Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials

The Council of State Science Supervisors (CSSS) developed the following rubric to assist a wide variety of audiences to develop an understanding of the desired characteristics of inquiry materials[1] and to describe the extent to which a given material contains the descriptors outlined in the rubric.

A wide range of audiences should be able to use the rubric for a variety of purposes. Someone with limited knowledge of inquiry can use the list of descriptors to develop an understanding of the desired characteristics of inquiry materials. A teacher or curriculum specialist could use the descriptors, coupled with a limited knowledge of the variations, to make informal analyses of materials for use in local classrooms. District or state level administrators can use the full instrument to select materials in a more official or policy-oriented capacity by selecting and training a group of reviewers in the use of the rubric. Instructional materials developers can use of the rubric to produce more inquiry oriented teaching materials. It should be noted that the more reliability demanded of the rubric, the more training and experience the users should have.

The rubric is based on the following definition of inquiry adapted from the National Science Education Standards.

> Inquiry is the process scientists use to build an understanding of the natural world based on evidence. Students can learn about the world using inquiry. Although learners rarely discover knowledge that is new to humankind, current research indicates that when engaged in inquiry learners build knowledge new to themselves.
>
> Learner inquiry is a multifaceted activity that involves making observations; posing questions; examining multiple sources of information to see what is already known; planning investigations; reviewing what is already known in light of the learner's experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

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[1] Instructional material refers to almost any material that is intended for use in the instruction of students. The material may be a textbook, laboratory guide, website, or a short instructional module.

> As a result of participating in inquiries, learners will increase their understanding of the science subject matter investigated (section A), gain an understanding of how scientists study the natural world (section B), develop the ability to conduct investigations (section C), and develop the habits of mind associated with science (section D).

The overarching purpose of inquiry is stated in the first paragraph. Inquiry, as described in the second paragraph, is a broadly defined collection of processes used to study the natural world. Some educators have viewed the purpose of inquiry in the classroom almost exclusively as students learning these processes. The definition used here views classroom inquiry as incomplete unless it also results in the four outcomes described in the third paragraph.

Those four outcomes provide the basis for the four sections of the rubric (Sections A, B, C, D). Within each section there are a number of descriptors that materials should align with if they are going to adequately support learners in the acquisition of the desired outcomes. The descriptor is stated in the first column followed by four variations on the degree to which the material satisfies the descriptor.

Although the rubric is designed to describe a range of four possibilities for each descriptor, the interpretation of the variations differs somewhat from section to section. There are descriptors, such as those in Section A for subject matter, that are evaluative in nature. It clearly is important that the instructional material be aligned with the applicable standards, is accurate, and provides an adequate opportunity for learners to acquire the content.

In other cases, such as most of Sections B and C where learners are engaged in developing the abilities and understanding of inquiry, the instructional material should be selected based on where the learners are in their development of the skills and understanding of inquiry. Instruction and the materials used can and should vary the amount of structure built into the activity and the degree to which learners ask their own questions, design an investigation, and develop their own explanations depending on their previous experience and understanding.

Often the inquiry in materials is described with terms such as “structured,” “guided,” and “open” used to describe the extent to which learners have control of the inquiry process when using the materials. Although the rubric does not use this language, there may be a temptation to label the variations in some of the descriptors in this manner. Since the rubric is designed to help teachers, materials reviewers, and material developers select or design instructional materials that best suit their learners’ needs, Sections B and C of the rubric should be use only to describe the materials but not to judge their quality. The ultimate goal of inquiry-based science education will be to have learners working with materials at variation IV on most descriptors. But learners usually cannot start with materials at this level; they need to progress over time to that end, thus the need for materials with a variety of levels of learner control.

The development of scientific habits of mind results in a set of values and mental attitudes on the part of the learner. These traits, taken from the Benchmarks for Science Literacy, include curiosity, honesty, openness, and skepticism are described in Section D. Although these values can be presented through direct instruction, they will develop in a more enduring and transferable form if they are presented in all elements of science teaching. As learners experience the role of investigations and develop their inquiry skill (as described in Section C) they can be encouraged to practice habits of mind associated with science. When they study the way scientists do their work to better understand the role of inquiry in science (as described in Section B) they become aware of how scientists demonstrate the values and habits of mind associated with science. Because these values an important part of what students learn through inquiry, they are considered as a group in Section D with references (links) to the related descriptors in sections B and C.

Once trained in the use of the rubric, educators can use this rubric to review instructional materials at any grade level. A person experienced in the use of the rubric and who understands the development of learners should be able to make judgments about the examples, questions, opportunities, and instructions, which are appropriate for the learners, in question. Based on these judgments educators can decide where on each descriptor continuum the materials belong for it to fit their needs.

Directions for use:

- This rubric is designed to evaluate most types of instructional material in science at any grade level.
- Many decisions are left to the evaluator because of the broad scope of the rubric.
- Texts containing multiple activities may be evaluated one activity at a time or in a holistic context.
- Materials do not have to be evaluated against every criterion.
- The rubric scores should not necessarily be aggregated. Scores for each descriptor should be examined separately since it is possible that the class objectives are best met by material that is high in some areas and lower in others.

As a result of participating in inquiries, learners will…

A. Increase their understanding of the science subject matter investigated

Developing a thorough understanding of subject matter content, as identified for each grade level in national, state, or local standards, is a major goal of science teaching and learning. When considering materials, the first judgment that needs to be made is whether the content of the material matches the standards. **If the content of the material does not match standards, then it should not be used. There is no need to proceed further with the analysis.** There is far too little time for teaching, and efforts must focus on helping all learners achieve identified learning goals. Well-aligned materials, with accurate scientific content, will help learners achieve those goals. Inquiry is both content and a means to achieve content. Materials that use inquiry as the centerpiece of science teaching and learning provide opportunities for learners to construct their own subject matter understanding while developing abilities to do science. This understanding takes time and involves authentic experiences in developing questions, gathering and analyzing data, developing explanations based on evidence, and communicating results. The variations in this section are based upon increasing levels of acceptability.

A1. Content				
Descriptor	**Variations**			
Material…	I	II	III	IV
A1a. …provides content aligned with national, state or local standards.	…does not match standards (displays no evidence of alignment). ***Stop here- no further evaluation needed.**	…matches the topic of the standard but not the specific outcome desired.	…matches the topic of the standard and addresses at least a part of the specific outcome desired.	…matches the specific outcome of the standard.

A1b. ..provides opportunity to develop enduring understanding of subject matter content.	…covers too many concepts and abilities (too much breadth and not enough depth). Coverage (time) is insufficient to develop understanding of concepts and abilities	…focuses on several important concepts and abilities, several of which are peripheral to each inquiry. More coverage (time) may be needed to develop enduring understanding.	…focuses on the specific concepts and abilities that are central to each inquiry although a few peripheral ideas are present. More coverage (time) may be needed to develop enduring understanding.	…focuses on the specific concepts and abilities that are central to each inquiry. Material provides ample opportunity to develop enduring understanding of the important content.
A1c. …contains accurate content.	…contains major inaccuracies.	…contains minor inaccuracies that are evident in statements and/or representations..	…is scientifically accurate but may contain the potential for misconceptions to occur from implied statements or representations.	…is scientifically accurate There is minimal potential for misconceptions to occur from implied statements or representations.

This section correlates to: NSES: pgs 6, 22, 103-113, 115-204
NSES Inquiry Addendum: pgs 41, 59, 60, 70
Benchmarks: pgs 3-21, 264-266, 268-270, 272-275, 277-279

B. Gain an understanding of how scientists study the natural world

The use of biographies, case studies and historical scientific materials can be very useful to learners in their understanding of how scientists study the natural world. The participation in actual scientific inquiry at the appropriate level for the learners allows them to compare their inquiry experiences to that of scientists. This set of descriptors is based on looking at the work of scientists and only meant as a comparative point to the work that the learners do. There is a difference in the work carried out by learners when compared to that of scientists' work but this difference should only be in the degree of sophistication of the work. The variations in this section are based upon increasing correlation of examples to the students' work.

B1. Understanding of how scientists work				
Descriptor	**Variations**			
Material…	I	II	III	IV
B1a. …provides an opportunity to learn how different kinds of questions based on prior scientific knowledge suggests different kinds of investigations	…provides no mention of how scientific questions are developed.	…provides a discussion of how scientific questions are developed but no examples are provided.	…provides a discussion of how scientific questions are developed and examples of different kinds of questions but no connections are made to the learner's work.	…provides an opportunity to learn how scientists use what is already known to develop different types of questions and investigations. This is accomplished by providing real world examples and facilitating the students in developing explanations of how the examples relate to the learner's work.
B1b. … provides an opportunity to learn that scientists conduct investigation for a variety of reasons.	… provides no mention of why investigations are conducted.	… provides a discussion of why investigations are conducted but no examples (reasons for investigations include discovering new aspects of the natural world, explaining recently observed phenomena, and (or) testing the conclusions of prior investigations).	… provides a discussion of why investigations are conducted and examples but no connections are made to the learner's work..	… provides real world examples showing one or more reasons for the investigation(s) and facilitates the students in connecting the examples to the learner's work.

B1c. … provides an opportunity to learn that scientists use a variety of tools, technology, and methods to extend the senses	… provides no mention of how the senses are extended.	… provides a discussion of how the senses are extended but no examples.	… provides a discussion of how the senses are extended and examples but no connections are made to the learner's work..	… provides real world examples of how the senses are extended to gather evidence, guide inquiry, and analyze data and facilitates students in connecting the examples to the learner's work. Material demonstrates that the accuracy and precision of data depend upon the quality and choice of tools
B1d. … provides an opportunity to learn that mathematics is essential in scientific inquiry.	… provides no mention of the use of mathematics in inquiry.	… provides a discussion of the use of mathematics in inquiry but no examples.	… provides a discussion of the use of mathematics in inquiry, and examples are provided. No connections are made to the learner's work.	… provides real world examples of the use of mathematics in inquiry for data collection, analysis, and the development and communication of explanations. Facilitates students in connecting the examples to the learner's work.
B1e. …an opportunity to learn that scientists use evidence, logic, and current scientific knowledge to propose explanations.	…no mention of how scientists propose explanations.	…a discussion of how scientists propose explanations but no examples.	…a discussion of how scientists propose explanations. Examples are provided but no connections are made to the learner's work.	…real world examples illustrating that proposed explanations are based on logical inference, analysis, and synthesis of evidence combined with prior scientific knowledge. Facilitates students in connecting the examples to the learner's work.

B1f. ... provides an opportunity to learn that scientists collaborate and communicate with each other in a variety of ways to reach well-accepted explanations	… provides no mention of how scientists collaborate and communicate.	… provides a discussion of how scientists collaborate and communicate but no examples.	… provides a discussion of how scientists collaborate and communicate. Examples are provided but no connections are made to the learner's work.	… provides real world examples of the importance of collaboration, clarity, accuracy, logic, criticism, and skepticism in communication as a means of reaching well-accepted explanations. Facilitates students in connecting the examples to the learner's work.

This section correlates to: NSES Inquiry Addendum: pg. 20
Benchmarks: pgs. 3-21, 37, 41-58, 129, 281-300

C. Develop the ability to conduct investigations

Teachers should choose materials/sites with the variation that matches their learners' abilities and interests, and corresponds to the objectives/outcomes or standards of the planned instruction. Precise definitions of the variations depend upon the learners for which the materials are being chosen. Materials meant for long-term use during the school year should show a progression to more advanced variations of inquiry. The variations in this section are based upon increasing levels of inquiry.

C1. Posing scientifically oriented questions				
Descriptor	**Variations**			
Material…	I	II	III	IV
C1a. …provides an opportunity to ask questions that can be answered through scientific investigations.	…allows learners to answer provided questions.	…allows an opportunity to clarify provided questions.	…allows an opportunity to select among provided questions and pose new questions for investigation.	…allows an opportunity for learners to pose new questions for investigation relevant to their understanding (interests).

C2. Designing and conducting investigations				
Descriptor	**Variations**			
Material…	I	II	III	IV
C2a. … engages learners in planning investigations to gather evidence in response to questions.	…provides the complete plan for the investigation.	…provides guidelines for learners to plan part or all of an (a full) investigation based on the (their determination of) necessary evidence and appropriate methodologies.	…encourages learners to plan a full investigation based on their determination of necessary evidence and appropriate methodologies. Minimal guidelines may be provided.	…requires learners to independently plan a full investigation based on their determination of necessary evidence and appropriate methodologies.
C2b. … engages learners in conducting the investigation.	…provides a procedure for the investigations.	…provides questions, directs the learner regarding procedure and specifies what data to collect.	…provides questions, engages learners in determining what constitutes correct procedure and appropriate data and in conducting the investigation to collect the data.	…requires learners to self-direct the full investigation based on their determination of necessary evidence and appropriate methodologies.
C2c. … engages learners in the use of analytical skills.	…does not allow for learner use of analytical skills.	…provides exact guidelines for learners to use analytical skills, mathematics, and technology to gather and analyze data.	… encourages learners to use analytical skills, mathematics, and technology to gather and analyze data. Minimal guidelines may be provided.	…requires learners to independently use analytical skills, mathematics, and technology to gather and analyze data.

C3. Proposing answers				
Descriptor	**Variations**			
Material…	I	II	III	IV
C3a. … engages learners **in** proposing answers and explanations to questions	…provides no opportunity for learners to propose answers and explanations to questions above the knowledge level.	…provides data and asks learners to analyze them to answer specific questions.	…encourages learner to collect and analyze certain data to answer questions arising from their investigation.	…requires learners to analyze (use) evidence from data they gather to propose answers and explanations to questions arising from their investigation.

C4. Comparing explanations with current scientific knowledge				
Descriptor	**Variations**			
Material…	I	II	III	IV
C4a. …engages learners in the consideration of alternative explanations.	…does not mention alternative explanations and the conclusion is obvious.	…provides learners with an opportunity to produce one conclusion and one explanation.	…encourages learners to consider and state alternative explanations.	…requires learners to construct, consider, state, investigate, and evaluate alternative explanations.
C4b. ...engages learners in linking explanations with scientific knowledge	… does not mention linking explanations with scientific knowledge.	…provides guidelines for learners to examine historical and current scientific knowledge and form links to explanations.	…encourages learners to examine historical and current scientific knowledge and form links to explanations.	…requires learners to independently examine historical and current scientific knowledge and form links to explanations.

C5. Communicating and justifying results				
Descriptor	**Variations**			
Material…	I	II	III	IV
C5a. …engages learners in communication of scientific procedures and explanations.	…does not mention communicating inquiry.	…provides an opportunity for learners to follow prescribed communication procedures.	… provides an opportunity for learners to communicate some aspects of the inquiry in their own format.	… provides an opportunity for learners to clearly communicate all aspects of the inquiry in their own format including the question, procedures, evidence, proposed explanations, and the review of alternative explanations.
C5b. … engages learners in appropriately responding to critical comments	…does not mention justification of explanations or encourage criticism.	… provides an opportunity for learners to be critiqued and to follow broad guidelines to clarify the justification.	… provides an opportunity for learners to be critiqued and to be coached in the development of the justification.	… provides an opportunity for learners to self direct and form reasonable and logical arguments; and to communicate a response to the criticism.
C5c. … engages learners in raising additional questions.	…provides no opportunity for additional questions to be generated during the activitiy.	… provides an opportunity for learners to raise additional broad questions to be answered while doing specified areas of the activity	… provides an opportunity for learners to generate additional specific questions that help clarify any area of the activity.	… provides an opportunity for learners to generate and redefine inquiry based on new evidence gained while engaged in the activity.

This section correlates to: NSES Inquiry Addendum pgs. 1-3, 7, 8, 18-20, 25-29, 35, 82, 161-167
NSES: 121-123, 143-145, 173-175
Benchmarks: 6-8, 11-13, 16, 19, 33, 285, 300

D. Developing the habits of mind associated with science

Habits of mind can be a difficult topic to teach but they should develop in an enduring form if they are presented in all elements of science teaching and modeled through classroom practice. As learners experience the role of investigations and develop their inquiry skill they can be encouraged to practice habits of mind associated with science. When they study the way scientists do their work to better understand the role of inquiry in science they become aware of how scientists demonstrate the values and habits of mind associated with science. These values are interdependent and not mutually exclusive from the development of the other outcomes of inquiry. The variations in this section are based upon Bloom's taxonomy.

D1. Developing the habits of mind associated with science				
Descriptor	**Variations**			
Material…	I	II	III	IV
D1a. …promotes the questioning of assumptions (skepticism)	…does not address the need to evaluate or consider the underlying assumptions of an investigation.	…provides explanations or examples of assumptions in scientific investigations.	…prompts learners to consider the assumptions inherent in a scientific investigation or to consider the consequences of the lack of skepticism in scientific investigations.	…prompts learners to reflect in oral or written form on the thinking involved in the assumptions underlying their own investigations and conclusions and to defend their thinking process.
D1b. …presents science as open and subject to modification based on communication of new knowledge and methods (openness)	…contains no references to the idea of challenging previous scientific knowledge.	…prompts learners to examine previously established scientific ideas, and provides explanations or examples that illustrate how new information can modify accepted scientific knowledge.	…engages learners in analyzing the basis for conclusions in other investigations or in considering the consequences of the lack of openness to modification in scientific knowledge.	…prompts learners to reflect on the reasoning leading to their own conclusions and to defend their thinking process.

D1c. …promotes longing to know and understand (curiosity)	…does not mention or prompt learners to explore the possibility of future investigations stemming from the current inquiry or observations.	…provides explanations and/or examples of how questions for further investigations can spring from a completed inquiry or interesting observations.	…engages learners in analyzing investigations for further questions or to consider the consequences of the lack of curiosity in science.	…prompts learners to reflect on their own development of ideas for investigations and to defend their reasoning.
D1d. …promotes respect for data (honesty)	…does not promote respect for data.	…explains and/or provides examples detailing the use of honest and dishonest data from scientific investigations.	…engages learners in analyzing the validity of data in other investigations or in considering the consequences of dishonest data in science.	…prompts learners to reflect on the importance of reporting and recording observations accurately (vs. reporting what they think it should be) and to articulate the bias and limitations of their data.