Classroom Events and Curricular Intentions: A Case Study in Science Education*

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Teaching any particular piece of subject matter can be done in many different ways. The authors of this paper recently completed work on a research and development study designed to explore how different ways of teaching can be designed systematically to make provision for students to attain *different* sets of objectives while mastering the *same* subject matter topic. The paper itself shows how different sets of classroom events can be interpreted in terms of differing curricular intentions (or "curriculum emphases" as they are called here). The potential of such a conceptualization of differences among ways of teaching is analyzed by comparing it to other conceptual frameworks in common use. While the case examined in this paper is drawn from science education in Ontario, the argument is a general one.

L'enseignement de toute matière académique vise inévitablement un mélange d'objectifs: ceux qui se rattachent à la matière enseignée et ceux que les auteurs définissent comme "objectifs de la méta-leçon". En explicitant ces derniers et en incorporant délibérément différents objectifs de méta-leçon à l'enseignement d'un même contenu académique, les auteurs ont élaboré différentes "versions" des mêmes unités d'enseignement du Intermédiate Science Curriculum Project de l'OISE. Cet article présente des transcriptions de classes de sciences qui illustrent des différences de substance au niveau des stratégies d'enseignement utilisées par deux professeurs pour des versions différentes d'une même unité. Les auteurs démontrent que les grilles d'interprétation utilisées lors de l'observation d'une activité d'enseignement doivent inclure des catégories qui visent non seulement la forme mais également la substance, ceci en vue de tenir compte des intentions académiques particulières et de leurs implications dans l'analyse et l'évaluation de l'enseignement.

This paper focuses on different ways to teach the same subject matter. The overall intent is to compare frameworks through which such differences may be interpreted, and thereby to contribute to a better understanding of the complex relationship between curriculum development and classroom instruction. The particular context from which this paper derives is a study in Grades 7–10 science education in Ontario, but the framework itself has wider potential. It can be readily used in other school program areas, with other grade levels, and in other jurisdictions.

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We take as self-evident the existence of many different teaching methods. The issue for us is the adequacy of the ways in which these differences are conceptualized both by educational theorists and by practitioners. The test of a useful framework for analyzing teaching is its potential to suggest to teachers ways of improving their work. Such a framework must therefore possess *empirical validity* – it must be capable of capturing the perceived distinctions between instances of teaching – and *normative force* – it must embody principles which can be used as criteria for the assessment and improvement of teaching. More of this later, however. For the present, consider two conceptual frameworks in common use in curriculum/instruction thought and practice.

In one, which we call the "experimental comparison framework," differences in ways of teaching are seen through the eyes of experimental research in the behavioural and social sciences. In that light, one asks of two different teaching strategies, "Which is the most effective?" Much of the research on teaching reported in educational research journals is devoted to attempting to answer such a question. A key assumption of this framework is that teacher/student interaction can be characterized in terms of a variety of global categories (e.g., inquiry, questioning, modelling, lecturing, recitation). This in turn leads to discussions in the literature of "models of teaching" (Joyce and Weil, 1972), "teaching styles" (Bennett, 1976), or "teaching strategies" (Allen and White, 1980). Once a formal taxonomy of ways of teaching is established, the question of which is the best (most effective, most appropriate, etc.) can be put to experimental test. With this framework, the normative basis for improving teaching is clear; a teacher will surely want to use the most "effective" methods. More problematic however is whether such formal categories can indeed capture the complexity of significant distinctions among different ways of teaching.

A radically different interpretive framework is discovered frequently when talking with teachers. For many teachers, differences in teaching strategies are perceived as unique responses to their own different and unique situations. In the light of this "practical knowledge framework," instances of teaching cannot be analyzed or assessed apart from an intimate and personal knowledge of the particular situation and context in which they occur, a form of knowledge moreover which is usually accessible to the teacher alone. For obvious reasons, such a conceptualization is rarely encountered in the theoretical literature, though Jackson hints at it when he writes "[the teacher] must be content with doing not what he *knows* is right, but what he *thinks* or *feels* is the most appropriate action in a particular situation" (1968, p. 167). Given this position, attempts at characterizing teaching in terms of formal categories or taxonomies are clearly out of place, and it is easy to understand why teachers resist attempts to devise general measures of teacher effectiveness. As Jackson and others have shown, distinctions among ways of teaching can certainly be captured in terms of practical knowledge – that is, such a framework has empirical validity, even if on a somewhat limited scale. The question concerning the practical knowledge framework relates to its value to suggest improvements in teaching.

We shall have more to say about both of these frameworks later in the paper. At this point, we shall present in some detail two actual instances of teaching which focus on the same science topic. Our explanation of the differences between the two provides a demonstration of the interpretive framework developed in this study. The third section of the paper compares this framework with the two just outlined, in terms of criteria previously established, and the conclusion suggests some important reasons for maintaining a balance between form and substance when interpreting classroom events.

TWO SIMILAR BUT DIFFERENT SCIENCE LESSONS

With these aims in mind, consider the work of two teachers in different schools (in the same Ontario school board) each teaching a class of Grade 7 science. In accordance both with the recently issued Ministry of Education curriculum guideline, and with locally developed Board of Education policies, each teacher was teaching a unit entitled "Properties of Matter" to his class. Amongst the topics within this unit, one, entitled "Diversity of Physical Properties," indicated the need to have the students investigate physical properties of a variety of different materials. The following two sections describe the observations taken from each teacher's classroom. (One of the investigators was present throughout the teaching of this unit in both classes; extensive notes and tape recordings were made, the latter being subsequently transcribed in full.)

Investigating the properties of materials: Class A

The class (of 33 students) had been divided into six groups of five or six students and each group was seated around a table with a tray of materials on it. On an overhead transparency, instructions for the investigation were set out. The students were expected to examine 10 specified substances, to note the presence or absence of a series of specified physical properties, and, under a heading of "E (for evidence)," to write "a brief statement of how you know whether a property is present or absent, e.g., 'by sight' or 'it disappeared.'" Following their investigations the teacher discussed results with students. The following excerpts are taken from the first part of a 40-minute discussion.

Teacher: Now we were working with salt as the first substance. I'd like one person to go down the table (*of data*) with salt: colour, texture, and so on. And I'd like that person also to tell the rest of us what we use for "E" for evidence. (*Teacher identifies a student to begin.*)

Student: For salt, I had the colour, white, and I could see that with my eyes.

Teacher: Good.

Student: And the texture is slightly smooth with sort of rough edges, and I found this out by feeling it.

Teacher: Right.

Student: And the hardness, I thought it was partly hard because (*inaudible*)

Teacher: What did you use to test the hardness of it?

Student: I used the bottle and (*remainder inaudible*)

Teacher: So you found you can crush it. Fairly easily? (*Student shrugs*) With a little bit of pressure. So how do you rate the hardness?

Student: I put "hard."

Teacher: OK. Did you ... That's fine, we'll leave yours for now. You may find that in relation to other materials you might have to change that. It may not be as hard as something else on the tray. OK?

Student: Lustre, and for lustre, I said it was bright if you held it up to the light.

Teacher: Did you use the hand lens for that?

Student: I, well, I sort of ... (*inaudible response*)

Teacher: OK. Evidence, again, was?

Student: Sight.

Teacher: All right. Good.

(*A few minutes pass, then another student is addressed.*)

Teacher: So the magnetic properties: was it "yes" or "no"?

Student: No.

Teacher: Good. How do you know?

Student: I put some on the plastic and I put a magnet up to it to see if it moved. And it didn't.

Teacher: So you can tell by movement. Right? OK, that's one down and several to go here. Cornstarch. Will you start please? (*indicating a student*)

The discussion moves on in a similar manner until all the substances have been reviewed. In a later lesson, the complete investigation is reviewed and the following interchange takes place.

Teacher: ... The water went away. The water evaporated. OK. Evaporating is something we can't really see, although you can see the water getting smaller, perhaps, can't you? What is the other word we said you could use? Yes, Julie?

Student: Dissolves.

Teacher: Right. If something dissolves, it really goes away somewhere. You can't really see what is happening to the substance but it does disappear. So we will call that "indirect evidence." Name something you could obviously use as direct evidence from your data sheet. Martha?

Student: Sight.

Teacher: All right. Specifically, what ... name one observation that you made right from the sheet.

Student: OK. Sight, touch and sight.

Teacher: All right, direct evidence. Name another, indirect evidence, a piece of evidence that we could use, that you did use in your group besides something dissolving, which was solubility.

Student: If it has a strong smell?

This discussion continued until the distinction between direct and indirect evidence was clear. The following summary statement was then put on the screen, for students to write down in their notebooks.

EVIDENCE FOR PROPERTY DETECTION: Not all we know about substances comes directly through our senses. Some properties are discovered by "indirect" evidence. These are characteristics which we cannot "see" or "feel", for example; however, something does happen which we can use as evidence for a property.

Q: List the properties tested from (a) direct evidence, and (b) indirect evidence.

Following this lesson, the teacher continued the unit with other topics.

Investigating the Properties of Materials: Class B

In the first lesson of this unit, the teacher had asked the students to imagine that he was a Martian and unfamiliar with "Earth" objects. He had asked them to describe, in as much detail as they could and in written form, the characteristics of a pencil. In the second lesson, excerpts of which follow, the teacher and class discussed their descriptions. On the blackboard there were two headings: PENCIL and, beside it, WHY. As the students provided him with information about pencils, it was recorded under the first heading. An example of this part of the discussion follows.

Teacher: Let's put down some descriptive statements that you could quote to me from your stories that are good to describe our pencil. Let's make a list here of statements that describe the pencil. Take your first one. Let's see.

Student: It's long, and smooth and narrow.

Teacher: (*writing*) Smooth and narrow. OK. Another one?

Student: Sharp at one end and the corners.

Teacher: (*writing*) The pencil is sharp at one end.

This type of dialogue continued until some fiteen points were collected on the left side of the blackboard. At this point, the teacher introduced another element to the discussion.

Teacher: OK. These statements are useful to describe a pencil, but none of these tells me *why* a pencil is like it is. In other words, to start off with, someone out there must have had reasons for all these things. Some of these reasons were why it is the way it is. The first one (*pointing at the list of descriptive statements on the board*) says that the pencil has smooth and narrow sides. Why is this?

Student: Because the pencil is ... If you hold the pencil like that (*demonstrates*) you can't help but see it.

Teacher: OK. So what you're saying is that the pencil has smooth and narrow sides so that you can hold it. Otherwise you will have a problem writing if it is too fat.

Student: That's true.

Teacher: OK. So, obviously the reason for having a narrow and smooth side is that it makes it easier to ... ?

Student: Easier to hold.

Teacher: Right. Makes it easier to hold (*writes this statement on the board at the top of the second column, under "why"*). The second statement was the pencil was sharp on one end. We've got it up there (*pointing at the board*). Why is that?

Student: (*inaudible response*)

Teacher: No. I don't think there is.

Student: It writes more clear.

Teacher: I think you are close. Yes?

Student: It is pointed on one end so that it can be used correctly.

Teacher: Why not use a flat piece of wood then?

Student: Because it won't sharpen clearly.

Teacher: Oh! So, it's got something to do with sharpening up clearly ...

This discussion continued until statements were written eventually on the right side of the board (under WHY) corresponding to each of the descriptive statements. The teacher then moved to a third point.

Teacher: Now, in each one of these cases, you will notice that the pencil has certain things about it that you might say man has made or designed. There are other things about the pencil that basically have to do with the materials the pencil is made out of ... For example, we said that the pencil has smooth and narrow sides so that it makes it easier to hold. Now, is that man's doing or is this the natural material it is made of?

Student: Man's doing.

Teacher: OK. Let's put MAN down to show that man designed it (*writes on board*). The next one says the pencil is sharpened by hand and this makes the marking very clear. Is that a sign of lead material always being sharp at one end or is it that man has something to do with it?

Student: Because man has done it.

Teacher: OK. Man again. The next one ...

After identifying, for each of the characteristics, whether it was man-made (a "design feature") or natural (a "property of the material"), the teacher asked the students to conduct an investigation of their own. They were asked to carry out an inquiry similar to that conducted with the whole class concerning the pencil, but this time using a ruler and a test tube. The results were discussed during a lesson following, and the discussion followed a similar format to the one used earlier. The teacher then moved on to other topics.

INTERPRETING THE DIFFERENCES

In the two illustrations of science teaching just described, there are clearly two quite different teaching approaches at work. In Class A, the teacher incorporated into the student's work on the properties of materials a concern for the nature of the evidence on which their developing knowledge was based. In Class B, by contrast, the teacher made no reference to evidence or to the basis of the students' knowledge. Instead, the approach directed their attention towards the distinction between properties resulting from the *design* of objects and those corresponding to the *materials* of which objects are made. Both teachers were concerned with the properties of materials, yet each used a quite distinct approach.

Before setting out our view of how such differences can be interpreted, it is necessary that some further information be made available to the reader.

Same Subject Matter, Different Curricular Intentions

The instructional materials used by the two teachers were deliberately designed as alternative versions of the same "unit" of science subject matter. (A unit, in this case, comprises about five weeks' worth of instruction.) That is, the same cluster of subject matter topics – all dealing with properties of matter – has been systematically developed into two teacher's manuals,[1] each aimed at different overall aims, or curricular intentions, for science instruction. Hence there are many subject matter objectives that are common to the two versions, but there are many other objectives which differ from version to version. These latter we describe as "meta-lesson" objectives.[2]

The teacher of Class A is using a version of the unit which incorporates aims dealing with the nature of science. In this particular excerpt of teaching, there are immediate subject matter objectives concerning the properties of materials. There is also an immediate meta-lesson objective that the students learn to distinguish between direct and indirect evidence. The unit has a pervasive, overall aim to illuminate the differences between observations and inferences and to show how these function within science. The teaching approach built into the teacher's manual is designed to make provision for this particular blend of objectives.

The teacher of Class B, though, is using a version of the unit which incorporates aims that clarify the way science can be used in the making of practical decisions. Again, the immediate subject matter objectives deal with the properties of materials. But in this case the meta-lesson objective is that students shall learn the distinction between "natural" properties and man-made features of a particular object (a pencil). The pervasive, overall aim of the unit is for the student to learn to distinguish between the role of *knowledge* and the role of *values* when making a practical decision. (In this case, each student eventually has to make a choice from among an array of different cups – styrofoam, china, tin, etc. – for serving hot drinks.) The teaching approach designed for this version of the unit makes provision for a substantively different blend of objectives.

The Role Played By Different "Curriculum Emphases"

Any effort to conceptualize and interpret the teaching encounters of Classes A and B must acknowledge differences in curricular intention to which we have just alluded. Both are Grade 7 science classes, both are in schools within the same Board of Education, both are learning about properties of materials. Yet the two contextual settings for the subject matter, and hence the meta-lesson objectives of the teaching, are quite different. It is time now for a more systematic look at the differences, and especially at their origin.

The concept "curriculum emphasis" has proved useful to represent the pervasive, overall curricular intention which is always present, even if unacknowledged, in debate and planning about the purpose of teaching any given school subject (Roberts, forthcoming). To give credence to the concept, we need only remind ourselves that there is a significant logical difference between the kinds of statements that make up the *content* of a school subject (e.g. the postulates of atomic-molecular theory) and statements used to express the *intent* of having students learn the stuff (students are to grasp the importance of postulates in the development of a useful scientific explanation). While subject matter objectives flow readily from content statements, meta-lesson objectives must be derived from statements of overall intent – that is, from the substance that makes up a given curriculum emphasis. It is the two different blends of objectives which can thus be seen to account for important differences in the two teaching episodes reported in this paper.

Nor is the concept of curriculum emphasis restricted to the interpretation of teaching episodes. Differences among instructional materials, including textbooks, may also be accounted for. Consider, for example, the disappearance of steam-shovel physics, industrial process chemistry, and civic biology from virtually all modern secondary-school science textbooks. The excision can be traced to the time of massive science course revision sponsored by the National Science Foundation in the United States and the Nuffield Foundation in the United Kingdom. In Canada the new courses met with considerable favour also. One curriculum emphasis – a subspecies of what we have called the "science and society" emphasis (Orpwood and Roberts, 1980b) – went out of vogue, and another, the "structure of science" emphasis (cf. Roberts, 1981), was ushered in. As a reminder of how radically different textbook material treating the same subject matter can actually be, when differing curriculum emphases are stressed, consider the following two examples of textbook treatments of the topic "Heat." (This comparison is adapted from Orpwood and Roberts, 1980a.)

The first example comes from a recently published text for Grades 9/10 (Andrews et al., 1978). The chapter on heat (Unit 13: Heat Energy) teaches the fundamentals of heat and temperature in the context of a comparison of eighteenth-century and modern theories of heat. The point of this comparison (for the student) is conveyed most forcibly in three sentences in the summary at the end of the chapter. "The Caloric Theory described heat as an invisible elastic fluid. The theory was discarded *because it could not explain* the results of experiments performed by Thomson and Davy. The Kinetic Molecular Theory *is able to explain* all heat phenomena" (p. 378, our emphasis). That "point" is quite clear. The meta-lesson objective is that the students shall learn a point about the purposes of theory construction: one criterion for the acceptance of rejection of theories. (That particular meta-lesson objective is not specific to the subject matter of heat, of course. It could be emphasized as readily in connection with electricity, with the structure of matter, or with many other subject matter topics.)

The second example provides a striking comparison. Again the topic is heat and temperature and again the intended audience is Grades 9/10. But this time the emphasis is very different. The example comes from a book (Bruce, 1938) published over forty years ago and approved for use in Ontario schools for many years. The emphasis is clear from the very beginning of its chapter on heat (Chapter 6). The first sub-heading is "The Part Played by Heat in Our Lives" and the chapter goes on to teach about heat and temperature in a context suggested by that heading. There are numerous illustrations (both verbal and graphic) of domestic appliances; there is a comparison of different methods of heating buildings; and there is a discussion of humidity and the effects of it (and lack of it) in houses. The questions at the end of the chapter indicate clearly what meta-lesson objectives students are intended to attain from their study of the fundamentals of heat. Three of the 11 questions follow.

1/Why do you think hot-water heating is unsuited to skyscrapers?
6/What principle is involved in the holding up of a wet finger to determine the direction of the wind?
9/Often the first snowfall in autumn leaves lawns covered but sidewalks clear. Why is there a difference? (p. 148)

The meta-lesson objectives in this text clearly have nothing to do with theory construction and such matters within a structure of science (or nature of science) emphasis. Rather, they deal with the relevance and applicability of scientific knowledge to what the author assumed to be the student's own experience and the world in which he/she lives; in that respect, they represent one subspecies of the science and society emphasis.

In sum, the role played by different curriculum emphases is important in determining the characteristics of teaching approaches, of instructional materials, and of textbooks. Let us turn now to an examination of some theoretical and practical issues which can be seen to follow from the recognition of "curriculum emphasis" *as an interpretive device*, especially in science education.

ALTERNATIVE FRAMEWORKS FOR INTERPRETATION

Consider again, now, the alternative interpretive frameworks with which the paper began. Why not use an interpretive framework based on experimental comparison, for instance? The techniques of multivariate statistical analysis are certainly adequate to the task of asking which teaching approach is most effective. But there are two problems, both of them related to the kind of knowledge which would be obtained.

First, for teachers, the two teaching approaches are not in that kind of competition. That is, a teacher does not ask which of these approaches is *more effective*. Instead, the teacher asks which of them he or she *will use*, given his or her own unique situation. Such a choice requires that the teacher take account of a host of contextual considerations and weigh the appropriateness of each teaching approach accordingly. And a complex choice of that nature does not translate simply into the researchable question of relative effectiveness. So the research results which would emerge from the use of an experimental comparison interpretive framework, while methodologically sound and scientifically impressive, would be answering questions different from those that teachers are asking.[3]

Second, the outcome of an experimental comparison study is a general statement of the strength of relationships between variables. Even if a teacher *were* to ask about the relative effectiveness of the two teaching approaches, the answer would be in terms of researchers' general "variables" rather than teachers' decisions for unique situations. This is a major problem with "putting research into practice," as discussed at length elsewhere (Roberts, 1980).

A recognition of the uniqueness of each teacher's situation and the complexity of the choices to be made can lead readily to an understanding of the other framework, equally as plausible (at first sight) as the experimental comparison framework. In the "practical knowledge" framework, the basic assumption is that a teaching approach can be analyzed and assessed only in terms of an individual teacher's unique perception and knowledge of the immediate situation.

Before the reader dismisses such a framework as anti-intellectual, we hasten to point out that we are talking about the interaction of practice and thought in the context of an individual teacher's own conceptual framework and habits of thinking. The notion has some very respectable intellectual roots (e.g., Dewey, 1933). Our point is simply that, as an interpretive framework for viewing differences in teaching approach, the practical knowledge viewpoint can lead to fatuous relativism and beg the very questions one needs to ask. (If the excess of the experimental comparison framework is that one approach *must* be better than others, the excess of the practical knowledge framework is that no approach *can* be better than others.) The strength of an interpretive framework based on practical knowledge lies in the honour it gives to the complexity of teaching and in providing the basis for a teacher's professional autonomy within the classroom. There is much to be done in tapping the potential of such a framework. (See Elbaz, 1980.) However, such a framework does not allow for any independent assessment of the adequacy of a teaching approach in terms of its consequences for students.

In order to satisfactorily interpret the differences between the teaching encounters experienced by Class A and Class B, one must be able first to conceptualize the differences from the perspective of a teacher faced with a real and important choice – the empirical validity criterion. Second, one must have an independent means for assessing whether each approach is appropriate given the intentions it was designed to fulfill; that is the criterion of normative force. As we have shown, the first of the these demands cannot be accommodated within the experimental comparison framework, while the second cannot be handled by the practical knowledge framework.

It follows from the first point that one cannot ask, simpliciter, whether Class A or Class B experienced "better" science teaching. One must ask the question instead in the more complex terms of the different curriculum emphases which gave rise to the differing meta-lesson objectives for Class A and Class B. Thus, if one *must* choose between alternative emphases, one quickly arrives at the following political or social (but certainly not empirical) question: "Are goals for science teaching consistent with a structure of science emphasis 'better' than goals consistent with a science and society emphasis?" It is not a question to be answered by researchers (cf. Orpwood, 1980). Nor is it a question to be answered in general terms, i.e. for all students. It is answerable only through the mechanism of deliberation, for it is a question of curriculum policy.[4]

It follows from the second point that it will not do to compare the teaching experienced by Class A and Class B through accounts by each teacher explaining *why* he or she did *what* he or she did, in terms solely of the teacher's own practical knowledge. To be sure, that comparison would give one a ready mechanism for getting an answer to the question above, concerning the "better goals" of science teaching. The answer would come from each individual teacher, and would be largely influenced by the teacher's practical knowledge of his or her unique teaching situation. But a teacher alone is neither empowered, nor does he or she have adequate resources, to make such a curriculum policy decision. Curriculum policy emanates from other sources and other people also, as Schwab reminds us in his account of four "clusters of curriculum determinants" (1962, pp. 31 ff).

A more adequate framework for interpreting differences in teaching approaches, then, is one which takes account of the nature of curriculum policies and their logical relationship to classroom events. The framework based on "curriculum emphases" and described in this paper meets both of these criteria: it points up the policy nature of choices among genuinely different teaching approaches; it also shows how individual teaching approaches may be independently appraised.

Balancing Form and Substance

We return to the two episodes of teaching with which this paper began, in order to make our final point. It was noted earlier that Allen and White

(1980) used the term "teaching strategy" in a way which emphasized the *form* of the teaching encounter, where we wish to emphasize *substance.*

Class A and Class B experience teaching which is deliberately planned to achieve different meta-lesson objectives, and therefore any framework for interpreting the differences in teaching approach must account for differences in the *substance* of the teaching. Generally speaking, however, the categories used in the study of teaching overemphasize matters of *form*. This is true for experimental comparisons as well as for descriptive studies based on the dozens of classroom observation schemes which are available in the literature. A simple example will quickly demonstrate how an overemphasis on form leaves us bereft of any meaningful interpretation in the case of Class A and Class B. Reflect for a moment on how "the method" of teaching might be compared, in the two classes, if we were using the *formal* categories "recitation," "discovery," and "guided discovery." Both teachers would likely be judged to be using "guided discovery"; such a result is so trivial as to be virtually meaningless. But that is not all.

The pressing issues in science education for the next decade or two have little to do with the *form* of teaching, or even the *form* of objectives. Instead, they relate to the overall curricular intentions of science teaching programs in schools, that is the world-wide concern about relating school science programs to personal and social issues (cf. McFadden, 1980), the continuing public and professional ferment about the creation-evolution controversy (cf. Nelkin, 1977), or the issues surrounding a Canadian context for science education (cf. Page, 1979). Those are all issues of curricular *substance*, for they directly influence the meta-lessons which are blended in with science subject matter in any teaching program. "More emphasis on skills and attitudes, less emphasis on facts" is a typical form-bound prescription; it would serve the needs of science education much better, we submit, to ask questions about *what kind of* skills, *which* attitudes, and *what* facts.

There is a means for interpreting teaching which respects both form and substance. We refer to analysis of teaching as developed in the context of "clinical supervision" (e.g. Cogan, 1973; Goldhammer, 1969). Mosher and Purpel (1972) make the point bluntly: "It is not considered feasible to analyze teaching effectiveness independently of the content of what is being taught" (p. 83). Their extended discussion of the analysis of teaching, complete with a number of examples, is perhaps one of the best illustrations of balance between form and substance which can be found.

Finally, it should be noted that the comments made in this paper about interpreting differences in teaching approach in the context of science education hold for other school program areas also. In every area, there is a logical distinction between the *content* of the teaching (the rules of soccer, the workings of Parliament) and the *intent* (coming to use team sports as an outlet for competitive aggression, grasping what it means to be a Canadian citizen). Further, there are variable intentions (and thus curriculum emphases) in physical education, in social studies education, in music education, etc., and these are matters of policy debate. Likewise, every school program area has its crises of the moment; science education has a creation-evolution controversy on its hands, but social studies education is caught up in a Canadian studies controversy which is just as pressing. Our analysis in this paper has proceeded from the problems of *one* school program area, in order to illustrate points which are equally applicable to other areas of the school curriculum.

NOTES

[1] The two manuals, together with a third incorporating yet another set of overall curricular intentions, are available in a single publication which also includes information concerning their development. (Roberts and Orpwood, 1979).

[2] The term "meta-lesson" is Schwab's (1962, p. 45) who used it to remind science educators of the essentially Deweyan point that students learn more than what is being explicitly taught to them at any one time. Dewey (1938/1963, p. 48) referred to such lessons as "collateral learnings."

[3] This is not intended to be a novel nor a particularly radical claim. The same point was made by Cronbach (1963) nearly twenty years ago, while the problematic nature of the questions being asked is discussed in depth by Walker and Schaffarzick (1974).

[4] Indeed, the Science Council of Canada study of Canadian science education is employing the concept "curriculum emphases" in this way in the context of its "deliberative inquiry" (Orpwood, 1981).

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