Technical Knowledge in Science Teaching

GARTH D. BENSON
The University of Calgary

The issues involved with learning are varied, but a central concern is the increasing use of technical knowledge to understand the world. This concern leads us to question the nature and conceptualization of knowledge and moves us into the philosophical areas of ontology and epistemology - the meaning and grounds of knowledge. We are also moving into a sociocultural area where justification of knowledge becomes important. In education, constrained as it is by curriculum guidelines and procedures for bureaucratic and administrative accountability, we also discover that the conceptualization of knowledge involves sociocultural constraints as to what counts as a viable understanding of the world. Technical knowledge has come to gain social and cultural predominance, both as an aim of education and as a means of educating. Thus, the place of technical knowledge in science teaching involves both an implicit philosophical world view and, indirectly, a sociocultural milieu which condones that view. It is the combination of these two factors that estranges students from scientific knowledge and helps reproduce technical knowledge.

Research in teacher education suggests that two types of knowledge are integral to the act of teaching. They are the disciplinary or repertory content of the subject matter and what has become known as the personal practical knowledge of the teaching process (Connelly & Clandinin, 1985). Clearly, the two types of knowledge are intertwined and the concepts leading to this conclusion suggest three basic questions: What does it mean to be a teacher of a specific discipline? What forms of knowledge are presented in classroom lessons? And what are the consequences for that knowledge in understanding the world?

The second question is the focus of this paper. The argument is that for a biology teacher, the two types of knowledge are presented during classroom lessons. Directing this knowledge is a philosophical orientation, the metaphysical belief that orients a person to the world and provides a philosophical basis for interpreting the world. An important element of the orientation is the person's conceptualization of the nature of reality. Thus, a world view determines how the world is made sense of and how a person comes to know what is accepted as knowledge. It is my contention that both curriculum in general, and science curriculum in particular, have adopted a world view which encourages students

to conceptualize knowledge in a technical way. Thus, the argument is that during the process of teaching, an analytic world view is presented to students and it results in the estrangement of a practical understanding of the world. The argument will be developed by providing an illustrative example of teaching that projects a world view, by examining the consequences that the projected world view has for student's understanding of the world, by examining the teacher's rationale from the knowledge that is presented, and by discussing the implications of such a rationale.

Analytic frame of reference

Pepper (1942) has provided us with a theory to account for the ways people come to understand reality and how they establish criteria for truth. The theory consists of six philosophical orientations or "world hypotheses" based on coherent sets of metaphysical beliefs. These beliefs focus on the ways people think of reality, criteria for truth, and what is considered acceptable evidence. Collectively, the metaphysical belief for each hypothesis form a structure which provides *one* way of looking at the world. Different hypotheses interpret the world in different ways; there are therefore multiple ways of knowing.

The two hypotheses that are of interest in the present context are formism and mechanism, as they represent analytical thought in mainstream Western philosophy. In formism, the root metaphor is similarity and the overriding philosophical concern is the form of objects. In mechanism, the root metaphor is the machine, while the overriding philosophical concern is correlating events and establishing causal relationships among those events.

The aim of both hypotheses is to analyze objects or events into their constituent parts. Individuals who understand the world from either a formist or mechanist perspective operate from an analytic world view. They may disagree as to the constituent parts, but there is no disagreement as to the theoretical possibility or the desirability or the aim. Analysis is seen as a linear process in which the similarities of events are established and causal connections among constituent parts are then intuited. In both hypotheses, truth is a form of correspondence where "real" events in the world are directly linked to idealizations or deterministic laws inherent in nature. In summary, an analytic frame of reference is realistic, atomistic and reductionistic.

Authorization of a world view

To understand how teachers authorize the form of knowledge that is presented to students, it is necessary to consider the conceptual boundary of a discipline, the pedagogic knowledge of that discipline, and the manner in which the boundary becomes evident. There are many potential methods to get at these issues, but a technique that appears productive is to ask a series of guiding questions about a person's teaching style. Esland contends that all teachers have "a subject and a pedagogic perspective of varying degrees of theoretical consistency and clarity" (1971, p. 85). These perspectives are evidenced in vocabularies, rationales, and

personal epistemologies; visible indications of the "what" and "how" of knowledge are contained in the person's teaching style.

To illustrate Esland's point, I will present data from a qualitative study in which a teacher's subject and pedagogical perspectives were examined for the manner in which biology was conceptualized and presented during a series of classroom lessons. The illustrative data consist of a description of a lesson and a segment of an informal discussion which focussed on the teacher's philosophical perspective on biology.

The data consist of the audio recordings of a Grade 12 biology teacher's lessons over a period of seventeen, sixty-four minute periods. During the seventeen classes, the researcher observed the teacher present biology as a subject in which specific, detailed empirically-based information is valued. The first lesson was devoted to introductory remarks stressing the concepts of energy and energy conversion. At one point in the lecture, the teacher summarized the objective of the lessons:

> And so we say the green plant is the bridge for us between sunlight and our energy needs. You want to look at the green plant, then, you can simply say that . . . one of its roles is to convert one energy form into another. . . . It doesn't create energy, it simply converts it. It's an energy conversion organism.

Statements of this nature were interpreted to mean that the teacher stressed major biological concepts so that students were taught the structure of the discipline.

In subsequent lessons specific, empirically based information organized in a linear fashion, was presented. The shift in stress from generalized biological concepts to specific information occurred during the second lesson when the teacher said

> We've done the . . . introduction, like laying the ground work. And now we're going to focus on procurement, that's really what we're after as students.

The contrast between the pedagogical intention of the introduction and what was subsequently taught is so transparent that this statement sensitized the researcher, who in subsequent lessons noted:

(a) The teacher stressed specific, content oriented information.
(b) The teaching style was recitation, in which questions constrained the students' responses to short, factual statements. The responses led to the next teacher-directed topic which was then elaborated.
(c) The subject matter was organized in a linear fashion with particular relationships, among a chronology of events, being highlighted.

In qualitative studies, interpretations need to be corroborated. In this study further data were obtained by holding a semi-structured interview with the teacher at the completion of the series of lessons. Questions during the interview focussed

on the teacher's views of biology, biological knowledge, philosophy of science as it relates to biological knowledge, and about points observed during the lessons.

The following (edited) excerpt from that interview corroborates the researcher's interpretation of the teacher's philosophical view of biology:

R: . . .I noticed you made a specific point of teaching the history of biology as you went through that [nutrition] section. Do you normally make a practice of doing that?

T: I would say that on this topic I normally do . . . for some reason I emphasize it more than with other topics . . . because the book presents quite a few men in the treatment of the subject, and secondly, I guess I find it an opportunity to see progression more clearly than in some other fields. Maybe just because I'm aware of it. But ah, you can see how ideas grow . . . . how they progress and become more and more complicated, and how the level of experimentation then becomes more complex as time passes. I think it is an opportunity to point that out.

R: Why do you feel that the history and the philosophy behind those experiments are important to the students?

T: Well, I suppose one reason is to show that curiosity concerning nature has been around for a long time . . . . It communicates something about how we satisfy that curiosity, how we go about finding answers, in terms of performing tests . . . .

R: So you have a reason other than merely presenting history as history? There is an objective behind your presentation of it?

T: I don't see any value in learning Priestly's name and date unless I'm using that to communicate progression or how knowledge grows.

R: Can you tell me what you think biological knowledge is? What is it to you?

T: Well, I think it is an accumulation of ideas or concepts about living things that have been developed over several hundred years. . . . Well that to me represents a body of information, but there is another dimension that would include the methodology.

Inferences of a world view

On the basis of the observations and interview data, an inference is made that the teacher conceptualizes biology and biological knowledge from an analytical frame of reference. By this I mean, the methodology is conceptualized as a process based on objective, empirical observations which form the first step in a version of the hypothetico-deductive method (Aune, 1970). The teacher understands the process as making empirical observations, developing a hypothesis to account for the regularities within the observations, deriving predictions from the hypothesis and then subjecting them to critical tests for accuracy. Depending upon the results of the tests, the hypothesis is either

confirmed or refuted. Repeated confirmations, with more and more critical tests, leads the teacher to deem the assumed regularities worthy of being accepted as true. Information that is repeatedly confirmed is considered knowledge and subsequent investigations add to this body of biological knowledge. In addition, the teacher's practical knowledge presents the discipline to students in a way that is consistent with this world view.

The previous illustration of a teacher's conceptualization of a discipline and the way the disciplinary knowledge is presented to students reflects an understanding and presentation of biology from an analytic world view. A natural question that follows is why the teacher presents biology in that way? The following section will attempt to answer that question.

A rationale

It is unrealistic to expect teachers to be passive presenters of knowledge. Therefore, one assumption underlying this paper is the notion that the teacher described above has developed both a conception of the discipline and a rationale for the knowledge presented. The previous section illustrated one such conception of biology, one that reflects an analytical world view. This is important because this is the world view that is explicitly presented to students who are informed of no others. The question naturally arises about the defensibility and desirability of educating people in this way.

The question of defensibility was addressed when the researcher began to question the teacher's rationale for the knowledge that was presented. The teacher's response referred to perceived institutional conditions operating within the school. The teacher described the school as being located in an "upper-middle class area with professional parents who push their kids academically. They expect their kids to go to university." Further, he stated "the guidance people insist the average I.Q. of the student body is equal that of first year university students." Based on this interpretation of socio-economic issues the teacher suggests his "academic teaching style" of presenting specific information from an analytic view is appropriate for these students because it is appropriate for university students. The teacher has, in short, rationalized his presentation of technical knowledge according to institutional constraints. Later in the discussion he identified pragmatic and personal motives for stressing an analytic view. During the corroboration discussion, the teacher stated his belief that biological knowledge is open to interpretation but he rationalized his authoritative presentation in terms of students' futures and his own personal career. In his words,

> students are competing for positions in post-secondary institutions and the work-force and the subject content needs be as specific as possible so that the students have the greatest opportunity to achieve high examination scores.

Further, he indicated that "a teacher's ability is judged by administrators on the basis of efficiency and the student's final examination results."

Implicit within his position is the equating of teaching ability with students' examination results; if a teacher has aspirations for promotion, technical information is taught such that students' grades are maximized. The combination of an analytic world view plus perceived practical and personal constraints results in the reproduction of technical knowledge. A danger in the foregoing orientation is the apparent "buying into" a world view without giving adequate thought to educational practice. Consequently, there are implications for science education.

Implications for the production of knowledge

Implications for the production of knowledge are found on two levels, the image of science and the form of knowledge that is reproduced in students. These two levels are obviously interconnected; it is through disciplinary knowledge that knowledge, *in general*, is discussed. I will not devote space to a discussion of the image of science. To do so would require another paper.

At the level of reproduction of general knowledge, the analytic world view filters events such that specific conceptions are encouraged while others are discouraged. The epistemology of this view is a version of realism where knowledge and the knower are separated. Further, such knowledge is understood to be objective, neutral, value-free and impersonal. This concept is based upon empiricism which suggests that innocent, unbiased observations of phenomena correlate positively in concrete experience. The concept also suggests that the role of science is to develop explanations of the observed regularities. Also, in science education the hypothetico-deductive truth strategy has become *the* approach and its unquestioned use reinforces the production of analytical knowledge at the expense of other ways of knowing. Consequently, students who come to the discipline are confronted at the outset with requirements of neutralization, depersonalization and objectification of their own interest and reaction to the subject matter. This removal of "ownership" of knowledge is an essential step in the reproduction of technical knowledge because it is the way in which students are coerced into understanding the world from an analytical viewpoint.

What is of importance, besides the repeated presentation of analytical knowledge, is how the data reveal a teacher who has been indoctrinated into a technical view and how that view is encouraged in students. The teacher's unquestioned acceptance of the supposed constraints of the community, the school's administrators, his interpretation of society's expectations of success, plus personal desires for career advancement imply that the reproduction of technical knowledge is seen as an effective way of satisfying these teaching demands. I contend the teacher has "bought into" this approach because he is unaware of looking at knowledge from a different world view and, more importantly, he has been rewarded within the technical system. It is worth noting that the inferences drawn are not generalizable to other teachers because the data represent one person and were selectively chosen for illustrative purposes. Despite this limitation, the important point is the ease with which one teacher unquestioningly accepts perceived constraints and then rationalizes the reproduction of technical knowledge because of those constraints.

Conclusion

Of major importance to education is the manner in which knowledge is conceptualized, what the perceived constraints are for that knowledge, and how knowledge is presented to students. Educators need to be aware of the epistemological consequences of an analytic world view and how institutional constraints influence the presentation of knowledge. An unquestioned, excessively narrow interpretation of a particular view results in dogmatism in which one form of knowledge is reproduced. In the case of an analytic view, educational practice produces a reductionistic, technical knowledge that is self justifying. In science education, current philosophy of science would suggest that students are being given a misrepresentation of the field and it is partially due to the over reliance on analytical thought and the non-critical acceptance of societal constraints. In contrast, an unquestioned synthetic approach may result in knowledge being seen as an extreme form of relativism. Either extreme cheats students of establishing an adequate understanding of the world.

The previous points are not to be interpreted as mutually exclusive. A teacher obviously has a preference for a world view and it will be reflected in that person's teaching style, but educators need to be aware of their conceptions of knowledge and what the consequences are for students coming to understand the world. Without such an awareness the production of technical knowledge will continue to overshadow a practical understanding of the world. The technical perspective will continue, not because it provides a more adequate understanding of the world, but because teachers are indoctrinated into it and they unwittingly present it as *the* way of knowing.

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