Rubric for Evaluating Essential Features of Facilitating Classroom Inquiry

As more and more classrooms move toward teaching science as inquiry, it is important that teachers have the tools available for evaluating the extent to which instruction complements this approach to learning. The Council of State Science Supervisors (CSSS) developed an Instructional Rubric (IR) to assist in identifying the characteristics of classroom instruction that are anchored in inquiry.

A wide range of audiences should be able to use the rubric for a variety of purposes. Someone with limited knowledge of inquiry could use the list of descriptors to develop an understanding of the desired characteristics of inquiry. A teacher or curriculum specialist could use the descriptors, coupled with a limited knowledge of the inquiry criteria, to make informal analyses of inquiry for use in local classrooms. Professional development specialists can use the rubric to guide more inquiry oriented teaching.

The rubric is based on the following CSSS definition of inquiry adapted from the National Science Education Standards (1996).

> Inquiry is the process scientists use to build an understanding of the natural world based on evidence. Learners 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 that is new to them.
>
> 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.
>
> 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).

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Inquiry is essential to effective science teaching and involves a variety of methods of investigation, analysis, interpretation and communication to understand a concept, a process or phenomena. Students need to understand the process of inquiry itself and to develop inquiry skills to study science and achieve all of the desired outcomes: 1.) Understanding the subject matter; 2.) Understanding of the methods that scientists use; 3.) Developing the ability to do investigations; 4.) Developing science habits of mind.

These outcomes form Sections A, B and C of the rubric. The first outcome, however, does not correlate to a specific section of the Instructional Rubric because it is assumed that this outcome has been previously addressed in the Instructional Materials (IM) "How to" session within the professional development package. It is further assumed that good science teaching is, by definition, aligned with the standards.

Each section of this rubric provides an overview of specific teaching behaviors in the descriptor column. Columns marked I through IV contain descriptions of variations of teaching behavior based on the degree to which inquiry is integrated into practice. The nature of the descriptor varies among the sections according to the desired outcomes stated in the section narrative.

The ultimate goal of inquiry-based science instruction is to have teachers functioning at variation IV level for most descriptors. Learners, however, are generally unable to begin with inquiry at this level and will need to progress toward that end over time. It is important that teachers recognize the level at which students are able to accommodate inquiry during instruction. Effective teachers observe students carefully and adjust the amount of structure and guidance for an activity according to the level at which learners are able to ask their own questions, design investigations, and develop their own explanations.

The development of scientific habits of mind results in a set of values and mental attitudes on the part of the learner. These traits, listed in Benchmarks for Science Literacy (1993), include curiosity, honesty, openness, and skepticism. They are described in Section C of the IR. Although these values can be addressed through direct instruction, these skills are developed in a more enduring and transferable form if imbedded in all elements of science teaching. As learners experience the role of investigation and develop their own inquiry skills they can be encouraged to practice habits of mind associated with science. When students study how scientists do their work they begin to understand the role of inquiry in science (as described in Section A), learners become aware of how scientists demonstrate the values and habits of mind associated with science. Because these values are an important part of what students learn through inquiry, they are considered as a group in Section C with references to the related descriptors in sections A and B.

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Upon becoming fluent with the rubric, educators can apply it to review instruction at any grade level. An experienced rubric user who also understands learner development should be able to make judgments about examples, questions, opportunities, and instruction appropriate for a specific group of learners. Based on these judgments, teachers can decide the location on each descriptor continuum where instruction should occur to meet their students' current needs.

Things to keep in mind while using the Instructional Rubric:

- This rubric is designed to facilitate inquiry instruction in science at any grade level.
- The broad scope of this rubric enables the user to apply it to a variety of situations.
- Instruction does not have to be examined against every criterion.
- The rubric scores should not necessarily be aggregated. Scores for each descriptor can be examined separately since it is possible that the objectives are best met by instruction that rates higher in some areas and lower in others.

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As a result of using inquiry to teach science, the instructor will…

A. 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 understanding how scientists study the natural world. Participating in actual scientific inquiry at an appropriate level for the learners allows them to compare their own experiences with that of scientists. This set of descriptors examines the work of scientists and serves as a comparative basis for the work in which learners are engaged. There is a clear distinction between the work carried out by learners as compared to that of scientists, but this difference should only reflect the degree of sophistication. The variations in this section are based upon an increasing correlation of the learner's experiences with their own work.

This section correlates to: NSES: Chapter 3, pgs 29-31
NSES Inquiry Addendum: Chapter 5
Benchmarks: Chapter 1

B. Develop the ability to conduct investigations

Teachers choose instructional strategies that match their learners' abilities and interests, and correspond with the objectives/outcomes or standards of the learning experience. Instruction throughout the school year should follow a progression toward more advanced variations of inquiry. The variations in this section are based upon increasing levels of sophistication.

This section correlates to: NSES: Chapter 3, pgs 29-37; 141, 170, 200
NSES Inquiry Addendum: Chapter 2
Benchmarks: Chapter 12
Foundations: Chapter 1

C. Developing the habits of mind associated with science

Habits of mind can be a difficult topic to teach but can 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 investigators and develop their inquiry skills, they can be encouraged to practice the habits of mind associated with science. When learners study the way scientists do their work they become aware of how scientists demonstrate the values and habits of mind associated with science inquiry. These ideas and attitudes are interdependent and well integrated into the development of the other outcomes of inquiry. Variations in this section are based upon Bloom's Taxonomy of Learning Outcomes (Cognitive Domain).

This section correlates to: NSES: Chapter 3, pgs 29-37; 141, 170, 200
NSES Inquiry Addendum: Chapter 2
Benchmarks: Chapter 12
Foundations: Chapter 1

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A1. Understanding of how scientists work				
Descriptor	Variations			
Instruction…	**I**	**II**	**III**	**IV**
A 1. … provides opportunities for all learners to discover how scientists use what is known to develop questions that lead to different investigations.	… does not mention how scientific questions are developed or why investigations are conducted.	… discusses how scientific questions are developed, but fails to provide direct experiences in asking questions or designing investigations.	… discusses how scientific questions are developed, and provides limited experiences designing investigations.	… provides direct experiences illustrating that scientists use what is already known to develop different types of questions and to design different investigations.
A 2. … provides opportunities for all learners to discover that scientists conduct investigations for a variety of purposes.	… does not mention why investigations are conducted.	… discusses why investigations are conducted but gives no examples that link the purpose to the investigation.	… discusses why investigations are conducted and gives examples but no connection is made between the purpose and the investigation.	… provides direct experiences for learners to see connections between the purpose and the investigation.
A 3. … provides opportunities for all learners to discover that scientists use a variety of tools, technology, and methods to extend the senses.	… does not mention why or how the senses are extended.	… discusses why the senses should be extended, but gives no examples of how this occurs.	… discusses why and how the senses are extended and gives examples, but provides no direct experiences.	… provides direct experiences that extend the senses to gather evidence, guide inquiry, and analyze data. Helps learners to connect the examples/experiences to their own work. Guides the learner in recognizing that the accuracy and precision of data depends upon the quality and choice of tools.
A 4. … provides opportunities for all learners to discover that mathematics is essential in scientific inquiry.	… does not mention the application of mathematics to inquiry.	… discusses the application of mathematics to inquiry but gives no examples.	… discusses the use of mathematics to inquiry, and examples are provided, but no connection is made with the learner's work.	… provides direct experiences that apply mathematics for data collection, analysis, and communication of findings. Helps learners to connect the experiences with their own work.

A 5. … provides opportunities for all learners to discover that scientists use evidence, logic, and current scientific information to support theories.	… does not mention how scientists use current scientific knowledge to support theories.	… discusses how scientists use scientific knowledge to support theories but no examples are provided.	… discusses how scientists propose explanations, examples are provided, but offers no direct experience based on analysis and synthesis of new evidence with prior scientific knowledge.	… provides direct experiences illustrating that proposed explanations are based on analysis and synthesis of new evidence with prior scientific knowledge.
A 6. ... provides opportunities for all learners to discover that scientists collaborate and communicate in a variety of ways to reach widely accepted explanations	… does not mention how scientists collaborate and communicate through oral and/or written communication.	… discusses how scientists collaborate and communicate, but gives no examples.	… discusses how scientists collaborate and communicate. Some examples are provided, but learners are not required to connect it with their own work.	… provides direct experiences that support the importance of collaboration, clarity, accuracy, logic, criticism, and skepticism in communication as a means of reaching commonly accepted explanations. Assists learners to connect the experiences with their own work through oral/written presentations.

B1. Posing scientifically oriented questions				
Descriptor	Variations			
Instruction…	**I**	**II**	**III**	**IV**
B1a. … provides opportunities for all learners to pose questions that can be feasibly explored through scientific investigation.	… does not provide opportunities for learners to pose questions for scientific investigation.	… enables learner to select among provided questions.	… enables learners to select among provided questions and to pose new questions for investigation without evaluating their feasibility.	… expects learners to pose and evaluate the feasibility of new questions for investigation.
B2. Designing and conducting investigations				
Descriptor	Variations			
Instruction…	**I**	**II**	**III**	**IV**
B2a. … engages all learners in planning investigations and gathering relevant evidence based on questions.	… provides a complete plan for the investigation.	… provides guidelines for learners to plan part or all of an investigation based on the required evidence and appropriate methods.	… assists learners to plan a full investigation based on their determination of required evidence and appropriate methods. Minimal guidance is provided.	… expects learners to plan an independent investigation based on their determination of required evidence and appropriate methods.
B2b. … engages all learners in conducting investigations.	… provides a procedure for conducting the investigation.	… provides questions, directs the learner regarding procedure, and specifies data to collect.	… engages learners in determining what constitutes correct procedure, appropriate data, and collection methods.	… expects learners to complete an independent investigation based on their own determination of what constitutes correct procedure, and appropriate data collection methods.
B2c. … engages all learners in using analytic skills, mathematics and technology.	… does not require learners to apply analytic skills.	… provides specific guidelines for learners to apply analytic skills, mathematics, and technology to gather and analyze data.	… assists learners in using analytic skills, mathematics, and technology to gather and analyze data. Minimal guidance is provided.	… expects learners to independently apply analytic skills, mathematics, and technology to gather and analyze data.

B3. Proposing explanations				
Descriptor	Variations			
Instruction…	**I**	**II**	**III**	**IV**
B3a. … engages all learners in proposing answers and explanations to questions.	… provides no opportunity for learners to propose answers and explanations to questions.	… provides data and encourages learners to analyze data for answering specific questions.	… guides learners to collect and analyze certain data to answer specific questions.	… expects learners to analyze data for proposing explanations to their original questions.
B4. Comparing explanations with current scientific knowledge				
Descriptor	Variations			
Instruction…	**I**	**II**	**III**	**IV**
B4a. … engages all learners in considering alternative explanations.	… does not describe a process for generating an explanation.	… guides learners to develop a conclusion and a single explanation.	… encourages learners to consider and state alternative explanations.	… expects learners to construct, consider, state, investigate, and evaluate alternative explanations.
B4b. ... engages all learners in linking explanations and conclusions with supporting scientific knowledge and experimental data.	… does not encourage learners to link explanations and conclusions with scientific knowledge or experimental data.	… provides guidelines requiring learners to link scientific knowledge and experimental data with explanations and conclusions.	… encourages learners to discover linkages between scientific knowledge and experimental data with explanations and conclusions.	… expects learners to independently link scientific knowledge and experimental data with explanations and conclusions.
B5. Communicating and justifying results				
Descriptor	Variations			
Instruction…	**I**	**II**	**III**	**IV**
B5a. … engages all learners in communicating scientific procedures and explanations.	… does not encourage communication of any aspects of the investigation.	… encourages learners to follow prescribed communication procedures for some aspects of the investigation.	… encourages learners to communicate some aspects of the investigation in their own style and format.	… expects learners to clearly communicate all aspects of their own investigation, including the question, procedures, alternative explanations, and conclusions.

B5b. … engages all learners in responding appropriately to critical commentary.	… does not encourage learners to use evidence to justify or critically evaluate explanations.	… coaches learners to use evidence in justifying and responding to critical comments.	… encourages learners to use guidelines for evidence to justify and respond to critical commentary.	… expects learners to use evidence to form reasonable and logical arguments and to adequately respond to critical commentary.
B5c. … engages all learners in raising new questions and refining previous questions.	… provides no opportunity for additional questions to be generated.	… encourages learners to raise additional questions without the opportunity to refine the questions.	… provides an opportunity for learners to generate and refine questions, using prescribed criteria.	… expects learners to generate and refine their questions based on new evidence acquired during an investigation.
B6. Supporting a climate for inquiry				
Descriptor	Variations			
The Instructor…	**I**	**II**	**III**	**IV**
B6a. … maintains a classroom environment that is safe for teaching science as inquiry.	… provides a classroom environment that marginally addresses classroom safety concerns.	… makes some attempt to provide a safe classroom environment.	… makes many attempts to provide a safe classroom environment.	… creates and maintains a safe classroom environment.
B6b. … makes accommodations for the needs of all learners as participants in inquiry.	… does not have the expectation that all learners are capable of engaging in science as inquiry.	… makes some accommodations for learner diversity, but has little or no expectation that all learners are capable of engaging in science as inquiry.	. makes accommodations for learner diversity, and expects that most learners are capable of engaging in science as inquiry.	… makes accommodations consistently that fully address learner diversity and supports engaging in science as inquiry for all learners.
B6c. … models habits of inquiry through instruction.	… seldom models the habits of inquiry.	… models the habits of inquiry inconsistently while expecting guidelines to be followed.	… models the habits of inquiry, but lacks an approach that stimulates learners' to assume the habits of inquiry.	… encourages and models the process of science as inquiry and evaluates progress toward development of these skills.

B6d. … makes resources necessary for inquiry available and accessible to all learners.	… does not provide adequate resources or make resources fully accessible.	… recognizes the need to provide a variety of resources for doing science, but does not provide full access to available resources.	… recognizes and addresses the need for diverse and adequate resources, but does not provide access to all learners.	… makes all appropriate science tools, materials, media, and technological resources available and accessible to all learners.
B6e. … customizes assessments for the conditions of inquiry for all learners.	… does not provide appropriate assessments for inquiry conditions.	… employs assessments that are appropriate for the conditions of inquiry occasionally.	… employs assessments that are appropriate for the conditions of inquiry generally.	… tailors assessments for the conditions of inquiry that are consistent with the needs and abilities of all learners.

C1. Developing the habits of mind associated with science				
Descriptor	Variations			
Instruction…	**I**	**II**	**III**	**IV**
C1a. … 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 assumptions inherent in a scientific investigation and to consider the implications of skepticism in scientific investigations.	… expects learners to reflect upon assumptions that underlie their investigation and conclusions and to defend their thinking process.
C1b. … presents science as open to change based on new information. (openness)	… does not encourage the examination of current scientific knowledge.	… encourages learners to examine previously established scientific ideas, but does not provide examples that illustrate how new information can modify accepted scientific knowledge.	… encourages learners to examine previously established scientific ideas and occasionally provides examples that illustrate how new information can modify accepted scientific knowledge.	… expects learners to examine previously established scientific ideas, explain how new information can modify previously accepted scientific knowledge, and reconsider conclusions when presented with new information.
C1c. … promotes the desire to know and understand. (curiosity)	… does not prompt learners to explore possibilities arising from the current investigation.	… encourages learners to explore possibilities arising from the current investigation.	… engages learners in analyzing investigations to seek further questions and to consider additional explanations or conclusions.	… expects learners to reflect upon their development of ideas for investigations, to search for additional questions, and to consider alternate explanations or conclusions.
C1d. … promotes respect for data. (honesty)	… does not promote the importance for accuracy, collection or reporting of data.	… explains the need for accuracy in reporting data, but does not provide examples of appropriate applications of data.	… explains the necessity for accuracy in reporting data, provides examples of the appropriate application of data.	… expects learners to reflect upon the importance of recording and reporting observations accurately and honestly, and to evaluate and consider biases and limitations inherent in reported data.