think the object started moving? If your object is in constant motion, why do you think it keeps moving? (SJ, p. 2-3).

Some objects, such as a leaf, a roll of masking tape, or a pencil, move in different ways. Describe what those motions could be and what might cause these objects to move (SJ, p. 4).

How do you know when something is moving? What evidence do you look for? (SJ, p. 4).

How is the motion of a coin thrown into the air similar to the motion of a coin moving on a horizontal surface? (SJ, p. 8).

In each of these questions, students are asked to consider the different kinds of forces that act on objects in order to change their speed or direction. In addition, throughout the entire unit, students are observing different forces (gravity, pushes, pulls) and their effects on the speed and direction of motion of various objects (marbles, sliding disks, speedcarts).

Target idea 2. The more massive an object is, the less effect a given force will have. (4F, 3-5, #1).

There is content alignment to this idea. In Exploration 16, the Teacher Manual (TM) presents the learning objectives as follows:

The purpose of this Exploration is to investigate the motion of a cart as washers are added to increase the mass of the cart. The more massive an object is, the longer it will take to move a given distance when acted upon by a push or pull of specific magnitude for a specific time. (TM, p. 111)

During this Exploration, students are asked to consider several key questions relating to the target idea:
“Would a cart with more mass move differently than a cart with less mass if each were pulled by the same force?” (SJ, p. 102) and “Why does the cart slow down when you add washers to the cart?” (TM, p. 115).

Students are expected to answer that adding washers to the cart increases the cart’s mass, which results in greater resistance to the pull from the falling mass. Therefore, because the cart has a greater mass, the same force (falling washer) will have less of an effect on the motion of the cart. Alignment to this target idea can only be found in Exploration 16 but it appears that there is enough emphasis on the idea to include it as one of the target ideas.

**Target idea 3. The greater the force is the greater the change in motion will be**

(4F, 3-5, #1).

There is content alignment to this idea. There are several activities in the unit that explore the idea of magnitude of force as it relates to change in motion. Specifically, Exploration 5 involves students in an activity and observation of “how the distance an object moves is affected by the magnitude of the force that sets it in motion” (TM, p. 24). The learning objectives for this activity are stated as:

The magnitude of a force (a push or pull) acting on an object affects the distance the object moves. A stronger push results in an object moving a greater distance. A weaker push results in the object moving a shorter distance (TM, p. 24).

In a later Exploration (15), the Teacher Manual describes a clear learning objective as:

The purpose of this Exploration is to observe the motion of the cart when more washers are added to the hook, increasing the falling mass and the pull on the cart. The magnitude of a push or a pull (force) that continues to act on an object affects the time it takes for the object to move a specific distance. The greater the magnitude of a push or pull, the faster the object will move (TM, p. 105).

In addition to these two activities, students spend considerable time (Explorations 9-12) predicting and observing the change in motion of marbles along both a flat and inclined track. There are numerous opportunities to observe that the longer a marble rolls along an inclined track (the greater the force), the faster it will roll along that track and the farther it will roll on a flat track (the greater the change in motion).
Target idea 4. An object at rest stays that way unless acted on by a force. An object in motion will continue to move unabated unless acted on by a force (Benchmarks, p. 90).

There is content alignment to this idea. There are several Explorations in the unit that address this idea. In the introduction to Unit 2, the Teacher Manual states:

The Super Sliding Disk tests two predictions of Newton’s model of motion: (1) an object at rest stays at rest unless an external force is applied to start it moving, and (2) a moving object maintains its motion unless it is acted upon by an external force. (TM, p. 13).

Consequently, Explorations 4-7 address Newton’s first law of motion, which is embodied in this target idea. Exploration 7 involves the construction and use of a floating Air Disk whereby students predict and observe its motion. Students are asked to answer questions such as “What do you think the motion of the disk would be like if you could find a way to reduce the friction force acting on the disk?” and “What do you think stops a disk in motion from staying in motion forever?” A key question from the student journal at the conclusion of Exploration 7 asks:

Once an object is in motion it seems to stay in motion, neither speeding up nor slowing down, unless a force (push or pull) acts on it. Scientists call this behavior inertia. Does your Air Disk exhibit inertia? If so, how? (SJ, p. 34)

Later in the unit, questions from the Teacher Manual ask, “Suppose your disk had a balloon that never ran out of air. What do you think the motion of the disk would be like?” and “How is the motion of your Air Disk different from the motion of other moving objects you have observed?” (TM, p. 42). Students are expected to answer that the Air Disk would continue to move in a straight line at a constant speed and that its motion would be different from other moving objects (perhaps more steady or constant).

Other activities also address this target idea. For example, Exploration 13 involves using a speedcart to help students understand that an object remains at rest unless an external force is applied. Students are asked the question, “Assume each of the vehicles is standing still. Do you think any one of them could start moving by itself? If so, how?” (SJ, p. 79). Students are expected to answer that the vehicle could not start moving by itself and that an external force is necessary for motion to occur.

In Exploration 14, which involves the speedcart attached to a string with falling washers, one of the learning objectives is stated as: “An object in motion remains in motion unless an external force is applied to change the motion” (TM, p. 99). Questions in the Student Journal help students to understand the target idea such as, “Describe the motion of the cart right after the washers have hit the ground” and “If the string came untied, do you think the cart would keep going?” Students should answer that the cart continues to move until another force (such as friction) acts on it to change its motion.
Building a Case

To build a case, the curriculum material is examined to determine if it develops an evidence-based argument in support of the target ideas, including whether the case presented is valid, comprehensible, and convincing. Motion and Forces does not provide an evidence-based argument for the target ideas around force and motion. Students are provided with numerous opportunities to observe phenomena that are specifically related to the target ideas but the material does not explicitly link these observations to students’ own conclusions about the target ideas or about the laws of motion. Rather, at the beginning of each Exploration, students begin by answering a series of questions about familiar contexts and then are asked to write their own question about forces and motion to lead them in the Exploration. Perhaps the question written in the student journal will be answered in the Exploration, but at no point does the material return to the original student questions or provide assurance that it will be answered.

Furthermore, at the conclusion of each Exploration, students are asked to write a few sentences in a section entitled, “What I know about…” before moving on to the next Exploration. Teachers are explicitly asked to have student volunteers read aloud their answers for this section, but at no point are teachers asked to link the students’ responses to target ideas or the laws of motion. It would be helpful to provide teachers with anticipated student responses and with specific strategies to link student ideas with the learning objectives or target ideas.

Although there seems to be a logical sequence to the Explorations, there are few explicit connections made between the Explorations to assist students in developing their thinking about their observations and the evidence gathered. It may have been helpful to include explanations about how similar observations of force and motion led to the development of the target ideas (laws of motion) or that these conclusions can probably be made in all situations involving the motion of objects.

Coherence

In examining the coherence of curriculum materials, one looks for connections that the curriculum material makes (1) among the target ideas, (2) between the target ideas and their prerequisites, and (3) between the target ideas and other, related ideas. Overall, it appears that Motion and Forces does not make explicit connections among the target ideas, but there are some connections made between the target ideas and the related and prerequisite ideas.

To present the target ideas, the unit requires that students construct three different objects (sliding disk, marble track, and speedcart) that will be used for various Explorations throughout the unit. These Explorations provide first-hand experiences for the students. Student responses to questions both prior to and after the activities help them to make connections between their experiences and the target ideas.

Motion and Forces does not make many explicit connections among the target ideas. While individual Explorations are based on phenomena related to the target ideas, it is often left to the student to determine how those ideas are related and which ideas learned from past Explorations are necessary for the next Exploration(s). The Explorations seem to ‘stand alone’ as independent activities with specific learning
Motion and Forces: Curriculum Analysis


objectives. For example, Exploration 7 (Floating on Air) addresses the important target idea of Newton’s First Law of Motion, but the unit uses this idea much later in Exploration 14, with a few questions (SJ, p. 91). Even then, the connection is not made explicit to the students who might successfully answer the questions in Exploration 14 without understanding the connection.

Motion and Forces makes some explicit connections between the target ideas and their prerequisite ideas. In the first unit, students revisit the ideas of pushes and pulls (forces) and the ways they can cause objects to move (see Figure 1). Students are also expected to describe gravity as a force (SJ, 7-9) that is acting on objects pulling them towards the Earth, which is an important prerequisite idea (see Figure 1), especially for the third and fourth units.

Motion and Forces also connects some of the target ideas to related ideas. Students often discuss the idea of friction (see Figure 1) and how friction relates to the motion of objects. Students are expected to learn that friction is an example of a force that can change the motion of objects in Exploration 6. Then in the next Exploration, students are expected to learn that when friction is reduced/minimized, it is possible to observe that ‘an object in motion will continue to move unabated unless acted on by a force’ (Target Idea 4). This is an important connection to the idea of friction.

Beyond Literacy

When determining if curriculum materials are beyond literacy, evaluators look to see if any information presented in the curriculum material is more advanced than the set of target ideas. They are particularly wary of information in the unit that may interrupt the presentation of the grade-appropriate information. Motion and Forces is designed for grades 5-8 and in general does not go beyond ideas that are needed for science literacy, as recommended by Benchmarks for Science Literacy (AAAS, 1993). In a unit dealing with these target ideas, it may seem possible to begin discussions of the more advanced ideas of potential and kinetic energy, but this unit appropriately avoids such discussions. In addition, it may also seem feasible during the unit (given the considerable data collection and graphing exercises that students complete), to include mathematical calculations of force, mass, and acceleration using formulas (i.e., F=m x a), but the unit appropriately avoids such discussions as they are not important to understanding the target ideas and may confuse students.

Overall, the unit does not go beyond the literacy abilities of the intended grade band; however there are a few exceptions worth noting. The unit attempts to introduce the idea of ‘inertia’ to students in the following way:

Once an object is in motion it seems to stay in motion, neither speeding up nor slowing down, unless a force (push or pull) acts on it. Scientists call this behavior inertia. Does your Air Disk exhibit inertia? If so, how? (SJ, p. 34).

It seems inappropriate to introduce the idea of inertia at this age level and in fact, it is not necessary for students to learn such vocabulary to understand the target idea in this
Exploration or understand Newton’s First Law of Motion. Furthermore, the presentation of the information is inaccurate and will be discussed in more detail in the next section.

In the Curriculum Overview (TM, p. xvii), the unit provides a rationale for its lack of emphasis on the words ‘speed’ and ‘acceleration’ (two difficult ideas for middle school students) throughout the unit. Instead, students are encouraged to use the words ‘faster’ and ‘slower’ to describe relative speed, use the words ‘speeding up’ or ‘slowing down’ in discussions of acceleration, and to discuss motion in terms of “changes in motion.” However, frequently the student journals will include the word acceleration, such as on the cover of the book (in the title) and in the last Exploration. In fact, the final question in the Student Journal reads: “What I know about acceleration” and students are given a few lines to write what they ‘know’ about acceleration. Discussions of speed are also included throughout the student journal (p. 35, 79, 108, 109, and 111), in discussions of acceleration, and in the title of the unit.

The above examples represent all of the instances found where the unit appeared to exceed the literacy expectations of the targeted grade level. However, because these examples are such a small portion of Motion and Forces (in total, the Student Journal asks for approximately 300 written student responses), they do not seem to interrupt the presentation of the grade-appropriate information.

Accuracy

In judging the accuracy of curriculum materials, the evaluators locate information that contains errors, misleading statements, or statements that may reinforce commonly held student misconceptions. Overall, Motion and Forces does not contain a large number of errors or misleading statements. However, the term inertia was unnecessarily introduced with a definition (SJ, p. 34) that could lead to reinforcing a misconception for both teachers and the students. The idea of inertia is quite complex and perhaps has more than one definition when considering inertial motion, inertial force, and inertial mass. In fact, the term ‘inertia’ appears nowhere in Science for All Americans (AAAS, 1989) and is not part of any benchmark (although mentioned) in the text of Benchmarks for Science Literacy (AAAS, 1993). Motion and Forces’ statement that objects ‘exhibit behavior’, which can be described as inertia is oversimplified, and misleading. It may have been more appropriate to exclude the use of the word inertia altogether.

The mass v. weight distinction was addressed ineffectively (and perhaps unnecessarily) as a footnote (SJ, p. 90). Most middle school students do not understand the distinction between these two ideas—weight is commonly associated with ideas of density and mass associated with size or volume (Driver, Guesne, & Tiberghien, 1985; Driver, Squires, Rushworth, & Wood-Robinson, 1994). The brief explanation given in the Student Journal in the absence of well-designed instruction may do more harm than good. The section “Gravity and your Weight on Earth” in the introductory material in the Teacher Manual does explain the difference between mass and weight, but in a cursory manner that is inadequate to deal with student misconceptions. It may have been more helpful to reserve the discussion (for teachers and students) for a different unit when this topic could be explored more thoroughly.
Instructional Analysis

The Instructional Analysis Team

The process was led by Dr. Curtis Pyke and facilitated by Dr. Sharon Lynch, professors of secondary education at George Washington University. For a list of those individuals who participated in the Motion and Forces Instructional Analysis, see Appendix A. The Project 2061 Instructional Analysis Criteria can be found in Appendix B. The complete ratings for the Motion and Forces Instructional Analysis can also be found at the end of the report, in Appendix D. The Instructional Analysis report is divided into seven sections or categories, each with a set of criteria. For each criterion there is a table showing Motion and Forces’ rating, the associated Project 2061 indicators and rating schemes, and the evaluation team’s written justification for the rating.

Instructional Analysis Team Report

The next section of this report was primarily the work of the evaluation team (see Appendix A), although the research staff edited and formatted its work for this report.

Category I. Providing a Sense of Purpose.

Criterion A. Conveying unit purpose. Does the material convey an overall sense of purpose and direction that is understandable and motivating to students?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A problem, question, representation (or otherwise identified purpose) is presented to students.</td>
<td>☐=All agree, ○=1/2 agree</td>
<td>●</td>
</tr>
<tr>
<td>2. The problem, question, representation (or otherwise identified purpose) is likely to be comprehensible to students.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>3. The problem, question, representation (or otherwise identified purpose) is likely to be interesting and/or motivating to students.</td>
<td>●</td>
<td></td>
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<tr>
<td>4. Students are given an opportunity to think about and discuss the problem, question, representation (or otherwise identified purpose).</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>5. Most lessons are consistent with the stated purpose and those that are not are explicitly labeled as digressions.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>6. The material returns to the stated purpose at the end of the unit.</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme

Excellent: The material meets indicators 1–6.
Satisfactory: The material meets indicators 1–3 and 5.
Poor: The material meets indicator 1 at best.

Rating=Poor

The unit received a poor rating because the first indicator was not met, and according to the Project 2061 scoring scheme, this was crucial. Although the first two Explorations (SJ, p.1-9) (which represent an initial “discuss” phase of a learning cycle) address the two main concepts that are central to the unit (motion and force), the connection between these Explorations and a large vision of the study of the interaction between force and
motion is not explicitly made for the students. Although it is discussed in the Module
Introduction of the Teacher Manual (p. xvii), we view this as insufficient justification to
say that the material has met the criterion for overall unit purpose.
There is a series of questions that should be addressed by these activities: “What causes
motion? Are different motions somehow related to each other? Can we use a model to
predict motion?” (TM, p. x). However, there is no indication that the teacher is instructed
to discuss these questions with the students. The initial instructions to either teacher or
student (TM, p. 1; SJ, p. 1) do not show that the students are presented with these
questions. Therefore, it is unclear that students would be sure about what they are doing
and why they are doing it, throughout the unit.

On the other hand, students are given the opportunity to think about and discuss the key
ideas. There is a strong correlation between the questions in the “Recording Ideas and
Discussion” sections in each Exploration (SJ, p. 5) “Is it possible for the ball to start
moving by itself?” with the stated goals in the (TM, p. x) “What causes motion?”
Students are asked to think about and discuss the questions. On page 4 of the Teacher
Manual, teachers are prompted to “Ask volunteers to read aloud what they wrote under
the heading ‘What I know about the motion of objects.” This provides obvious
opportunities for students to express their ideas about force and motion.

The lessons are consistent with the questions presented in the Teacher Manual (p. x) even
though these questions were not presented to students.

While the materials return briefly to the stated purpose at the end of the unit (TM, p. 129)
the reviewers felt that the final activities using the fan cart (SJ, p. 103-113) are not
explicitly integrative, nor is there any guidance to the teacher as to how to pull the
threads of the concepts together into a coherent framework. Students will not know if
they achieve the purpose of the unit, and one could continue to do additional activities
with no apparent contradiction.

**Criterion B. Conveying lesson/activity purpose. Does the material convey the purpose of
each lesson and its relationship to others?**

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree, ◇=1/2 agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material conveys or prompts teachers to convey the purpose of the activity to students.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The purpose is expressed in a way that is likely to be comprehensible to students.</td>
<td>◇</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The material encourages each student to think about the purpose of the activity.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The material conveys or prompts teachers to convey to students how the activity relates to the unit purpose.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The material engages students in thinking about what they have learned so far and what they need to learn/do next at appropriate points.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets all indicators.
Satisfactory: The material meets any three out of the five indicators.
Poor: The material meets no more than one out of the five indicators.

Rating=Satisfactory
Overall, the materials do a satisfactory job of conveying a sense of purpose for each lesson. However, the interconnection of each lesson or set of lessons (referred to as a “unit” by the materials) to the key ideas cannot be met because the students were never informed of the overall purpose of the curriculum.

In the “Recording Ideas and Discussion” section of the Science Journal for each Exploration, the students are prompted to answer a question, which has the Exploration purpose embedded. They are prompted to make a prediction that relates to the activity or to think about how to test a prediction. For example, “Prediction: The higher up along the inclined track a marble starts, the faster it will roll along the incline. How could you test this prediction?” (SJ, p. 53).

Throughout the Science Journal, the sentences are clear and appear to be written using language appropriate to grade level. The questions sometimes invoke experiences children likely have had, such as “Imagine a child sitting at the top of a slide. Then the child starts to go down the slide. Why do you think the child keeps moving?” (SJ, p. 35). These questions effectively lead students to phenomena that are then explored in the lesson.

Students are engaged before an Exploration by prompting them to ask their own questions about the ideas, but there is no explicit connection with prior lessons, with rare exceptions (such as in SJ, p. 92). The students are prompted to think about what they have learned so far at the end of each Exploration, but these questions do not lead to subsequent Explorations. A good example of this is question 5 (SJ, p. 91) “If the string came untied, do you think the cart would keep moving?” The question does not lead to an experiment (the string is never cut), and the question “What if the cart were more massive?” is never posed – even though that is the subject of a subsequent investigation.

Criterion C. Justifying lesson/activity sequence. Justifying activity sequence. Does the material involve students in a logical or strategic sequence of activities (versus just a collection of activities)?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material includes a logical or strategic sequence of activities.</td>
<td>●=All agree</td>
<td>Met</td>
<td>Not Met</td>
</tr>
<tr>
<td>2. The material conveys the rationale for this sequence.</td>
<td>●=All agree</td>
<td>Met</td>
<td>Not Met</td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets both indicators.
Satisfactory: The material meets the first indicator.
Poor: The reviewer can infer a logical rationale for the sequence of only a few activities.

Rating=Satisfactory

A set of learning objectives is presented to provide a strategic sequence (TM, p. xviii–xxiii). Unit 1 involves student Explorations on basic observation and descriptions of motion, and progresses to how to start and stop motion. Unit 2 has students building a device to investigate the role of friction and make observations about motion in the
absence of friction. Unit 3 allows students to investigate motion on an inclined plane. Students look specifically at relationships between starting height, distance, average speed, constant speed, and changing speed. Unit 4 explores how forces affect motion, and the effect of mass on the amount of change in speed for a given force.

Explorations within each unit are often linked to one another. In Unit 2, Explorations are provided to first make exploratory devices (Super Sliding Disc and Launcher). Later lessons are then based on observations of how these devices work, before using these devices to explore key ideas.

The final Exploration in Unit 4 (How Fast Can the Fan Cart Move?) culminates the unit by having the students design an experiment to determine whether a fan cart is accelerating or moving at a constant speed. While the Exploration does this adequately, there is no culminating Exploration for all the key ideas from all the units. The learner appears to be left hanging as to where to go next.

While there is often a logical thread within the units, a rationale is not conveyed to either the teacher or the students. The units comprise several lessons around a phenomenon or device, but stand independently from each other and are not linked to other units (such as Unit 3: Rolling Motion on an Inclined Plane). Therefore, the teacher is unaware of which ideas from one unit are needed in order to build on those ideas in the next unit.

Category II. Taking into Account Student Ideas.

Criterion A. Attending to prerequisite knowledge and skills. Does the material specify prerequisite knowledge/skills that are necessary to the learning of the benchmark(s)?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material alerts the teacher to specific prerequisite ideas or skills (versus stating only prerequisite topics or terms).</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The material alerts teachers to the specific ideas for which the prerequisites are needed.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The material alerts students to prerequisite ideas or experiences that are being assumed.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The material adequately addresses (provides instructional support for) prerequisites in the same unit or in earlier units (in the same or other grades). (The material should not be held accountable for addressing prerequisites from an earlier grade range. However, if a material does address such prerequisites they should count as evidence for this indicator.)</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The material makes adequate connections (provides instructional support for connections) between ideas treated in a particular unit and their prerequisites (even if the prerequisites are addressed elsewhere).</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets indicators 1, 2, 3 or 4, and 5 for all or most prerequisites.
Satisfactory: The material meets indicators 1, 2, 5, and either 3 or 4 for some prerequisites.
Fair: The material meets indicators 5 and either 3 or 4 for some prerequisites.
Poor: The material meets no more than one indicator.

Rating=Poor
Overall, these materials do a poor job in taking into account student ideas, despite the emphasis on questions to students about their ideas in the Exploration portion of each lesson. The questions do not appear to be guided by cognitive research in physics (see McDermott & Redish, 1999 or Driver, et al., 1994), nor do they adequately address prerequisite knowledge for the students.

The materials provide the teacher with few examples of known student conceptual difficulties. The section “Gravity and your Weight on Earth” in the introductory material in the Teacher Manual does explain the difference between mass and weight, but in a cursory manner that is inadequate to deal with the common misconception. There is no discussion of the commonly held belief that an applied force is required to keep an object in motion. Nor is there any discussion of the nature of novice problem solvers in physics, even though extensive research has been done on novice-expert differences in physics. In general, the Teacher Manual does little to prompt the teacher to be aware of known student difficulties or provide instructional support for dealing with student difficulties.

Prerequisite knowledge, such as “what is speed?” is never directly addressed for students, even though it is used throughout the material. The difference between mass and weight is treated as a prerequisite for the students. However the information on page 90 of the Science Journal in the “Force Fields” footnote is inadequate, and it is presented in the same format as enrichment in earlier lessons, thus minimizing the chance that a student will seriously review the information. The materials treat the distinction between mass and weight as prerequisite, but handle it poorly. It is not clear that the lesson needs to deal with this issue. The notion of acceleration is not developed and explicitly connected to changing speed (SJ, p. 78) even though in subsequent lessons, it is used explicitly (SJ, p. 113).

Criteria B. Alerting teacher to commonly held student ideas. Does the material alert teachers to commonly held student ideas (both troublesome and helpful) such as those described in Benchmarks Chapter 15: The Research Base?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material accurately presents specific commonly held ideas that are relevant to the key ideas and have appeared in scholarly publications (rather than just stating that students have difficulties with particular ideas or topics).</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The material clarifies/explains commonly held ideas (rather than just listing them).</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme

Excellent: The material meets indicators 1 and 2 for a considerable proportion of commonly held ideas that have appeared in scholarly publications.

Satisfactory: The material meets indicators 1 and 2 for some commonly held ideas that have appeared in scholarly publications.

Poor: The material meets indicator 1 at best.

Rating=Poor

The material seldom mentions students’ commonly held ideas about force and motion, nor does it discuss how these ideas could possibly be expressed in the classroom with the particular activities in the Explorations.
There are several instances where the material attempts to address student misconceptions. However, aside from a few, they are rarely related directly to the larger issues of force and motion. For example, the Teacher Manual states: “students may think the air escaping acts as a jet… propelling the disk” (TM p. 37). “Instead of the more massive objects accelerating more slowly as we might expect, they undergo the same acceleration” (TM, p. xvi, Gravity and Freely Falling Bodies Section). When discussing the time vs. starting height graph: “Students may incorrectly associate taller columns with greater speeds” (Teacher Manual, p. 73, Q1). “Students may also point out that the sun appears to rise and set, but it is we who are seeing it from a turning earth.” (TM, p. 2, Q6).

While many of these misconceptions are correctly identified, the misconception about freely falling bodies and acceleration is not correct. Students, and many adults, typically think that more massive objects are pulled by gravity at a faster rate (not more slowly) and therefore have greater acceleration than less massive objects.

On the other hand, the basic notion that researchers refer to as “Aristotelian” (force is proportional to velocity, etc.) is not discussed. There is an extension, which suggests that students change the mass of the rolling ball (Teacher Manual, p. 88, third bullet). The balls provided in the kit are plastic and steel. The steel ball indeed rolls faster, due to a lower coefficient of friction. This extension could inadvertently reinforce naïve notions about heavy objects falling faster, rather than illuminating how friction is independent of the mass and the heavy ball rolls faster because the coefficient of friction is smaller for a steel ball than for the plastic ball, thus the steel ball rolls farther. A discussion of these issues is not included in the Teacher Manual.

In conclusion, the material does not identify the main conceptual difficulties associated with motion and force identified by research; therefore, it cannot explain or clarify them.
Criterion C. Assisting teacher in identifying own students’ ideas. Does the material include suggestions for teachers to find out what their students think about familiar phenomena related to a benchmark before the scientific ideas are introduced?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material includes specific questions or tasks that could be used by teachers to identify students' ideas.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The questions/tasks are likely to be comprehensible to students who have not studied the topic and are not familiar with the scientific vocabulary.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The questions/tasks are identified as serving the purpose of identifying students' ideas.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>4. The material includes questions/tasks that ask students to make predictions and/or give explanations of phenomena (rather than focus primarily on identifying students' meanings for terms).</td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>5. The material suggests how teachers can probe beneath students' initial responses to questions or interpret student responses (e.g., by providing annotated samples of student work).</td>
<td></td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material provides a sufficient number and variety of questions/tasks that meet indicators 1 and 2 and meet indicators 3–5.
Satisfactory: The material provides some questions/tasks that meet indicators 1–4.
Poor: The material provides some questions/tasks that meet indicator 1 or indicators 1 and 2.

Rating=Satisfactory

Systematically, all Explorations ask the students to reflect on prior knowledge and ask questions (Recording Ideas and Discussion Section) or provide an opportunity to give explanations of their observations (Interpreting Results and Discussion Sections). The questions are often related to students’ life experiences (SJ, p 35, Q1-2). The questions at the beginning of a lesson often ask the students about the evidence needed to support a point of view (SJ, p. 53, p. 62, p. 79.) In general, the authors avoided the use of complex scientific vocabulary.

The Teacher Manual clearly indicates that the opening questions are designed to elicit student ideas (for example, TM, p. vii). Opening questions encourage students to put their prior ideas into words. After the students are given the opportunity to build these foundations, teachers are instructed to, “Accept all answers as ideas that students may re-examine as they do the following Explorations” (TM, p. 8).

Each lesson requires students to write their own questions and explanations for their data (for example SJ, p. 30, p. 35, p. 44). Students are asked to develop ideas for testing predictions with evidence (for example SJ, p. 53).

While the Teacher Manual provides additional follow-up questions and enrichment activities, such as “Extend the class discussion with the following questions,” (TM, p. 64) these questions and activities are never used to assess student understanding. There is no attempt to probe beyond initial responses, nor guidance to the teacher for posing questions that probe for the persistence of misconceptions or attainment of the key ideas.
Criterion D. Addressing commonly held ideas. Does the material attempt to address commonly held student ideas?

Indicators of meeting the criterion: ●=All agree, ◯=1/4 agree  Met  Not Met

1. The material explicitly addresses commonly held ideas.
   ●

2. The material includes questions, tasks, or activities that are likely to help students progress from their initial ideas, for example, by
   a. explicitly challenging students’ ideas, for example, by comparing their predictions about a phenomenon to what actually happens
   b. prompting students to contrast commonly held ideas with the scientifically correct ideas, and resolve differences between them
   c. extending correct commonly held ideas that have limited scope.
   ●

3. The material includes suggestions to teachers about how to take into account their own students’ ideas.
   ◯

Rating Scheme
If there is research on commonly held student ideas:
Excellent: The material meets indicators 1 and 2 for a considerable proportion of commonly held ideas that are documented in the literature.
Satisfactory: The material meets indicators 1 and 2 for some commonly held ideas that are documented in the literature.
Poor: The material meets the first indicator at best.

Rating=Poor

The material does not directly address many basic misconceptions identified by research, such as the belief that a force is required to keep an object in motion at a constant speed, though it does discuss the common confusion of weight and mass. However, there are activities in the unit that actually could serve to reinforce misconceptions, such as the confusion between mass and weight in Exploration 15 and the extension involving a heavier ball in Exploration 12. The materials provide a steel ball that has a lower coefficient of friction than the lighter plastic ball. Therefore, the steel ball rolls faster down the ramp and further along the horizontal track. Students will interpret this as evidence that heavier objects fall faster, another well-known misconception.

The structure of the unit asks students to examine their predictions by making direct observations or measurements. These predictions and related discussions, while of limited scope, can help students progress toward understanding these common notions, such as the questions (SJ, p. 35) asking students to consider their own experience with sliding down a slide, which, in turn, leads into the Exploration’s activity of rolling the ball down the ramp.

The Teacher Manual continually instructs the teacher to accept all answers during the Recording Ideas and Discussion (for example, Teacher Manual, p 50) of an Exploration. It does not, however, provide guidance for reconciling students’ original ideas with the results of the Exploration. Thus, one does not find explicit reevaluation of student ideas, nor any discussion of the need for students’ predictions to be directly confronted by experiences, as discussed in research literature on conceptual change.
III. Engaging Students with Relevant Phenomena

Criterion A. Providing variety of phenomena. Does the material provide multiple and varied phenomena to support the benchmark idea(s)?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Phenomena are useful in making the key ideas real.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Phenomena are explicitly linked to the relevant key ideas.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material provides a sufficient number and variety of phenomena that meet indicators 1 and 2.
Satisfactory: The material provides some phenomena that meet indicators 1 and 2.
Poor: The material provides, at best, one phenomenon that meets indicators 1 and 2.

If the benchmark for which the material is analyzed includes several ideas, the reviewers should proceed as follows:
a. Identify the ideas for which there is a content match.
b. Score the treatment of each idea that results from step a. The overall score for this criterion will be the average of the scores for each idea.

Rating=Excellent

The materials overall provide an excellent variety of phenomena that are relevant to the key ideas being conveyed by the materials of instruction. These serve to make the key ideas real and accessible through direct experience. Instruction centers on hands-on experiences with equipment constructed from everyday materials. Connections with life experience are made in the introductory questions of each Exploration (for example, SJ, p. 30 hockey pucks; p. 35 child going down slide, p. 79 four wheeled vehicles). In addition, the unit is filled with nuggets of information relating the key ideas of this unit with life experiences. Phenomena include personal life experiences, cultural and news items in the “Force Fields” section (SJ, p. 53, p. 30, p. 21).

The phenomena are also tightly linked with the target ideas. The target ideas center around changes in speed being caused by forces, that if no forces act on the object the speed remains constant, and that the change in speed produced by a force depends on the mass of the object with more massive objects having a smaller change in speed for a given force. One example of the linkage between target ideas and lessons is Exploration 2 (SJ, p. 5-9), which links to target idea 1. Teachers are expected to help students understand that “a push or pull is required to start the motion” (TM, p. 8) which conveys the benchmark to the students. Exploration 16 (SJ, p. 98 – 102) links to target idea 3.
Criterion B. Providing vivid experiences. Does the material include activities that provide firsthand experiences with phenomena when practical or provide students with a vicarious sense of the phenomena when not practical?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree, ◐=1/2 agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Each firsthand experience is efficient (when compared to other firsthand experiences) and, if several firsthand experiences target the same idea, the set of firsthand experiences is efficient. (The efficiency of an experience equals the cost of the experience [in time and money] in relation to its value.)</td>
<td>◐</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The experiences that are not firsthand (e.g., text, pictures, video) provide students with a vicarious sense of the phenomena. (Please note that if the material provides only firsthand experiences, this indicator is not applicable.)</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>3. The set of firsthand and vicarious experiences is sufficient.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets all indicators or just indicators 1 and 3 or indicators 2 and 3, if firsthand experiences are not possible.
Satisfactory: The material includes some efficient firsthand experiences and, if several firsthand experiences target the same idea, the set of firsthand experiences is sufficient. When firsthand experiences are not practical, the material provides students with a vicarious sense of the phenomena for some of the experiences that are not firsthand.
Poor: The material includes at best only one efficient firsthand experience or provides students with a vicarious sense of one phenomenon that is not firsthand.

Reviewers should proceed as follows:
a. Identify the key ideas for which there is a content match.
b. Score the treatment of each idea that results from step a. The overall score for this criterion will be the average of the scores for each idea.

Rating=Excellent

Overall, the materials do an excellent job of providing a set of vivid, firsthand experiences, though there are a few concerns.

The cost of implementing this unit is reasonable because most of the equipment is constructed from everyday supplies (TM, p. 1, 15, 47, & 93). The students have the opportunity to understand the equipment because much of it is constructed during the lessons (SJ, Explorations 3 & 4, p. 10 – 20; Exploration 8 p. 35 – 43; & Exploration 13 p. 79 – 85). However, time could be an issue when class time is used for the students to construct equipment. It makes sense to construct the Sliding Disk, the Track and the Speedcart because they are used for many labs. It is not clear that the fan car is durable and it may be unreliable for extended student use. Therefore, there are some concerns about the cost-effective use of class time in these Explorations (17 & 18).

The experiences related to Target Ideas 1 and 4 are sufficient, but there are probably not a sufficient number of experiences to communicate Target Ideas 2 and 3. The relationships between applied forces, changes in motion, and mass of the objects require more experiences.
Category IV. Developing and Using Scientific Ideas

Criterion A. Introducing terms meaningfully. Does the material introduce technical terms only in conjunction with experience with the idea or process and only as needed to facilitate thinking and promote effective communication?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material links technical terms to relevant experiences that develop the idea as the term is used (rather than just having students learn definitions of terms).</td>
<td>◇</td>
<td>●</td>
</tr>
<tr>
<td>2. The material restricts the use of technical terms to those needed to communicate intelligibly about key ideas.</td>
<td>●</td>
<td>◇</td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets both indicators.
Satisfactory: The material fully meets one indicator and partially meets the other.
Poor: The material marginally meets both indicators at best.

Rating=Satisfactory

For the most part, technical terms were introduced using relevant material. For example, motion is defined through experience (SJ, p. 4), force is defined through experience (SJ, p. 5 – 14), and friction is defined through experience (SJ, p. 26-34). However, the connection between change in motion and acceleration is not introduced through experience. In fact, the connection is never overtly mentioned. The term inertia was unnecessarily introduced with a definition (TM, p. 41, Q4 - “Scientists call this behavior inertia.”) that could lead to furthering a misconception for both the teacher and the students. The prerequisite information about the difference between mass and weight was handled as a footnote in a “Force Field” Section (Student Manual, p90).

Overall the meaning of technical terms was established through experience. Most of the technical terms were appropriate and essential.
**Criterion B. Representing ideas effectively. Does the material include accurate and comprehensible representations of scientific ideas?**

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>◇=1/2 agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Representation is accurate (or, if not accurate, then students are asked to critique the representation).</td>
<td>◇</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Representation is likely to be comprehensible to students.</td>
<td>◇</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Representation is explicitly linked to the real thing.</td>
<td>◇</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rating Scheme**

Excellent: The material includes a sufficient number and variety of representations that meet indicators 1–3 and none of the representations included in the material are inaccurate. (In order to judge whether there is a sufficient number and variety of representations, reviewers should first consider which key ideas require representations and then decide whether these are adequately represented. However, reviewers are not expected to evaluate and rate each idea separately and average the scores.)

Satisfactory: The material includes some representations that meet indicators 1–3 and few (if any) of the representations included in the material are inaccurate. (In some cases, including one accurate and comprehensible representation for a specific idea may be sufficient for a material to receive a "satisfactory" rating. However, most of the key ideas must be adequately represented.)

Poor: Even though the material includes a few representations that meet indicators 1–3, few or none of the key ideas are adequately represented.

**Rating=Satisfactory**

This unit contains many analogies and metaphors for the key ideas. Some examples from the unit include sliding down a slide (SJ, p. 35), curling (SJ, p. 30), fan boats in the Everglades (SJ, p. 103), a soapbox derby (SJ, p. 53) earth’s motion around the sun (SJ, p. 79), and Mercury and Pluto orbiting the sun (SJ, p. 108). The content of the representations is, for the most part, accurate. The curling example is not directly related to the life experience of most students. The relationship of the fan boat in the everglades with speed car is apt, but the mention of sound pollution is unrelated to the key ideas. The example of orbital motion in a unit about linear motion introduces higher-level benchmarks with no explanation.

In most cases, the students will be able to relate the representation to the content of the lesson. The vocabulary is within their reach. In some cases, the students may not comprehend the relationship between the representation and the target ideas.

The students are asked to make graphical representations of their data for many Explorations (SJ, p. 60, 65, 77, 96, & 101). These graphical representations help the student to gain a visual perspective of their data. However, due to the consistent use of time on the vertical axis, the representation may get in the way of allowing the students to internalize the relationship of distance traveled per unit time and the speed of the object.
Criterion C. Demonstrating use of knowledge. Does the material demonstrate/model or include suggestions for teachers on how to demonstrate/model skills or the use of knowledge?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material consistently carries out (or instructs teachers to carry out) the expected performance (e.g., the student text explains a particular phenomenon using the kinetic molecular theory). (Teacher's guides often include responses to questions posed in the student text. If the material does not instruct the teacher to use the answers to model the use of knowledge, such responses do not count as instances of modeling.)</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The performance is step-by-step.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The performance is explicitly identified as a demonstration of the use of knowledge or skill.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The material provides running commentary that points to particular aspects of the demonstration and/or criteria for judging the quality of a performance.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
- Excellent: The material meets all 4 indicators.
- Satisfactory: The material meets indicators 1 and 2.
- Poor: The material meets indicator 1 at best.

Rating=Poor

While the Teacher Manual has guidance for the teacher in some places, in many Explorations the teacher is given no guidance about how to assist the students in developing their models of the target ideas. Each lesson is stand-alone. There are no connections drawn from one lesson to the next. Explorations 1 through 7 (and many others) provide no guidance to assist teachers in moving from one lesson to the next. Some Explorations (8 & 9) do provide some assistance for teachers in helping students make connections from one lesson to the next. There are also no transfer tasks for students to use their new knowledge in other situations.
**Criterion D. Providing practice. Does the material provide tasks/questions for students to practice skills or using knowledge in a variety of situations?**

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material provides a sufficient number of tasks in a variety of contexts, including everyday contexts. (In order to determine whether the task/question addresses the actual substance of the key idea, reviewers will need to consider both the question and the expected response in the teacher's guide.)</td>
<td>●=All agree</td>
<td>●</td>
</tr>
<tr>
<td>2. The material includes novel tasks.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>3. The material provides a sequence of questions or tasks in which the complexity is progressively increased.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>4. The material provides students first with opportunities for guided practice with feedback and then with practice in which the amount of support is gradually decreased.</td>
<td>●</td>
<td></td>
</tr>
</tbody>
</table>

**Rating Scheme**

Excellent: The material meets indicators 1, 2, and either 3 or 4.
Satisfactory: The material provides some tasks/questions, including novel tasks.
Poor: The material provides at best some tasks/questions, but no novel tasks.

Reviewers should proceed as follows:

a. Identify the key ideas for which there is a content match.
b. Score the treatment of each idea that results from step a. The overall score for this criterion will be the average of the scores for each idea.

**Rating=Poor**

There is no evidence that the materials provide tasks/questions for students to practice or use their knowledge in any situation. Preliminary questions include everyday contexts, but the teacher is instructed to accept all answers. The interpretation questions are only about the systems that are used for experimentation and the Teacher Manual has only sketchy information about expected responses. Only early lessons bring in real world examples. Once the experimentation gets to the track Explorations (Student Manual, p35, Exploration 8), the focus of instruction narrows to only include questions about the system associated with that specific Exploration.

These activities do not provide any practice for students to use what they have learned.
Category V. Promoting Student Thinking about Phenomena, Experiences, and Knowledge

Criterion A. Encouraging students to explain their ideas. Does the material routinely include suggestions for having each student express, clarify, justify, and represent his/her ideas? Are suggestions made for when and how students will get feedback from peers and the teacher?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Material routinely encourages students to express their ideas.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Material encourages students not only to express but also to clarify, justify, and represent their ideas each time they are asked to express their ideas; however, in the course of teaching a particular key idea the material should provide students with opportunities to clarify, justify, and represent ideas.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Material provides opportunities for each student (rather than just some students) to express ideas.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Material includes specific suggestions on how to help the teacher provide explicit feedback to students or includes text that directly provides students with feedback.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Material includes suggestions on how to diagnose student errors, explanations about how these errors may be corrected, and recommendations for how students' ideas may be further developed.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme

Excellent: Material meets all indicators.
Satisfactory: Material meets 3 out of 5 indicators.
Poor: Material meets no more than 1 out of 5 indicators.

Rating=Satisfactory

Throughout the entire Science Journal the material routinely encourages students to express their ideas. Students are asked to answer questions or prompts in “Recording Your Ideas” (e.g., Student Manual, p10, “So why do you think so?”) “Exploration Procedures” (e.g., Student manual, p41, “What do you predict would happen if you placed a marble halfway up the inclined track?”) and “Interpreting the Results” (e.g., Student Manual, p34, “Why do you think the Air Disk eventually stopped moving?”)

The students are routinely asked to clarify, justify and, represent their ideas in every Exploration. For example in Exploration 3, students are posed the question, “Is the distance the objects moves affected by how hard you initially push it? If so, in what way is it affected?” (SJ, p. 10). Students are given opportunities not only to answer questions but to ask questions as well. The Teacher Manual also directs the teachers to hold a period of discussion in order to allow the students to share their responses.

The expectation is that children will complete their own workbook. The Teacher Manual does not provide explicit instructions for the teacher to elicit responses from each student during class discussions. Therefore, students are given the opportunity to respond in writing, although many students may not be able to express their ideas in other formats, such as drawings or presenting their own ideas to the class.
At best, the Teacher Manual provides factual answers (e.g., TM, p. 79). On rare occasions, there is mention of possible student misunderstanding (TM, p. 73), but there are no connections with past material and no indications of bridging to the next activity. There is an underlying assumption that the teachers know the answers, especially in the earlier units. Later in the manual, the answers are given, but often without clarifying explanations or information.

There is no evidence in the Teacher Manual about how to correct student errors. There are often enrichment sections, but there is no instruction about how to use them to further students’ ideas about the key ideas.

**Criterion B. Guiding student interpretation and reasoning. Does the material include tasks and/or question sequences to guide student interpretation and reasoning about experiences with phenomena and readings?**

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material includes specific and relevant tasks and/or questions for the experience or reading.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The questions or tasks have helpful characteristics such as</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. framing important issues</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. helping students to relate their experiences with phenomena or representations to presented scientific ideas</td>
<td></td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>c. helping students to make connections between their own ideas and the phenomena or representations observed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. helping students to make connections between their own ideas and the presented scientific ideas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. anticipating common student misconceptions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. focusing on contrasts between student misconceptions and scientific alternatives. Please note that while a single high quality task or question sequence might have only one of these characteristics, the set of sightings should exhibit several of them.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. There are scaffolded sequences of questions or tasks (as opposed to separate questions or tasks).</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rating Scheme**

Excellent: Material consistently meets all three indicators.

Satisfactory: Material consistently meets indicators 1 and 2.

Poor: Material meets indicator 1 at best.

**Rating=Poor**

The Science Journal is formatted in a series of specific questions guiding the student towards understanding the target ideas. Every Exploration includes preliminary questions in the “Recording Ideas and Discussion” sections, as well as the “Interpreting Results and Discussion” follow-up questions. The activities are also linked with the target ideas as Exploration 2 links to target idea 4 and Exploration 7 links to target idea 4. Answers in the Teacher Manual instruct teachers to convey the idea to students that “a push or pull is required to start the motion.” Explorations 2 and 4 also link to target idea 1 and Exploration 16 links to target idea 3. Exploration 15 links to target idea 2, however, there was a concern that the use of the phrase “The greater the magnitude of a push or pull the faster the object will move” (TM, p. 105) could lead to confusion of
ideas regarding speed and acceleration. It may have been more appropriate to simply state “the greater the change in motion” rather than using the word “faster.”

The questions do a good job of framing important issues. There is an attempt to relate the phenomena to experiences, but there is little or no formal attempt to help the students make connections between their own ideas and the phenomena, or with important scientific ideas. The students are not guided to make connections either with their previous experience or with the direction the next activity takes them.

The questions within each Exploration are posed in a sequence designed to assist the students in a particular direction (SJ, p62, Q1-4). The questions seem carefully chosen and written in a manner that does not give away the expected answer. However, students are seldom required to return to ideas or questions from a previous Exploration and therefore, the Explorations seem to stand alone as distinct classroom exercises. The Explorations do follow a logical thread that is easy to discern by an experienced teacher, although the connections may not be completely clear to a novice.

Criterion C. Encouraging students to think about what they’ve learned. Does the material suggest ways to have students check their own progress?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material gives students an opportunity to revise their initial ideas based on what they have learned (without asking them explicitly to think about how their ideas have changed).</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The material engages (or provides specific suggestions for teachers to engage) students in monitoring how their ideas have changed, but does so infrequently in the unit.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The material engages (or provides specific suggestions for teachers to engage) students in monitoring how their ideas have changed and does so periodically in the unit.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets indicator 3.
Satisfactory: The material meets indicator 2.
Poor: The material meets indicator 1 at best.

Rating=Poor

The materials do a poor job of encouraging students to think about what they’ve learned, despite meeting the first of the three indicators.

Students are provided opportunities to revise their initial thinking, but not in an explicit way that directs them to consider how their ideas have changed. For example, on page 78 of the SJ, students are asked, “What do I know about how the speed of an object changes as it rolls down an incline?” This is an opportunity for students to reconsider and compare responses at the beginning of the lesson to similar questions on page 67.

However, the lessons are basically stand-alone with no prompting for the student to find the connections with previous activities. There is no opportunity to rethink previous answers based on the results of the current activity. There is no prompting for the teacher or the students to monitor or reflect upon how their ideas have changed over time.
Category VI. Assessing Progress

Criterion A. Aligning assessment to goals. Assuming a content match between the curriculum material and this benchmark, are assessment items included that match the same benchmark?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The specific ideas in the key ideas are necessary in order to respond to the assessment items.</td>
<td>☐</td>
<td>●</td>
</tr>
<tr>
<td>2. The specific ideas in the key ideas are sufficient to respond to the assessment items (or, if other ideas are needed, they are not more sophisticated than key ideas and have been taught earlier).</td>
<td>●</td>
<td>☐</td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material provides a sufficient number [9] of assessment items that meet indicators 1 and 2.
Satisfactory: The material provides some assessment items that meet indicators 1 and 2.
Poor: The material provides no more than one/a few assessment items that meet indicators 1 and 2.

Rating=Poor

Overall, these materials do a poor job of aligning the assessment to the goals, even though the materials meet (in a legalistic sense) the two indicators.

Several assessment tools are provided to the teacher at the end of the Teacher Manual. These include a rubric for evaluating student journals, an observation rubric for student participation, and an end of unit assessment (where “unit” here refers to the entire curriculum package), which is the only explicit assessment of content knowledge for the teacher. The questions in the end of unit assessment are simple, and it can be argued that knowledge of the key concepts is not needed in all cases to receive the points on the rubric provided in the teachers manual. While several questions can be answered in accordance with the rubric with little knowledge of the target ideas, there are no questions that require more knowledge than the target ideas. In general, the consensus is that the end of unit assessment does require knowledge of the target ideas, but does not exceed it. Thus both of the indicators are met.

However, the materials still receive a poor rating because of the paucity of assessment opportunities provided. Some of the target ideas have only one assessment item. This is not a sufficient number of assessment items per target idea. There is only one explicit content assessment, the end of unit assessment. For these reasons the materials receive a poor rating.
Criterion B. Testing for understanding. Does the material include assessment tasks that require application of ideas and avoid allowing students a trivial way out, like using a formula or repeating a memorized term without understanding?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>● = All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Assessment items focus on understanding of key ideas.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Assessment items include both familiar and novel tasks.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material provides a sufficient number of assessment items that meet indicators 1 and 2.
Satisfactory: The material provides some assessment items that meet indicators 1 and 2 or sufficient assessment items that meet indicator 1.
Poor: The material provides no more than one/a few assessment items that meet indicator 1.

Rating = Poor

Overall, these materials do a poor job of testing for understanding.

The end of unit assessment (where “unit” here refers to the entire curriculum package) does directly relate to target ideas, and it is the only explicit assessment of content knowledge for the teacher. The end of unit assessment does contain both familiar and one novel task (the bicycles rolling down the hill).

However, the materials still receive a poor rating because of the paucity of assessment, with few assessment items per key idea. Also, some of the assessment items are trivial, and the teacher answer key does not require significant explanation of thinking in order to rate a student as having met the standard.

Criterion C. Using assessment to inform instruction. Are some assessments embedded in the curriculum along the way, with advice to teachers as to how they might use the results to choose or modify activities?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>● = All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material uses embedded assessment as a routine strategy (rather than just including occasional questions).</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The material assists teachers in interpreting student responses to diagnose what learning difficulties remain.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The material provides specific suggestions to teachers about how to use the information from the embedded assessments to make instructional decisions about what ideas need to be addressed by further activities.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets all indicators.
Satisfactory: The material meets indicators 1 and 2 or indicators 1 and 3.
Poor: The material meets indicator 1 at best.

Rating = Poor

The Teacher Manual includes a rubric for evaluating student journals, implying that teachers are to do so, presumably on a regular basis. However, there is no guidance as to
how to use this information. Other assessments, such as applications of knowledge to transfer tasks, are not distributed throughout the material, resulting in a lack of explicit embedded assessment to gauge student understanding. Thus, teachers do not have a clear idea of student difficulties with target ideas, particularly those that will be required for subsequent investigations. In fact, the bulk of the lessons constitute incomplete learning cycles, in that there is no application phase, or explicit embedded assessment at the end of a set of lessons (or “unit” in the parlance of the materials). For these reasons, the materials receive a poor rating.

**Category VII. Enhancing the Science Learning Environment**

**Criterion A. Providing teacher content support. Would the material help teachers improve their understanding of science, mathematics, and technology necessary for teaching the material?**

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>●=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material provides content information for teachers that is relevant to the learning goals they are teaching.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The material alerts teachers to how ideas have been simplified for student and what the more sophisticated versions are (even though students are not expected to understand the more sophisticated ideas).</td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>3. The material provides sufficiently detailed answers to questions in the student book for teachers to understand and interpret typical student responses.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The material makes suggestions for how to use recommended resources for improving teachers understanding of the learning goals.</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rating Scheme**

- Excellent: The material meets all indicators.
- Satisfactory: The material meets indicator 2 out of the 4 indicators.
- Poor: The material meets indicator 1 at best.

**Rating=Poor**

The module introduction has historical and factual background information (TM, p. x-xvii) for force and motion. Simplified descriptions of Newton’s models of motion are provided along with explanations of friction forces, “gravity and your weight on earth” and “gravity and freely falling objects.” In addition, each unit in the Teacher Manual begins with content background that is explicitly related to the target ideas to be addressed in that unit. This part of the teacher content support is reasonably good.

The material does provide more sophisticated explanations for models of forces and motion for the teachers. However, while the students are not expected to understand at that level of sophistication, there is no explanation of how the material has been simplified for the student.

There is no systematic presentation of expected student answers and the significance of the misconceptions for incorrect answers. There are however, a few instances (particularly in the beginning of the unit) of possible student answers. On page 8 of the Teacher Manual there are examples of how students may respond to question 1. After
this first Exploration, however, the Teacher Manual merely instructs the teachers to either ask volunteers to read aloud what they wrote or to “accept all answers as ideas that students may re-examine as they do the following Explorations.”

While directions are given for outside resources (books, journal articles, web sites, etc...), some of the resources are of a nature that make them too difficult or obscure for most middle school teachers. These include a 1961 article from the journal Science, a 1957 book written on Galileo, and Newton’s The Principia, Volume I (at least an English translation, rather than the original Latin version, is recommended). Furthermore, there is no guidance about how to use the suggested resources as they relate to the content of force and motion or the curriculum materials.

**Criterion B. Encouraging curiosity and questioning. Does the material help teachers to create a classroom environment that welcomes student curiosity, rewards creativity, encourages a spirit of healthy questioning, and avoids dogmatism?**

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>→=All agree</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material provides opportunities for students to express their curiosity and creativity.</td>
<td>→</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The material provides occasion for students to ask questions and guides their search for answers.</td>
<td>→</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The material provides opportunities to respect and value students’ ideas (e.g. by suggesting how each student’s ideas can be heard and considered and held up to evidence).</td>
<td>→</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The material sends the message that science is more than rules or facts to be learned and that problems may have more than one solution.</td>
<td>→</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The material provides examples of classroom interactions—e.g. dialogue boxes, vignettes, or video clips—that illustrate appropriate ways to respond to student questions or ideas, etc.</td>
<td>→</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rating Scheme**

- Excellent: The material meets all indicators.
- Satisfactory: The material meets indicator 3 out of the 5 indicators.
- Poor: The material meets indicator 1 at best.

**Rating=Satisfactory**

The students are asked in each Exploration (Recording idea and discussion section) to write their own question (e.g., My question about motion is...) about the key ideas as one way to express their curiosity about force and motion. There are also many opportunities for students to devise their own trials and create their own graphs of the data collected (SJ, p. 5, 13, 26, 76, & 84). Overall, the unit does a good job of providing students opportunities to ask questions about the key ideas and the activities both in their student journals and in classroom discussion.

In addition, teachers are often instructed to “accept all answers” from the Recording Ideas and Discussion and also to have students share their “What I know about...” responses after the interpretation and discussion of results. This provides ample opportunities for students’ ideas to be shared, respected and valued. Overall, by allowing for these levels of curiosity and creativity, the reviewers felt the unit did not send the
message that science was just ‘rules and facts’ and that often there was more than one correct answer. In the cases were there was a correct answer, it was often possible for students to arrive at the correct answer in more than one way.

Criterion C. Supporting all students. Does the material help teachers to create a classroom community that encourages high expectations for all students, that enables all students to experience success, and that provides all students a feeling of belonging in the science classroom?

<table>
<thead>
<tr>
<th>Indicators of meeting the criterion:</th>
<th>Met</th>
<th>Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material avoids stereotypes or language that might be offensive to a particular group.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>2. The material illustrates the contribution or participation of under-represented groups to science-related fields.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>3. The material suggests alternative formats for students to express or develop their ideas during instruction and assessment.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>4. The material includes specific suggestions about modifying activities for students with special needs, interests, or abilities.</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>5. The material provides strategies to validate students’ personal and social experiences as being relevant to mathematical or scientific ideas.</td>
<td>●</td>
<td></td>
</tr>
</tbody>
</table>

Rating Scheme
Excellent: The material meets all indicators.
Satisfactory: The material meets indicator 3 out of the 5 indicators.
Poor: The material meets indicator 1 at best.

Rating=Satisfactory/Poor (Minority View)

The material clearly avoids stereotypes or language that might be offensive to a particular group. The material personalizes all questions by asking students for their thoughts, or made the students the star of the situation posed.

The only references to the contribution of scientists are references to Newton and Galileo (TM, p. x–xvii). No attempt was made to include contributions by under-represented groups in related contexts.

This unit allows for the kinesthetic learners (hands–on), it allows for the visual learner (watching the ball roll down the ramp), it allows for the auditory learner (encouragement of group discussion of the experiences). The students are expected to write their concluding thoughts about each activity. The Teacher Manual (p. 132, ARIES Science Journal Rubric) includes a rubric for assessing the students’ work to provide intermediate feedback.

These units will be very difficult for students with written expression learning disabilities or students with limited English Language proficiency. There is reference to sketches/drawings in the rubric, but the journal has lines that imply written responses. There is no direct instruction to make sketches. The students are often directed to read their response to the class. This can cause serious difficulties for students with low reading proficiency.
Although there is token questioning from real life in the early lessons, but there was no follow through in later lessons. In some lessons, the students are given roles that set up a social structure in the class (SJ, p. 47, Starters, Recorders Track Managers, & Track Inspector; p. 94, Cart Commander, Mass Master, & Timer Recorder). The official job titles help establish a positive social structure in the classroom.

Minority View from one member of the evaluation team: In many ways this curriculum unit provides support for a wide variety of students using a rich experiential approach. However, the lack of support for the teacher in addressing the special needs for a diverse student population, causes this review to only accept Indicators 1 & 3 as met well. These ratings do not allow for the “satisfactory” rating granted by my fellow reviewers. My evaluation of this criterion is a rating of Poor.
References


Appendix A.

List of Evaluation Team Participants for Instructional Analysis

(May 14th - 17th, 2003).

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Appendix B

AAAS Project 2061 Instructional Analysis.

Category I. Providing a Sense of Purpose
Criterion A. Conveying unit purpose. Does the material convey an overall sense of purpose and direction that is understandable and motivating to students?
Indicators of meeting the criterion
1. A problem, question, representation (or otherwise identified purpose) is presented to students.
2. The problem, question, representation (or otherwise identified purpose) is likely to be comprehensible to students.
3. The problem, question, representation (or otherwise identified purpose) is likely to be interesting and/or motivating to students.
4. Students are given an opportunity to think about and discuss the problem, question, representation (or otherwise identified purpose).
5. Most lessons are consistent with the stated purpose and those that are not are explicitly labeled as digressions.
6. The material returns to the stated purpose at the end of the unit.
Rating Scheme
Excellent: The material meets indicators 1–6.
Satisfactory: The material meets indicators 1–3 and 5.
Poor: The material meets indicator 1 at best.
Criterion B. Conveying lesson/activity purpose. Does the material convey the purpose of each lesson/activity and its relationship to others?
Indicators of meeting the criterion
1. The material conveys or prompts teachers to convey the purpose of the activity to students.
2. The purpose is expressed in a way that is likely to be comprehensible to students.
3. The material encourages each student to think about the purpose of the activity.
4. The material conveys or prompts teachers to convey to students how the activity relates to the unit purpose.
5. The material engages students in thinking about what they have learned so far and what they need to learn/do next at appropriate points.

Rating Scheme

Excellent: The material meets all indicators.
Satisfactory: The material meets any three out of the five indicators.
Poor: The material meets no more than one out of the five indicators.

Criterion C. Justifying lesson/activity sequence. Does the material involve students in a logical or strategic sequence of activities (versus just a collection of activities)?

Indicators of meeting the criterion

1. The material includes a logical or strategic sequence of activities.
2. The material conveys the rationale for this sequence.

Rating Scheme

Excellent: The material meets both indicators.
Satisfactory: The material meets the first indicator.
Poor: The reviewer can infer a logical rationale for the sequence of only a few activities.

Category II. Taking Account of Student Ideas.

Criterion A. Attending to prerequisite knowledge and skills. Does the material specify prerequisite knowledge/skills that are necessary to the learning of the key idea(s)?

Indicators of meeting the criterion

1. The material alerts the teacher to specific prerequisite ideas or skills (versus stating only prerequisite topics or terms).
2. The material alerts teachers to the specific ideas for which the prerequisites are needed.
3. The material alerts students to prerequisite ideas or experiences that are being assumed.
4. The material adequately addresses (provides instructional support for) prerequisites in the same unit or in earlier units (in the same or other grades). (The material should not be held accountable for addressing prerequisites from an earlier grade range. However, if a material does address such prerequisites they should count as evidence for this indicator.)
5. The material makes adequate connections (provides instructional support for connections) between ideas treated in a particular unit and their prerequisites (even if the prerequisites are addressed elsewhere).
Rating Scheme
Excellent: The material meets indicators 1, 2, 3 or 4, and 5 for all or most prerequisites.
Satisfactory: The material meets indicators 1, 2, 5, and either 3 or 4 for some prerequisites.
Fair: The material meets indicators 5 and either 3 or 4 for some prerequisites.
Poor: The material meets no more than one indicator.

Criterion B. Alerting teacher to commonly held student ideas. Does the material alert teachers to commonly held student ideas (both troublesome and helpful) such as those described in Benchmarks Chapter 15: The Research Base?
Indicators of meeting the criterion
1. The material accurately presents specific commonly held ideas that are relevant to the key ideas and have appeared in scholarly publications (rather than just stating that students have difficulties with particular ideas or topics).
2. The material clarifies/explains commonly held ideas (rather than just listing them).

Rating Scheme
Excellent: The material meets indicators 1 and 2 for a considerable proportion of commonly held ideas that have appeared in scholarly publications.
Satisfactory: The material meets indicators 1 and 2 for some commonly held ideas that have appeared in scholarly publications.
Poor: The material meets indicator 1 at best.

Criterion C. Assisting teacher in identifying own students' ideas. Does the material include suggestions for teachers to find out what their students think about familiar phenomena related to key ideas before they are introduced?
Indicators of meeting the criterion
1. The material includes specific questions or tasks that could be used by teachers to identify students' ideas.
2. The questions/tasks are likely to be comprehensible to students who have not studied the topic and are not familiar with the scientific vocabulary.
3. The questions/tasks are identified as serving the purpose of identifying students' ideas.
4. The material includes questions/tasks that ask students to make predictions and/or give explanations of phenomena (rather than focus primarily on identifying students' meanings for terms).

5. The material suggests how teachers can probe beneath students' initial responses to questions or interpret student responses (e.g., by providing annotated samples of student work).

Rating Scheme
Excellent: The material provides a sufficient number and variety of questions/tasks that meet indicators 1 and 2 and meet indicators 3–5.
Satisfactory: The material provides some questions/tasks that meet indicators 1–4.
Poor: The material provides some questions/tasks that meet indicator 1 or indicators 1 and 2.

Criterion D. Addressing commonly held ideas. Does the material attempt to address commonly held student ideas?

Indicators of meeting the criterion
1. The material explicitly addresses commonly held ideas.
2. The material includes questions, tasks, or activities that are likely to help students progress from their initial ideas, for example, by
   a. explicitly challenging students' ideas, for example, by comparing their predictions about a phenomenon to what actually happens
   b. prompting students to contrast commonly held ideas with the scientifically correct ideas, and resolve differences between them
   c. extending correct commonly held ideas that have limited scope.
3. The material includes suggestions to teachers about how to take into account their own students' ideas.

Rating Scheme
If there is research on commonly held student ideas:
Excellent: The material meets indicators 1 and 2 for a considerable proportion of commonly held ideas that are documented in the literature.
Satisfactory: The material meets indicators 1 and 2 for some commonly held ideas that are documented in the literature.
Poor: The material meets the first indicator at best.

**Category III: Engaging Students with Relevant Phenomena**

Criterion A. Providing variety of phenomena. Does the material provide multiple and varied phenomena to support the key ideas?

Indicators of meeting the criterion

1. Phenomena are useful in making the key ideas real.
2. Phenomena are explicitly linked to the relevant key ideas.

Rating Scheme

Excellent: The material provides a sufficient number and variety of phenomena that meet indicators 1 and 2.

Satisfactory: The material provides some phenomena that meet indicators 1 and 2.

Poor: The material provides, at best, one phenomenon that meets indicators 1 and 2.

If the benchmark for which the material is analyzed includes several ideas, the reviewers should proceed as follows:

a. Identify the ideas for which there is a content match.

b. Score the treatment of each idea that results from step a. The overall score for this criterion will be the average of the scores for each idea.

Criterion B. Providing vivid experiences. Does the material include activities that provide firsthand experiences with phenomena when practical or provide students with a vicarious sense of the phenomena when not practical?

Indicators of meeting the criterion

1. Each firsthand experience is efficient (when compared to other firsthand experiences) and, if several firsthand experiences target the same idea, the set of firsthand experiences is efficient. (The efficiency of an experience equals the cost of the experience [in time and money] in relation to its value.)

2. The experiences that are not firsthand (e.g., text, pictures, video) provide students with a vicarious sense of the phenomena. (Please note that if the material provides only firsthand experiences, this indicator is not applicable.)

3. The set of firsthand and vicarious experiences is sufficient.

Rating Scheme
Excellent: The material meets all indicators or just indicators 1 and 3 or indicators 2 and 3, if firsthand experiences are not possible.

Satisfactory: The material includes some efficient firsthand experiences and, if several firsthand experiences target the same idea, the set of firsthand experiences is sufficient. When firsthand experiences are not practical, the material provides students with a vicarious sense of the phenomena for some of the experiences that are not firsthand.

Poor: The material includes at best only one efficient firsthand experience or provides students with a vicarious sense of one phenomenon that is not firsthand.

Reviewers should proceed as follows:

a. Identify the key ideas for which there is a content match.

b. Score the treatment of each idea that results from step a. The overall score for this criterion will be the average of the scores for each idea.

**Category IV. Developing and Using Scientific Ideas**

Criterion A. Introducing terms meaningfully. Does the material introduce technical terms only in conjunction with experience with the idea or process and only as needed to facilitate thinking and promote effective communication?

Indicators of meeting the criterion

1. The material links technical terms to relevant experiences that develop the idea as the term is used (rather than just having students learn definitions of terms).

2. The material restricts the use of technical terms to those needed to communicate intelligibly about key ideas.

Rating Scheme

Excellent: The material meets both indicators.

Satisfactory: The material fully meets one indicator and partially meets the other.

Poor: The material marginally meets both indicators at best.

Criterion B. Representing ideas effectively. Does the material include accurate and comprehensible representations of the key ideas?

Indicators of meeting the criterion

1. Representation is accurate (or, if not accurate, then students are asked to critique the representation).

2. Representation is likely to be comprehensible to students.
3. Representation is explicitly linked to the real thing.

Rating Scheme

Excellent: The material includes a sufficient number and variety of representations that meet indicators 1–3 and none of the representations included in the material are inaccurate. (In order to judge whether there is a sufficient number and variety of representations, reviewers should first consider which key ideas require representations and then decide whether these are adequately represented. However, reviewers are not expected to evaluate and rate each idea separately and average the scores.)

Satisfactory: The material includes some representations that meet indicators 1–3 and few (if any) of the representations included in the material are inaccurate. (In some cases, including one accurate and comprehensible representation for a specific idea may be sufficient for a material to receive a "satisfactory" rating. However, most of the key ideas must be adequately represented.)

Poor: Even though the material includes a few representations that meet indicators 1–3, few or none of the key ideas are adequately represented.

Criterion C. Demonstrating use of knowledge. Does the material demonstrate/model or include suggestions for teachers on how to demonstrate/model skills or the use of knowledge?

Indicators of meeting the criterion

1. The material consistently carries out (or instructs teachers to carry out) the expected performance (e.g., the student text explains a particular phenomenon using the kinetic molecular theory). (Teacher's guides often include responses to questions posed in the student text. If the material does not instruct the teacher to use the answers to model the use of knowledge, such responses do not count as instances of modeling.)

2. The performance is step-by-step.

3. The performance is explicitly identified as a demonstration of the use of knowledge or skill.

4. The material provides running commentary that points to particular aspects of the demonstration and/or criteria for judging the quality of a performance.

Rating Scheme

Excellent: The material meets all 4 indicators.
Satisfactory: The material meets indicators 1 and 2.
Poor: The material meets indicator 1 at best.
Criterion D. Providing practice. Does the material provide tasks/questions for students to practice skills or use knowledge in a variety of situations?
Indicators of meeting the criterion
1. The material provides a sufficient number of tasks in a variety of contexts, including everyday contexts. (In order to determine whether the task/question addresses the actual substance of the key idea, reviewers will need to consider both the question and the expected response in the teacher's guide.)
2. The material includes novel tasks.
3. The material provides a sequence of questions or tasks in which the complexity is progressively increased.
4. The material provides students first with opportunities for guided practice with feedback and then with practice in which the amount of support is gradually decreased.
Rating Scheme
Excellent: The material meets indicators 1, 2, and either 3 or 4.
Satisfactory: The material provides some tasks/questions, including novel tasks.
Poor: The material provides at best some tasks/questions, but no novel tasks.
Reviewers should proceed as follows:
a. Identify the key ideas for which there is a content match.
b. Score the treatment of each idea that results from step a. The overall score for this criterion will be the average of the scores for each idea.

Category V: Promoting Student Thinking about Phenomena, Experiences, and Knowledge.
Criterion A: Encouraging students to explain their ideas. Does the material routinely include suggestions for having each student express, clarify, justify, and represent his or her ideas? Are suggestions made for when and how students will get feedback from peers and the teacher?
Indicators of meeting the criterion
1. Material routinely encourages students to express their ideas.
2. Material encourages students not only to express but also to clarify, justify, and represent their ideas (a material is not expected to encourage students to clarify, justify, and represent ideas each time they are asked to express their ideas; however, in the course of teaching a particular key idea the material should provide students with opportunities to clarify, justify, and represent ideas).

3. Material provides opportunities for each student (rather than just some students) to express ideas.

4. Material includes specific suggestions on how to help the teacher provide explicit feedback to students or includes text that directly provides students with feedback.

5. Material includes suggestions on how to diagnose student errors, explanations about how these errors may be corrected, and recommendations for how students' ideas may be further developed.

Rating Scheme
Excellent: Material meets all indicators.
Satisfactory: Material meets 3 out of 5 indicators.
Poor: Material meets no more than 1 out of 5 indicators.

Criterion B: Guiding student interpretation and reasoning. Does the material include tasks and/or question sequences to guide student interpretation and reasoning about experiences with phenomena, representations, and ideas?

Indicators of meeting the criterion
1. The material includes specific and relevant tasks and/or questions for the experience or reading.
2. The questions or tasks have helpful characteristics such as
   a. framing important issues
   b. helping students to relate their experiences with phenomena or representations to presented scientific ideas
   c. helping students to make connections between their own ideas and the phenomena or representations observed
   d. helping students to make connections between their own ideas and the presented scientific ideas
   e. anticipating common student misconceptions
f. focusing on contrasts between student misconceptions and scientific alternatives.
Please note that while a single high quality task or question sequence might have only one of these characteristics, the set of sightings should exhibit several of them.
3. There are scaffolded sequences of questions or tasks (as opposed to separate questions or tasks).

Rating Scheme
Excellent: Material consistently meets all three indicators.
Satisfactory: Material consistently meets indicators 1 and 2.
Poor: Material meets indicator 1 at best.

Criterion C: Encouraging students to think about what they've learned. Does the material suggest ways to have students check and reflect on their own progress?
Indicators of meeting the criterion
1. The material gives students an opportunity to revise their initial ideas based on what they have learned (without asking them explicitly to think about how their ideas have changed).
2. The material engages (or provides specific suggestions for teachers to engage) students in monitoring how their ideas have changed, but does so infrequently in the unit.
3. The material engages (or provides specific suggestions for teachers to engage) students in monitoring how their ideas have changed and does so periodically in the unit.

Rating Scheme
Excellent: The material meets indicator 3.
Satisfactory: The material meets indicator 2.
Poor: The material meets indicator 1 at best.

Category VI: Assessing Progress
Criterion A: Aligning assessment to goals. Assuming a content match between the curriculum material and the key ideas, are assessment items included that match the key ideas?
Indicators of meeting the criterion
1. The specific ideas in the key ideas are necessary in order to respond to the assessment items.
2. The specific ideas in the key ideas are sufficient to respond to the assessment items (or, if other ideas are needed, they are not more sophisticated than key ideas and have been taught earlier).

Rating Scheme
Excellent: The material provides a sufficient number [9] of assessment items that meet indicators 1 and 2.
Satisfactory: The material provides some assessment items that meet indicators 1 and 2.
Poor: The material provides no more than one/a few assessment items that meet indicators 1 and 2.

Criterion B: Testing for understanding. Does the material include assessment tasks that require application of ideas and avoid allowing students a trivial way out, like using a formula or repeating a memorized term from the text without understanding it?

Indicators of meeting the criterion
1. Assessment items focus on understanding of key ideas.
2. Assessment items include both familiar and novel tasks.

Rating Scheme
Excellent: The material provides a sufficient number of assessment items that meet indicators 1 and 2.
Satisfactory: The material provides some assessment items that meet indicators 1 and 2 or sufficient assessment items that meet indicator 1.
Poor: The material provides no more than one/a few assessment items that meet indicator 1.

Criterion C: Using assessment to inform instruction. Are some assessments embedded in the curriculum along the way, with advice to teachers as to how they might use the results to choose or modify activities?

Indicators of meeting the criterion
1. The material uses embedded assessment as a routine strategy (rather than just including occasional questions).
2. The material assists teachers in interpreting student responses to diagnose what learning difficulties remain.
3. The material provides specific suggestions to teachers about how to use the information from the embedded assessments to make instructional decisions about what ideas need to be addressed by further activities.

Rating Scheme
Excellent: The material meets all indicators.
Satisfactory: The material meets indicators 1 and 2 or indicators 1 and 3.
Poor: The material meets indicator 1 at best.

**Category VII. Enhancing the Science Learning Environment**

**Criterion A. Providing teacher content support.** Would the material help teachers improve their understanding of science, mathematics, and technology necessary for teaching the material?

Indicators of meeting the criterion.
1. The material provides content information for teachers that is relevant to the learning goals they are teaching.
2. The material alerts teachers to how ideas have been simplified for student and what the more sophisticated versions are (even though students are not expected to understand the more sophisticated ideas).
3. The material provides sufficiently detailed answers to questions in the student book for teachers to understand and interpret typical student responses.
4. The material makes suggestions for how to use recommended resources for improving teachers understanding of the learning goals.

Rating Scheme
Excellent: The material meets all indicators.
Satisfactory: The material meets indicator 2 out of the 4 indicators.
Poor: The material meets indicator 1 at best.

**Criterion B. Encouraging curiosity and questioning.** Does the material help teachers to create a classroom environment that welcome student curiosity, rewards creativity, encourages a spirit of healthy questioning, and avoids dogmatism?

Indicators of meeting the criterion.
1. The material provides opportunities for students to express their curiosity and creativity.
2. The material provides occasion for students to ask questions and guides their search for answers.
3. The material provides opportunities to respect and value students’ ideas (e.g. by suggesting how each student’s ideas can be heard and considered and held up to evidence).
4. The material sends the message that science is more than rules or facts to be learned and that problems may have more than one solution.
5. The material provides examples of classroom interactions—e.g. dialogue boxes, vignettes, or video clips—that illustrate appropriate ways to respond to student questions or ideas, etc.

Rating Scheme
Excellent: The material meets all indicators.
Satisfactory: The material meets indicator 3 out of the 5 indicators.
Poor: The material meets indicator 1 at best.

Criterion C. Supporting all students. Does the material help teachers to create a classroom community that encourages high expectations for all students, that enables all students to experience success, and that provides all students a feeling of belonging in the science classroom?
Indicators of meeting the criterion.
1. The material avoids stereotypes or language that might be offensive to a particular group.
2. The material illustrates the contribution or participation of under-represented groups to science-related fields.
3. The material suggests alternative formats for students to express or develop their ideas during instruction and assessment.
4. The material includes specific suggestions about modifying activities for students with special needs, interests, or abilities.
5. The material provides strategies to validate students’ personal and social experiences as being relevant to mathematical or scientific ideas.

Rating Scheme
Excellent: The material meets all indicators.
Satisfactory: The material meets indicator 3 out of the 5 indicators.
Poor: The material meets indicator 1 at best.

Appendix C.

Sightings for Exploring Motion and Forces

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Target Idea</th>
<th>TM Page #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>1</td>
<td>the forces (pushes or pulls) that initiate, maintain, or retard motion.</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>3</td>
<td>they think caused the object to move in the first place. If the object is in constant motion, they write why they think it keeps moving.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>3</td>
<td>The initial push or pull to put each of these objects in motion is different.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1 &amp; 2</td>
<td>4</td>
<td>Describe the motion of an object thrown up into the air.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>6,8</td>
<td>A force (push or pull) is required for an object to start moving.</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>6</td>
<td>&quot;a force,&quot; is removed, the object slows down, then stops moving.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>2</td>
<td>6</td>
<td>Students also discover that a larger force will cause the object to move farther.</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>6</td>
<td>This model states that objects in motion tend to stay in motion, and objects at rest tend to stay at rest.</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>6</td>
<td>the friction force acts in a direction opposite to that of the motion.</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>6</td>
<td>The belt applies a force opposing this motion…</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>2</td>
<td>7</td>
<td>the greater the force exerted… the farther it will travel</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>8</td>
<td>Is it possible for the ball to start moving by itself?</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>2</td>
<td>8</td>
<td>…how would the strength of the push affect the motion?</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>8</td>
<td>Once the ball starts moving, will it keep moving forever?</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>2</td>
<td>9</td>
<td>Students push slightly harder (apply a larger force) and describe how the motion is affected.</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>10</td>
<td>Students describe the motion of the object on the moving book and what happens when the book stops.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>10</td>
<td>Student record how they made the coin move upward.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1 &amp; 2</td>
<td>10</td>
<td>Students write what they think affected how high the coin went.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>10</td>
<td>They then write why the coin came back down.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>10</td>
<td>give it a push and describe the motion</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>10</td>
<td>They write why the coin stopped moving.</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1 &amp; 2</td>
<td>10</td>
<td>Students write what they think affects how far they can throw a coin…</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>2</td>
<td>11</td>
<td>Is there a relationship between how hard you push an object in a horizontal direction and how far it moves?</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>11</td>
<td>Describe the motion of an object from the instant that it is thrown up in the air until it returns to the ground.</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>11</td>
<td>Was there a difference between the motion of the object placed on the book and the motion of the book?</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1 &amp; 2</td>
<td>11</td>
<td>What affects how high a ball can be thrown?</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1</td>
<td>11</td>
<td>Why does a ball thrown up in the air come back down?</td>
</tr>
<tr>
<td>4F 3-5 #1</td>
<td>1 &amp; 2</td>
<td>11</td>
<td>What affects how far you can throw a ball horizontally?</td>
</tr>
<tr>
<td>pg. 90</td>
<td>4</td>
<td>13</td>
<td>an object at rest stays at rest unless an external force is applied to start it moving, and a moving object maintains its motion unless it is acted upon by an external force.</td>
</tr>
</tbody>
</table>
Motion and Forces: Curriculum Analysis

4F 3-5 #1 2 13 set the disk in motion with different amounts of force.
pg. 90 4 13 and a moving object maintains its motion unless acted upon by an external force.
pg. 90 4 13 This model postulates a friction force which acts in the opposite direction to that of the motion. Without this - or another - force, … maintain its motion.
pg. 90 4 14 prediction that a moving object remains in steady motion, unless a force acts on it to change this motion.
4F 3-5 #1 1 16 A force (push or pull) is required for an object to start moving.
pg. 90 4 16 Once an object starts moving, it stays in motion without an external force pushing or pulling it.
pg. 90 4 16 Friction forces oppose the motion of moving objects and slow them down.
4F 3-5 #1 2 16 Is the distance the object moves affected by how hard you initially push it?
4F 3-5 #1 4 & 2 19 …limited how far the disk traveled?
4F 3-5 #1 2 19 how could you get the disk to move farther than it did?
pg. 90 4 19 What do you think eventually caused the disk to stop moving?
4F 3-5 #1 1 20 A force (push or pull) is required for an object to start moving.
4F 3-5 #1 2 23 Does the amount of force used to start the disk in motion affect how far the disk moves?
4F 3-5 #1 2 24 to observe how the distance an object moves is affected
4F 3-5 #1 2 24 The magnitude of a force (a push or a pull) acting on an object affects the distance the object moves.
4F 3-5 #1 2 24 A stronger push results in an object moving a greater distance.
4F 3-5 #1 2 28 How does the motion of your disk change as you release it from further back in the launcher?
4F 3-5 #1 2 28 is a greater (stronger) or lesser (weaker) force applied to the disk the farther you pull it back in the launcher
4F 3-5 #1 2 29 describe the relationship the graph shows between the distance the disk is pulled back and the distance it moves.
pg. 90 4 30 An object moving along a horizontal surface slows down and stops.
pg. 90 4 30 Only the action of an external force on an object can change its motion.
pg. 90 4 30 One source of external force acting on a moving object comes from the object's contact with the surface on which it is moving. This force is called a friction force.
4F 3-5 #1 1 30 Forces (pushes or pulls) have direction as well as magnitude.
pg. 90 4 30 there is a force pushing on the disk in a direction opposite to that of its travel. This force is called friction.
pg. 90 4 31 Friction always acts in the direction opposite to that of an object's motion.
pg. 90 4 36 nonetheless eventually stops moving. In Newton's model, the stopping is attributed to the effect of friction and air resistance.
pg. 90 4 37 In an environment with low friction, an object can move very far at a nearly steady speed.
pg. 90 4 38 What do you think the motion of the disk would be like if you could find a way to reduce the friction force acting on the disk.
pg. 90 4 38 is the motion of the air disk the same as or different from the motion of a regular disk? If different, in what way is the motion different?
pg. 90 4 40 in what ways did the air cushion change the disk's motion?
pg. 90 4 41 why do you think the air disk eventually stopped moving
pg. 90 4 41 once an object is in motion it seems to stay in motion, neither speeding up nor slowing down, unless a force (push or pull) acts on it.
4F, 3-5, #1 1 p. 47 a push or pull is required to start the ball moving. The force ("pull") that starts the ball rolling down the inclined track and that continues to act on the ball is called gravity.
Motion and Forces: Curriculum Analysis

the horizontal motion of the rolling ball is affected by the friction force, which slows and then stops the ball

the force or pull on the marble that causes it to roll down the track is that of gravity

if a force is constantly applied to a moving object...it will travel faster and faster. A marble is said to have uniform acceleration in that it speeds up at a rate that is the same throughout the period of time that it is under gravity's influence.

the higher up an inclined track a ball starts, the farther it will roll along a horizontal track at the bottom of the incline

do you think a marble starts moving because of a push or a pull when you set it on the incline?

the higher up an inclined track a ball starts, the farther it will roll along a horizontal flat track

the higher up along an inclined track a ball starts, the greater its average speed as it rolls along any section of a horizontal track at the bottom of the incline

the higher up along the inclined track a marble starts, the faster it will roll along the horizontal, flat track (twice)

how starting height affects rolling speed

the higher up along the inclined track the ball starts, the faster it will roll along the first part of the horizontal track

about how the speed of a marble at the bottom of the incline is affected by the starting point on the incline

when a ball is rolling along a horizontal plane, it slows and then stops.

after a marble rolls down the incline, do you think it speeds up, slows down, or moves at a constant speed as it rolls along the flat track.

rolled along a flat track, do you think it was speeding up, slowing down, or moving at a constant speed

if an object speeds up, slows down, or moves at a constant speed as it rolls down an incline

a ball rolling down a smooth, inclined track increases its speed at a constant rate while rolling down the incline

why do you think a marble keeps rolling down the inclined track

students investigate how the motion of the cart changes as more washers are...increasing the pull on the cart

an object remains at rest unless an external force is applied to it. An object remains in motion at constant speed and in a straight line unless an external force is applied to change the motion

as students try to start the cart moving, they observe that a certain minimum push is required before motion starts

the more washers....and the greater the pull on the cart

the greater the hanging mass

the washers hit the floor, there is no longer a pull, yet the cart keeps moving

an object remains in motion at constant speed and in a straight line unless an external force is applied to change the motion

when the propeller turns, the cart moves

these measurements allow students to observe how motion changes as the forces acting on them are changed....motion of an object rolling down an incline, pulled by a falling mass, or being pushed by a fan, students observe that the nature of the motion of all three is the same: the object accelerates
a push or pull is required for an object to start moving
an object remains at rest unless an external force is applied
students list different methods to make the Speedcart start moving
the air disk and speedcart both move horizontally across the surface and eventually slow down and stop
an object remains at rest unless an external force is applied to change the motion
if a push or pull continues to act on an object, the object continues to accelerate (that is its speed, increases with time)
magnitude of a push or pull that continues to act on an object affects the time it takes for the object to move a specific distance
the minimum number of washers you need to add to the hook to make the cart start Moving
What do you observe about the motion of the cart as you add more washers to the hook
describe the motion of the cart right after the washers hit the ground
what makes a washer-driven cart start moving
how does adding more washers affect the motion of the cart
what happens to the motion of the cart after the washers hit the ground
if the string came untied, do you think the cart would keep going?
magnitude of a push or pull that continues to act on an object affects the time it takes for the object to move a specific distance.
the greater the magnitude of a push or pull, the faster the object will move
adding more washers to the hook increases the falling mass. The pull on the cart is increased, and the cart moves faster
what did you observe about the motion of the cart as you added more washers to the hook
what did you observe about the motion of the cart as you added more washers to the hook?
what did you observe about the motion of the cart as you added more washers to the hook? the great the falling mass, the greater the force (a pull) acting on the cart, and the faster the cart moves
the more massive an object is, the longer it will take to move a given distance when acted upon by a push or pull of a specific magnitude for a specific time
magnitude of a push or pull that continues to act on an object affects the time it takes for the object to move a specific distance.
with 6 washers on the hook, how could you make your cart go slower than it did?
if they were to increase the cart's mass, it would go slower.
do you think it is possible to make a cart with more mass move as fast as a cart with less Mass
what did you observe about the motion of the cart as you added more washers to it?
would a cart with more mass move differently than a cart with less mass if each were pulled by the same force?
increases the cart's mass, which results in greater resistance to the pull from the falling Mass
adding more washers (more mass) to the hook increases the pull on the cart
if the mass of the cart stays the same, then the net force on the cart is increased and the washers fall faster
the mass of an object (such as the cart) directly affects its horizontal motion
observe the motion of the cart as it is propelled by a fan
a push or pull is required for an object to start moving
if a push or pull continues to act on an object, the object continues to accelerate (that is its speed, increases with time)

the fan cart starts from rest and then goes faster and faster…

they then find and record a way to change the direction of the fan cart while it is still Moving

what do you think makes the fan cart move?

if the propeller stopped turning, would the fan cart continue to move?

if the fan cart is speeding up, slowing down, or moving at a constant speed as it is propelled by the fan

if a push or pull continues to act on an object, the object continues to accelerate (that is its speed, increases with time)

strategies you might use to determine if the fan cart is speeding up, slowing down, or moving at a constant speed.
Appendix D.

Complete ratings of Instructional Analysis for ARIES: Exploring Motion and Forces.

<table>
<thead>
<tr>
<th>Instructional Categories</th>
<th>Indicator 1</th>
<th>Indicator 2</th>
<th>Indicator 3</th>
<th>Indicator 4</th>
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<th>Indicator 6</th>
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