One Size Fits None?

Kip Ault
Lewis & Clark College

VEXATION

A zoologist friend of mine once remarked, "The science is in the debate." He was referring to community process—to scrutiny of contested claims in a public forum, with resolution dependent about judging the quality of inquiry. Those debating hold stature according to their expertise while aspiring to achieve explanatory ideals, which may be, in turn, under debate. Presumably, debate and scrutiny promote the progress of understanding as well as uphold standards of reasonable discourse. These ends (progress and reason) depend upon how a community of practice, in pursuit of shared purposes, organizes its patterns of interaction and communication. These patterns ought to restrain the irrationality of individuals resulting in poor science and thus contribute to the common good.

In large measure, the existence of the profession of science educators depends upon translating and transforming patterns characteristic of "what scientists do" into school science. This shared purpose permeates science educators' community of practice and leads to educational (as well as explanatory) ideals. Among these are introducing science to novices as a culture—with distinctive patterns of discourse, methods of investigation, and approaches to adjudicating disputes made explicit. The science education community, in concert with political processes and policies, has codified this aim into various state and national standards for teaching and learning science. These standards function to hold students (and schools) accountable to prescribed ends (ends similar to the way scientists are held accountable); these ends embodying what scientists do and know. Central to this codification for the sake of accountability is the depiction of what patterns of communication and interaction promote progress in understanding and the achievement of explanatory ideals.

What notions of scientific culture(s) do standards embody? Are these depictions valid? Are they educationally sound? The most enduring word subsuming depictions of science for the sake of guiding and improving school science is "process." The notion that a small set of abstract processes unify the sciences appears endemic within standards documents. Among these processes are observation, inference, and the pursuit of controlled experiments.

My vexation, over the course of 30 years, is that the over-generalization of process and de-contextualization of content in school science misrepresents what different scientists in different disciplines do in solving particular problems. It diverts attention away from actual expertise—from how the work of scientists, in keeping with distinctive purposes and interests, actually happens. As a consequence, science standards (whether national, state, or district) tend to bifurcate between depicting science as generalized processes and science as content in three, traditional domains (earth/space, physical, and life science).

Process-dominance encourages the integration of particular subjects with generic methodologies in order to abstract general principles about the nature of science—focusing, for example, on observing and inferring, whatever the topic. The precise ways in which inferences unfold within a purposeful context remains back, if not off, stage. For example, paleontologists in attempts to draw inferences about fossil dinosaur footprints invoke analogies: to bipedal birds in some instances and fighting hippos in others. Such imagery powers inference-making specific to the discipline, a clear indication of the intellectual capital the paleontological research community depends upon.

Bifurcation emphasizes the content (typically expressed in propositional form) students ought to know while simultaneously valuing their ability to design and carry out scientific investigations—or at least to appreciate the qualities that distinguish scientific investigation from other approaches to inquiry. Bifurcation, at the same time, discounts how knowledge of a particular phenomenon functions as a tool of inquiry, molding and shaping appropriate methodology—methodology judged effective at achieving particular insights, important within a community of shared purpose.

The quest for universal aspects of science—for the one size that fits all representation—obscures how methods of investigation and conceptual understandings mutually interact in productive and distinct ways. Instead of first asking, "How do paleontologists interpret fossil footprints in order to figure out how dinosaurs behaved?" curriculum design, as promoted by *Science for All Americans* (1989), proceeds by identifying the common themes and habits of mind spanning all the disciplines—a clear case of one size fits all thinking.

For some time science educators have embraced this quest for generic abstractions or common themes and habits of mind ("the" method, process, or nature of science) that might subsume all subjects in science. This embrace merits a skeptical response and consideration of an alternative aim: casting content areas themselves as different ways of conducting inquiry, as potential social capital: flows of information, ways of communicating, commitments to explanatory ideals, and methods of investigation that constitute, in a word, expertise. Rather than integrate a generic conception of inquiry with specific content, the aim becomes to see understanding itself (root metaphors, trusted propositions, the heritage of disciplined thinking within particular contexts) as inquiry's primary resource.

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A recasting the essential questions of curriculum design away from the generic and toward the particular follow from this change in perspective. Asking, “How do geologists use the concept of time?” might replace, “What themes and habits of mind are common to all the sciences?” Instead of trying to determine “Which processes define inquiry as scientific?” perhaps science educators might ponder, “What is the value of understanding geologic time?” Rather than worrying about “What aspects of the nature of science should all students learn?” attention might better focus on “How does a paleontologist figure out the behavior of extinct beasts from fossil footprints?” This last question, at first glance almost painfully specific, does allude to a general idea: science is what scientists do. In this respect, particular questions are quite general in nature.

Here is another question of similar type from a different content area: “Which protocols yield reliable measures of the scale of invasion of habitats by non-native species?” Such questions aim to integrate concepts about phenomena of interest (geologic time, extinction, fossils, non-native species, habitats) with how these phenomena are investigated. The ideas themselves are tools of inquiry—understandings recycled in order to learn more. The geologic time scale, for example, organizes the rock record of the past and thus enables asking questions about extinction rates. Such questions get at expertise—the combination of knowledge and know-how needed to pursue inquiry in particular contexts, making what scientists do interesting and productive.

These questions keep attention focused on phenomena of interest (footprints and behavior) within a context of importance (the fossil record and extinction). Methods of inquiry (or “processes of science”) are deemed appropriate if adapted to the purpose of deepening understanding of both the phenomenon and its context. Methods of inquiry, from this perspective, are very important, but not because they unify the sciences. Quite the opposite point of view emerges: the diversity of the sciences. Ultimately, the quest for unification fades to the status of misplaced myth—a myth that functions to justify inculcation of a worldview in which scientific inquiry as a unified enterprise produces objective truth. Thus, in my view, the process-centric approach wanders far afield from the aim of crafting experiences and constructing ideas useful to the conduct of particular inquiries.

VENTURE

A physics teacher once shared with me, “Scientists don’t do labs, they design investigations.” Classroom teachers tend to gravitate to this principle, especially those anxious to promote scientific inquiry in their classrooms. Often they instruct their students in the processes of science as a way to prepare them to design investigations—yet all too often find student confusion, disinterest, and avoidance of risk a common response. The students may be saying that there is too much uncertainty for them to tolerate, especially in a climate of accountability. Perhaps they do not trust that what they are being asked to do will serve them well.

I convened this past spring from a local high school a small number of science teachers anxious to promote inquiry in their classrooms. I listened carefully to their own views on scientific processes, accountability, and subject-specific problem solving. The first meeting produced a desire to meet again on the topic—a very satisfying result, given the reality of looming layoffs and class-size increases expected for next year. Creating trust between the teachers and me will be paramount. I wondered, however, will my perspective—and framing of the debate (one-size-fits-all versus tools-of-the-trade) be embraced or resisted, comprehended or misunderstood?

I would like to collaborate with them to examine differences among students’ responses to instruction in generalized processes of inquiry versus particularized methods of investigation.

- What design ought I to pursue? I realize that I need to engage teachers in designing such research so that various exercises for students lead, in the teachers’ minds, toward instructional aims they value.
- How do I engage the teachers successfully?
- What records of student thinking/learning would be most appropriate?
- What difference does the representation of science as unified versus the representation of science as diversified makes to teachers and students?
- How does one investigate such a question in real classrooms?