Reports from Other Journals

The Inquiry Wheel, an Alternative to the Scientific Method

A View of the Science Education Research Literature

by William R. Robinson

For many years I have felt that the scientific method as presented in many textbooks was not how my colleagues in chemistry did research. Even so, when I wrote a general chemistry text I was told to put in a description of the scientific method because it was expected. Now, Reiff, Harwood, and Phillipson have developed a more satisfactory model of scientific inquiry, the inquiry wheel, based on information gathered from practicing scientists. This model is described in their paper "A Scientific Method Based upon Research Scientists' Conceptions of Scientific Inquiry" *(1)* based on interview data described in "Scientists' Conceptions of Scientific Inquiry: Voices from the Front" *(2)*.

The informants in this research were 52 science faculty members in nine science departments (anthropology, biology, chemistry, geography, geology, medical sciences, physics, applied health, and environmental affairs) at a large midwestern research university. They were interviewed using a protocol designed to probe their conceptions of scientific inquiry. The interview began with the question "what is your definition of scientific inquiry?", wound through other related questions, then finished up with an opportunity for the scientists to revise their definitions of scientific inquiry after articulating ideas that came up during the interview. Transcripts of the recorded interviews and field notes were read, reread, and discussed as the data were collected and coded. It was apparent that concepts and descriptions from one interview often corresponded to concepts in another. Thus, categories and concepts regarding the process of scientific inquiry emerged and led to the description of the inquiry wheel illustrated in Figure 1 and discussed below.

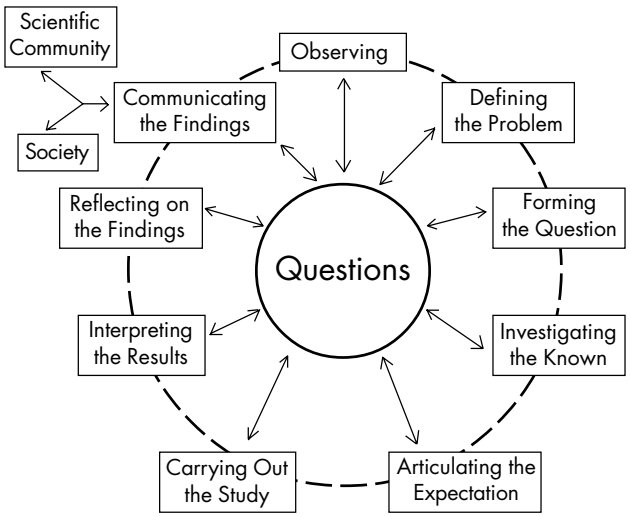

Figure 1. The Inquiry Wheel, Stages of Scientific Inquiry.

However, before we look at the inquiry wheel, I think it worth noting that the majority of the scientists interviewed (38 of 52) identified the most important aspect of an investigation as being literature based. To them a worthwhile investigation was one that crossed the boundary from the known to the unknown and a knowledge of the literature is important in identifying that boundary.

Stages of Scientific Inquiry

As a result of their interviews *(2)*, the investigators describe the process used by scientists as they pursue research as a wheel with questions at the hub and various stages of the inquiry in a circular arrangement around the hub *(1)*. They note that the process of scientific inquiry can begin from any stage and that stages may be revisited as often as the particular inquiry requires. They also state that all stages will be engaged at least once during an inquiry and that the force driving the inquiry is an investigator's questions.

Harwood, Reiff, and Phillipson also point out that the stages that occur during an inquiry need not follow the circular path found around the periphery of the inquiry wheel. In fact, a scientific inquiry may begin at any one of the states around the wheel. Even the process of communicating the results of one investigation can prompt questions from the community that lead to another investigation.

Observations

The observations implied in this stage are not those obtained while carrying out the study, rather they are the observations that generate questions. These include observations resulting from using the senses in the field or in the laboratory, from reading the literature, and from a sense of curiosity.

Defining the Problem

Based on their observations, knowledge of the literature, and communications with colleagues, scientists identify a problem. They must then decide, based on their experience and that of others, what problems are capable of resolution and worth investigating. In some cases these decisions reflect not only input from the scientific community but also input from society.

Forming the Question

Many times a problem is turned into a question that serves as the focus of an investigation. However, in textbooks describing the scientific method defining the problem tends to be followed sequentially by forming a question. In fact, the results of the interviews in the study suggest that any of

the stages in the inquiry wheel could lead to new or revised questions.

Investigating the Known

Reading the literature or communicating directly with other scientists allows scientists "to define the boundary between what is already known and unknown about the issue" *(1).* The authors cite a medical scientist who described this process as moving from "the certainty to uncertainty." Their informants place a high value on seeking answers to questions that have the potential to extend our understanding from the known to the unknown.

Articulating the Expectation

A knowledge of what is known about a question and an understanding of the answers to related questions guide a scientist in developing a preliminary answer to the question or to developing a revised question. These preliminary answers are the hypotheses of the scientific method as commonly described.

Carrying out the Study

After planning and designing an investigation scientists seek an evidence-based answer to the question. Each scientist chooses from the various methods that are appropriate to his or her discipline to conduct a study.

Interpreting the Results

To quote the authors, "For some scientists, this is where science really begins. A health scientist explains, 'I think too many people think science is collecting data in the lab. What I tell my students is that science begins after you have collected the data.' The final stages of checking procedures, going back to the literature, synthesizing data, taking a step back from the data, sharing results are places where meaningful discoveries can be made."

Reflecting on the Findings

Again to quote the authors, "Unlike the interpretation stage where findings deal with what the results *say*, reflecting on the findings determines what the results *mean*." Reflection involves trying to find significance in the data, looking for patterns in the data, and thinking about how it might connect to other known information.

Communicating the Results

"If information is not shared with others then it may as well not have existed." This is the opinion expressed by a geographer who stressed the necessity of communicating findings to both the scientific community and to the public *(1).* Communication does not just happen at the end of an investigation, scientists communicate with other scientists throughout most investigations. The authors also note that a second, and also important, audience for scientific information is the general public. The gap in the public's perceptions of science and how to obtain scientifically valid information concerned some informants.

Questions

The authors describe the inquiry wheel as a process that is fueled by questions that spark investigations. Questions are the core of inquiry.

Summary

In the authors' words:

> This study provides an insight into scientists' beliefs regarding scientific inquiry; that is, what scientists believe they do and the general approach they believe they use. Lederman *(3)* indicates that the conventional wisdom is that approaches to scientific inquiry vary widely within and across scientific disciplines and fields. Our results suggest that the approach to scientific inquiry is common to the diverse group of scientists who participated in our study regardless of discipline. The tools and techniques that scientists use in a particular study will, of course, vary with the goals of the study. It is clear that the formal rules that scientists use for reporting out the results of their scientific inquiries differ from discipline to discipline. Thus, the process of scientific inquiry is discipline-free, while its implementation is discipline specific.

Literature Cited

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