A Rubric for Selecting Inquiry-Based Activities

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Abstract

Evaluating instructional materials for their merits as inquiry activities is challenging for teachers. This article introduces a definition of inquiry and the *Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials*, both developed by an initiative called NLIST (Networking for Leadership, Inquiry, and Systemic Thinking).

Introduction

The National Science Education Standards (NSES) encourage the use of inquiry-based learning in science classrooms. The power of inquiry learning has been established by research, summarized in *Inquiry and the National Science Education Standards* (National Research Council, 2000). Benefits of inquiry for students include increased comprehension, development of thinking skills, firsthand observation and experience, collaboration, metacognition, transfer, and others. According to Haury (1993), inquiry-based science may produce scientific literacy, knowledge of science procedures, vocabulary, conceptual understanding, and positive attitudes toward science. In 1999, Von Secker and Lissitz (1999) found that laboratory inquiry correlated with greater science achievement. Why, then, has inquiry not yet become a primary pedagogical method in most science classrooms?

One answer to this question is that there are a number of challenges associated with inquiry. Prominent among them is selecting instructional materials – curriculum units, lesson plans, and activities – that reflect the philosophy of science as inquiry and contain all of its components as delineated by the NSES.

The Networking for Leadership, Inquiry, and Systemic Thinking (NLIST) initiative sponsored by the Council of State Supervisors and NASA, has sought to implement science as inquiry teaching in classrooms since March of 1999. Addressing the educational system as a whole, this initiative seeks to produce tools to assist in the implementation and evaluation of inquiry-based learning. Two products – a Definition of science as inquiry and a Rubric for evaluating instructional materials – should help address the challenge of selecting appropriate instructional materials. This article introduces the Definition and Rubric, which are available now for all teachers to use.

Challenges in Implementing Inquiry

A number of studies indicate that several barriers to using inquiry in science education exist, including lack of administrative understanding and support, and lack of time and resources (Costenson & Lawson, 1986). Teachers have little planning time (Smagorinsky, 1999), and substantial amounts are needed to develop innovative instruction. Instructional time is also limited, and inquiry processes consume lengthy periods, especially in the short term. Teachers may well lack the physical materials needed to support inquiry, but instructional resources have been a more pressing need. Many textbooks have not provided adequate inquiry infusion in the past (Budiansky, 2001; Roseman, Kulm, & Shuttleworth, 2001; Yager, 1997). Without reliable support for inquiry from textbooks, teachers are required to use their limited planning time to seek out and choose inquiry activities, which have been in short supply.

Another barrier has to do with the nature of many widely available “inquiry activities.” In an effort to simplify the complex inquiry process for classroom application, authors of these activities often present them as recipe-like procedures. A good example of this was anatomical dissection, which often resulted in students cutting up a frog merely to see its insides with no real idea of why they should do so. Many teachers over the years have grown to associate such activities with “inquiry.” Failing to see their usefulness, they understandably select other ways to use instructional time.

The scarcity of inquiry instructional materials has changed somewhat over the past five years. The NSES have stimulated the production of commercial science materials that purport to support inquiry, including textbooks (Raloff, 2001). New programs like *SciLinks*[1] help to link textbook materials with Internet-based resources. In addition, the Internet abounds with "inquiry-based" lessons posted by educational and commercial agencies and teachers themselves. Unfortunately, close examination of many of these materials reveals that they do not always live up to their claims. How might a teacher choose wisely from among the new wealth of these resources?

Selecting good inquiry resources: The Rubric

Selecting inquiry resources is a difficult task for at least two reasons. First, it is likely that many teachers in schools today have had little opportunity to study, or practice the inquiry process, especially those teaching in general fields or out of field. Second, many teachers feel that there are many facets to the inquiry process and that remembering all of them is difficult. A succinct but comprehensive tool is needed to evaluate inquiry materials.

In 1999, the Council of State Science Supervisors began an initiative called Networking for Leadership, Inquiry and Systemic Thinking, or NLIST. Funded by NASA, a group of leading science educators from across the country convened to design a systemic plan to facilitate inquiry in science teaching on a national scale. As a first step, NLIST produced a definition of "science as inquiry," based upon the short descriptions of inquiry found in the NSES, which were in turn built upon current ideas and research from within the science education discipline. After months of work reviewing and synthesizing current literature with the NSES and the work of Project 2061, this Definition of Inquiry was established:

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[1]SciLinks (http://www.scilinks.org) partners with several publishing companies to provide "codes" in textbooks that link to online resources and materials.

> Inquiry is the process scientists use to build an understanding of the natural world. Students can learn about the world using inquiry. Although students rarely discover knowledge that is new to humankind, current research indicates that students engaged in inquiry build knowledge new to themselves.
>
> Student inquiry is a multi-facetted 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 student'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, gain an understanding of how scientists study the natural world, develop the ability to conduct investigations, and develop the habits of mind associated with science.

The next step, beginning in July of 2000, was to construct a rubric that educators could use to evaluate instructional materials according to the principles of inquiry laid out in the Definition. The result was the *Rubric for Evaluating Essential Features of Classroom Inquiry in*

Instructional Materials. Due to its grounding in the NSES, the Rubric reflects the spirit of inquiry as expressed by the NSES.

Understanding the Rubric

From the beginning, this Rubric was visualized as an online product to be widely shared among science educators. According to the Definition, science as inquiry provides four learning outcomes for students: content knowledge, understanding of how scientists work, ability to conduct investigations, and habits of mind associated with science. The four sections of the Rubric are based upon these four outcomes. Each section contains descriptors, or characteristics, that materials should have in order to support learners as they work toward these outcomes (see Box 2).

The first section, Section A, deals with content. If an instructional resource fails to address relevant science content, then it is of little use, regardless of its strength in the area of inquiry. The three descriptors in this Section assure that content aligns with applicable standards, that the material provides adequate opportunity for learners to develop content knowledge, and that content is accurate.

The Definition of Inquiry holds that learners should understand how scientists conduct their work. This understanding gives students an overview of the inquiry process, and context for interpreting the many research studies that are presented and misrepresented in the press. For example, through understanding the nature of experimentation, students should understand that science rarely establishes the cause of phenomena, but that through observation and experimentation two types of phenomena can be found to be closely related or dependent in part upon one another. Section B explores how well a material provides opportunities for learners to understand that science is based upon questions, and that different kinds of questions lead to different kinds of investigations; and that scientists use tools, mathematics, evidence, logic, communication, and collaboration in the inquiry process.

Section C of the Rubric establishes that an inquiry activity should provide opportunities for students to conduct investigations themselves. The five subsections here with their 14 descriptors provide a framework of the inquiry process, encouraging students to participate in each step of an investigation and to acquire the related skills.

Finally, Section D deals with ways of thinking, or “habits of mind,” that should accompany and result from the inquiry process. This section provides descriptions of how a material might promote skepticism, openness (the flexibility to consider new explanations although an opinion may have already been formed), curiosity, and honesty (emphasizing that conclusions must be based upon evidence). Without at least these four habits of mind, an instructional material fails to tap the power of inquiry-based learning. More habits of mind than the ones listed are associated with science as inquiry, such as creativity, but these four characteristics leant themselves to description in this Rubric.

Four variations are provided for each descriptor, ranging from I (little or no alignment with the Definition) to IV (reflecting a high level of independent inquiry immersion for learners). A full-scale inquiry project, such as an advanced science fair project conducted independently by a student, will reflect Variation III’s or IV’s on each descriptor. However, it is unlikely that every material will align with Variation IV on each descriptor. For example, Mrs. Smith plans for her seventh grade students to practice their skills of observation within the context of an inquiry and may wish to select an activity that aligns strongly with Variation III or IV in the C2 and C3 areas of the Rubric.

Further, it is important to acknowledge that the Level Variation IV's for the entire Rubric represent an ideal accumulation of inquiry skills that instructional materials might facilitate. The levels that run across any particular descriptor are not intended to represent a seamless continuum or developmental level for a particular grade level, but the degree of alignment at which instructional materials models a particular facet of science as inquiry. One particular strength of this Rubric is that each of the Variations presents concrete strategic ideas about how a material can help learners develop their inquiry skills. For example, if Mr. Brown wants his 8^{th} grade students to develop their ability to ask questions, and he knows that they are typically able to take a general provided question and sharpen it so that it is then suitable for investigation (C1a, Level Variation II), then he might may select an activity that allows an opportunity to select a question from a provided list, and/or to propose questions of their own (C1a, Level Variation III).

An outline of the *Rubric* descriptors is provided in Box 2. The full Rubric can be found at: http://www.inquiryscience.com/inquiry/resources/samplerubric.htm. Although the Rubric is still undergoing reliability testing and final editing, NLIST welcomes teachers, media specialists, curriculum directors, and administrators to use the Rubric.

A. Increase their understanding of the science subject matter investigated

A1. Content:

A1a. The material provides content aligned with national, state or local standards.

A1b. The material provides opportunity to develop enduring understanding of subject matter content.

A1c. The material contains accurate content.

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

B1. Understanding of how scientists work

B1a. The material provides an opportunity to learn how different kinds of questions based on prior scientific knowledge suggest different kinds of investigations.

B1b. The material provides an opportunity to learn that scientists conduct investigation for a variety of reasons.

B1c. The material provides an opportunity to learn that scientists use a variety of tools, technology, and methods to extend the senses.

B1d. The material provides an opportunity to learn that mathematics is essential in scientific inquiry.

B1e. The material provides an opportunity to learn that scientists use evidence, logic, and current scientific knowledge to propose explanations.

B1f. The material provides an opportunity to learn that scientists collaborate and communicate with each other in a variety of ways to reach well-accepted explanations.

C. Develop the ability to conduct investigations

C1. Posing scientifically oriented questions

C1a. The material provides an opportunity to ask questions that can be answered through scientific investigations.

C2. Designing and Conducting Investigations

C2a. The material engages learners in planning investigations to gather evidence in response to questions.

C2b. The material engages learners in conducting the investigation.

C2c. The material engages learners in the use of analytical skills.

C3. Proposing Answers

C3a. The material engages learners in proposing answers and explanations to questions.

C4. Comparing explanations with current scientific knowledge

C4a. The material engages learners in the consideration of alternative explanations.

C4b. The material engages learners in linking explanations with scientific knowledge.

C5. Communicating and justifying results

C5a. The material engages learners in communication of scientific procedures and explanations.

C5b. The material engages learners in appropriately responding to critical comments.

C5c. The material engages learners in raising additional questions.

D. Developing the habits of mind associated with science

D1. Developing the habits of mind associated with science

D1a. The material promotes the questioning of assumptions (skepticism).

D1b. The material presents science as open and subject to modification based on communication of new knowledge and methods (openness).

D1c. The material promotes longing to know and understand (curiosity).

D1d. The material promotes respect for data (honesty).

Applying the Rubric

An educator in any position who has limited knowledge of inquiry may use the Rubric's list of descriptors to develop an understanding of the desired characteristics of inquiry materials. Educators who might find themselves in the position of needing to learn more about inquiry include administrators, media specialists, policy makers, and developers of educational materials, in addition to teachers themselves.

Another need that most educators have is to implement standards. Because this Rubric is based upon national standards, it will help in selecting materials that will in turn help to ensure that standards are met. Further, teachers desiring to focus on specific inquiry skills (such as observation in the case of Mrs. Smith above) may use the Rubric to identify materials that emphasize that particular skill.

A third application is the formal selection or adoption of educational materials, such as textbooks or online resources. Although applying the *Rubric* to a textbook or web site as a whole would be difficult since it is designed for evaluating a single inquiry activity, the principles it contains can be used to ensure that a textbook or site carries the spirit of inquiry at least on a general level if not in every single activity.

Finally, anyone who develops science materials, such as software designers, textbook authors, and teachers, may use the *Rubric* to identify characteristics needed for inquiry materials, and how to enrich existing materials to make them more inquiry-friendly.

Summary

In the face of today's information explosion, students must acquire the ability to conduct disciplined inquiries based on their own questions. It is no longer possible for educated adults to know everything about a topic, but it is essential that they know how to discover answers to questions that are relevant in their personal and professional lives. Scientific inquiry is one essential tool for discovering answers. With this overarching goal in mind, the Council of State Science Supervisors, in conjunction with funding from NASA, has outlined the NLIST systemic vision, which is generating products to help increase the effectiveness of all the elements in the educational system. The *Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials* is a product that can help bring the NLIST vision to life.

In the months to come, the next phase of NLIST will generate a plan for the professional development of educators as related to science inquiry. Be sure to visit http://www.inquiryscience.com/inquiry/resources/resources.htm to keep abreast of these products as they become available.

Authors' Note:

NLIST has sponsorship and/or representation from each of the following organizations: National Aeronautics and Space Administration, American Academy for the Advancement of Science, Eisenhower National Clearinghouse, Council of Chief State School Officers, National Science Education Leadership Association, Council of Basic Education, National Research Council, and Council of State Science Supervisors. Participants include Erma Anderson, Lucille Andolfo, G. Kip Bollinger, Leah Bricker, Al Byers, Rowena S. Douglas, Sue Drummer, Jeane Dughi, Sue Darnell Ellis, Brenda Evans, Joseph Exline, Mary Ann Fitzgerald, Robin Fogarty, Tom Gadsden, Mary Gromko, Carol Hanley, Tony Heiting, Marcie Hickman, Christina Hilton, Linda Jordan, Page Keeley, Tricia Kerr, Shelley Lee, Kathleen Lundgren, Arthur E. Mitchell, Brett Moulding, George Nelson, Harold Pratt, Elise Russo, Linda Sinclair, Cheryl Tibbals, Deborah Tucker, CJ Varnon, Laurie Martin Vermilyea, Richard Vineyard, Steve Weinberg, Marsha Winegarner, and Jim Woodland.

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