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ABSTRACT

This study sought to identify and elaborate significant strategic elements in the process of assisting science teachers in the application of philosophical analysis to their teaching, and in the modification of their teaching according to the results of analysis. The research is based on case studies of work with teachers, individually and in small groups. The basic data for the study were tape recordings of classroom lessons and of teachers' deliberations in the analysis of teaching and the design and evaluation of alternative teaching strategies. Analyses of the data confirmed that teachers were willing to examine their methods of teaching, in a nonevaluative setting. Discussions of how the teachers reacted to analysis of their teaching and how they used these analyses to alter their teaching are given. (MH)

APPLYING PHILOSOPHICAL ANALYSIS TO SCIENCE TEACHING: STRATEGIES FOR INSERVICE WORK WITH TEACHERS

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As researchers in science education, we live in a world in which our relationship to science teachers is dominated by the view that theory is something we develop and they put into practice. Theory and practice are seen as quite separate from each other, and the distinction implies that we and they do quite different work. The stereotypes perpetuate themselves when "we" accuse teachers of failing to implement our findings and when "they" accuse researchers of irrelevance.

This paper is one of a set of papers[1] based on an approach to science education research which alters the familiar "theory-practice" dichotomy, in the direction of bringing researcher and teacher closer together while respecting their necessary differences. "Theoretical perspectives" (not theories) developed by philosophical analysis are translated into "clue structures" for the specific purpose of analyzing science education practices--objectives, curriculum materials, and classroom events. The decision about the kind of theoretical perspective one will use is made in direct response to the practical concerns or problems which prompt one to undertake analysis.[2]

One would not expect science teachers to follow this approach to research on their own. Identifying theoretical perspectives and working them into a form for analyzing science education practices rightly sound

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like the work of a researcher, not a teacher. Yet application of philosophical analysis to science teaching does result in implications for change. This paper addresses the question of how a researcher works with a science teacher to use philosophical analysis to improve practice. Because my topic is the process of using a particular research approach, not explaining the approach itself, I ask the patience of those to whom the approach is mysterious. Illustrative examples are provided in the course of my discussion. My focus is on the analysis of classroom teaching, but the issues I raise can be translated directly to the analysis of objectives and curriculum materials.

Four Major Issues of Strategy

The title's reference to "strategies" for inservice work with teachers is not to specific techniques of interaction but rather to significant issues in the relationship between teacher and researcher. Over the course of several years' work, I have identified four major issues which it seems essential to address in inservice work if the use of philosophical analysis is to result in improved science education practices.

1. Has the teacher developed an analytic perspective on his own teaching?
2. Is the application of philosophical analysis to practical issues based on rational authority?
3. Do the results of philosophical analysis permit the teacher to design alternative practices?
4. Is the teacher prepared to deal with the responses which changes in practice will generate?

It is possible, of course, for a researcher to do the analysis himself, inform the teacher of the results, and identify the changes which are called for. But to do so is to ignore the converging experiences of curriculum developers[3] and students of the supervision process.[4] The "top-down" approach cannot be made teacher-proof. And the changes such

an approach seeks to achieve fail to appear not because teachers resist them but because, like all humans, they misunderstand, lack necessary skills, feel unsupported, or more boldly are unwilling to change without participating in the identification of appropriate changes.

Before I examine each of the four issues of strategy in turn, I should identify the research context which has permitted me to recognize and collect data relevant to these issues. In 1975 the Ontario Ministry of Education provided Grant-in-Aid-of-Research funding for a proposal to study the significance of teaching strategies in the implementation of curriculum materials and courses of study.[5] Specifically, the intention was to study the effects of training teachers to design teaching strategies specially suited to achieving affective and higher-order cognitive objectives (such as inquiry, critical thinking, and scientific literacy). A basic element of the rationale is the idea that the teaching "medium" is a significant part of the classroom "message" students learn, and accordingly there is more to curriculum change than rearranging and updating content. Contrary to the view that methodology does not matter and may be selected to suit teacher and student preferences, we (the research staff) hold that strategies make a significant difference and would venture the suggestion that the recitation and the "Socratic" method are not well-suited to enabling students to achieve non-recall objectives.

The research is being carried out at the Ottawa Valley Centre of The Ontario Institute for Studies in Education (OISE), one of nine field centres set up to help carry out the "field development" mandate of OISE. Over the course of two school years (1975-76 and 1976-77), more than forty teachers have participated on a voluntary basis in The Ottawa Valley Teaching Project.[6] In a setting oriented toward growth and development rather than evaluation, virtually all participants have demonstrated a willingness to examine their own teaching. Not surprisingly, designing and practicing alternative strategies has been more complex and challenging than analysis of present strategies, and only a few teachers have reached the stage of regularly attempting to design, carry out, and evaluate alternatives. Teachers' various responses to the goals and procedures of

the Project (after initially volunteering to participate) and the many issues raised in the course of trying to help teachers analyze and modify their teaching constitute the basic data on which this paper is based. Making sense of these data has generated the four questions posed above, to which I now turn.

Developing an Analytic Perspective

The first question I would ask in the process of helping a science teacher draw from philosophical analysis to examine practice is "Has the teacher developed an analytic perspective on his own teaching?" Essentially, this is a question of readiness to begin. Analysis of what happens in one's own classroom produces feedback very different from that which teachers collect as they teach. Few teachers have experienced such feedback often enough to know how to interpret and act on it, not to mention how to be comfortable with it. It would be counterproductive to assume that a teacher has developed the skills for dealing with the recording and analysis of his own teaching.

Pattern analysis

For the purposes of the Ottawa Valley Teaching Project, we have adopted with modifications the technique of "pattern analysis" from the supervisory style known as clinical supervision.[7] We assumed that teachers attempting to change how they teach should first become more aware of the nature and significance of their present strategies. We also wanted an analytical procedure which teachers could use themselves and which would allow them to influence the kinds of events which are brought out by the analysis. Pattern analysis met these criteria because it is a straightforward and open-ended procedure in which one reviews recorded classroom data in search of behaviors which occur over and over again--"patterns" rather than individual instances of behavior. This procedure is quite unlike Flanders' "Interaction Analysis" or the scores of other observation procedures which have been developed in recent years, for there are no fixed categories and each review of the data is likely to yield additional patterns. Pattern analysis is very responsive to the individual interests and concerns of a teacher. While it is not as quick and clear as a

preconceived set of categories, it is also not as constraining when one is trying to identify what one wants to look at more closely.

While it is not my purpose to explain pattern analysis in detail, a few comments and examples of patterns should be helpful. We have worked almost exclusively from transcriptions of audiotape recordings. While this format cannot capture non-verbal behavior as videotape can, it is much simpler to use and much less obtrusive in the classroom. (Students' permission to record is always obtained in advance.) Transcribing a recording of an entire class period is very time-consuming, but teachers can find time to transcribe a five- or ten-minute portion of particular interest to them. Having the data on paper permits one to review many times and also to invite others to search for patterns in the same data.

To introduce the technique to teachers, we use examples such as the following patterns which might occur in a classroom.

> To every student response, the teacher replies with the phrase, "O.K., very good."
>
> Virtually all questions are asked by the teacher.
>
> After the teacher speaks, a student speaks, then the teacher, a student, the teacher, ...

Patterns are always stated in descriptive language, to keep them as non-evaluative as possible; assumptions about the intentions and effects of behavior are avoided. The actual intentions and effects of behavior patterns are the subject of subsequent inquiry after patterns have been identified. Thus if a teacher has a regular way of using words of praise, that pattern is so stated, but it is not assumed that praise is intended or that the words actually have the effect of praise on any or all students.

Teachers' responses to pattern analysis

All the teachers seemed to enjoy learning the technique of pattern analysis; some even invited students to suggest patterns characteristic of their classroom. But knowing the technique does not ensure than one will apply it to his own teaching, as we learned when we held back from requiring our earliest participants to record and analyze their own teaching. We now require teachers to record, transcribe, and analyze a portion of a lesson, and they have done so quite willingly. This requirement contributes to a

more open, honest relationship between researcher and teacher by making it clear to the teacher what analysis involves, both intellectually and emotionally.

I doubt that every teacher is ready to adapt to the feedback which pattern analysis or philosophical analysis provides, and I expect that some teachers withdrew from our Project simply because it was easier to withdraw than to adapt. But a number of teachers have persevered and adapted, developing an analytic perspective on their teaching. One of the participants provided a very good illustration of what I mean by an analytic perspective, during an interview recorded immediately after he taught a lesson in his original, "traditional" style. I regard his ability to refer to himself in the third person ("the teacher," not "I") and to comment as he does on the style he had just used as evidence that he is now capable of accepting and responding rationally to systematic analysis of his teaching.

> My idea as a traditional teacher is the facts take precedence. The students are there to learn facts. Now maybe I'm reading it wrong, but that's how I see a traditional style. And assuming that, I think it went well in that the teacher was up there giving the facts to the students, the teacher knew the facts got there, he went so far as to put them on the board to make sure they did get there, and the traditional teacher could come to the satisfaction of "I got all the facts out, I've got them down in their notes, that's that." Now looking at it in a different way, my ideas now are more that I would prefer the students to do a bit of the thinking, the research, organizing of facts, basically just do the thinking. And given that as an objective, this style certainly didn't serve the purpose. They were force fed as opposed to searching out the facts themselves.

While conveying clearly and concisely just how well suited the "traditional" style of teaching is to the objectives of retention and recall which he rejects, this teacher raises the significant issue of the satisfaction a "traditional" style provides to a teacher. Any alternative style which survives must satisfy the need to feel "job well done" as it also enables students to "do the thinking."

Analytic perspective as a stage in teacher development

My recognition of the significance of a teacher's developing an analytic perspective owes a substantial debt to Gaskell's participant-observation study[8] of a preservice teacher education program (at Harvard) which began in a six-week summer school in which groups of students shared teaching responsibilities and received feedback based on the tenets of clinical supervision. When these student teachers moved to semester-long assignments with cooperating teachers untrained in the "rational analysis of actual teaching performances," they began to seek out trained individuals who could provide the type of feedback to which they had become accustomed.[9]

Gaskell's study indicates that the teachers-in-training moved through perspectives of "survival" and "responsibility" (for entire classes of students) to an "analytic" perspective in which they value feedback which informs and guides the improvement of one's teaching. The first two perspectives are more than familiar to teacher educators: once one gains the confidence that one can cope in front of a class, one is then eager to become skilled in managing complete class groups which are the basic assignment of almost all teachers. My personal interpretation is that very few teachers reach an "analytic" perspective in preservice or inservice training. Gaskell's work has definite implications for the objective of training teachers who seek to continually improve their teaching. I now regard development of an analytic perspective as a precondition for a teacher's successful application of the technique of philosophical analysis.[10]

Rational Authority for the Application of Philosophical Analysis

The second major question of strategy to be put to the researcher-teacher relationship is, "Is the application of philosophical analysis to practical issues based on rational authority?" Here I leap over the details of actual application[11] to ask whether the researcher has ensured that the teacher sees the use of philosophical analysis as a complete rational argument. The researcher can be assumed to have greater experience and understanding in the use of this research approach, and there is a high

probability that the teacher will give the researcher the benefit of the doubt and accept some portion of the application on the researcher's "say-so," rather than on complete understanding of the logic of the procedure which has been followed. There are two strong reasons for taking pains to place the application of philosophical analysis on a completely rational footing for the teacher: (1) If the results seem in any way arbitrary, the teacher has grounds for less than full acceptance. (2) The teacher is less likely to succeed in designing and practicing appropriate alternatives if he does not understand how the need for change has been demonstrated. Also, there is the less immediate but still significant reason that the researcher will be modeling the use of rational authority as one might hope the teacher would use the same authority with his pupils.

At this point I would like to illustrate how I have used this and the preceding question in my relationship with one of the teachers who has participated in the Ottawa Valley Teaching Project. The example is one which resulted in a mutual decision to "part company." In the course of the discussion I will explain what I see as the relationship between pattern analysis and philosophical analysis.

A case study in the use of pattern analysis

The transcription which follows is a portion of a Grade 7 physical science lesson on the formation of mountains by folding. The teacher recorded the lesson himself, listened to the entire recording, and selected this portion for us to work on together. When we first met to consider the patterns in the lesson, I had not seen the transcription. The teacher explained that he had "heard" patterns as he listened to the recording; thus the patterns which he noticed are not necessarily evident as recurring behaviors in the following transcription of a small portion of the recording. The teacher stated and explained seven patterns which I present in advance as a guide to reading the transcription.

1. "Response by teacher after answer by student." This refers not to the fact that the teacher responds but to the lack of variety in the teacher's responses.

2. "Using an adult word and then saying it in simpler language."

3. "Use of O.K. when I want to begin something new." The teacher wonders whether he uses "O.K." and "Now" too often.

4. "Raise your hand if you want to say something or don't understand." At present this rule for student participation is working well.

5. "Going back to what we talked about before." This identifies the teacher's practice of referring to previous lessons, as in the phrase "Remember yesterday when . . . ."

6. "If a student doesn't get a question, rephrase the question." This practice seems to achieve the results the teacher desires.

7. "Repeat questions at times." This pattern of teacher behavior is intended to ensure that students realize a question is being asked, to give them time to participate, and to ensure they understand the question.

Because we did not record our discussion on tape, I later wrote up notes from which these explanations of the patterns are taken. Notice, not surprisingly, that the teacher has focused primarily on his own behavior. The transcription of the lesson follows; numbering each speaker makes later reference much easier.

1. Teacher (T): Now one of the methods that form mountains is folding. We talked about that yesterday. Could someone tell us about folding? Would you raise your hand if you can tell us how mountain building occurs, sorry how folding occurs, how it happens, why it happens, what happens? O.K., Karen, do you want to start us off?

2. Karen: (inaudible)

3. T: All right, that's pretty simply stated, more or less what happens. There are a few details that I think we can add. One thing I'd like to clarify is the idea of what was underneath the water. What did it look like when it was under the water? What type of rock is it? Remember we talked about three types of rocks. What type of rock is it underneath the water?

4. Jeff: Sedimentary.

5. T: Right. And what does sedimentary rock look like? We have them around Ottawa. There along the Queensway on the way of Kanata or at Hogsback. You can see really good examples of it.

6. Bryan: Layers of rock.

7. T: Right. O.K., limestone, shale, those are examples of it, sandstone too. Right, now we have this sedimentary rock. At the bottom of the ocean, usually it's at the bottom of the ocean and that's why it's covered with water. Does the water exert much pressure on this rock? Is there any pressure built up by the water or does the rock just lie there sort of flatly and calmly?

8. Cathy: (inaudible)

9. T: Does the water exert any presure on the rock?

10. Cathy: (inaudible)

11. T: Does water exert any pressure on anything? If you have a large body of water, let's say an ocean and you were sitting at the bottom of the ocean, would you feel any pressure?

12. Cathy: Yes.

13. T: Do you think the ocean would exert pressure on the sedimentary rock?

14. Cathy: Yes.

15. T: All right, good. Now there are frequently pressures from above, in other words from the water on the sedimentary rock. There are other pressures that can occur. And how can these occur? And where do they come from? What is their source?

16. Ian: Well like sometimes you can get storms underwater, like if you get a big tidal wave or something there's pressure under the water, and like it just builds up on the sedimentary rock. It just adds more and more pressure.

17. T: Well, not exactly. The only pressure you would have would be coming from below. But there are also pressures coming in from the sides. When, what would be an example of pressure coming in on these sedimentary rocks? . . . When would you have pressure coming in from the sides? Remember we talked yesterday of "bumpem" cars at the Ex? Remember if you've ever been on "bumpem" cars, how does this pressure come about? Bryan?

18. Bryan: Well, it usually comes from an earthquake.

19. T: Good point, there's a possibility. Now can you tie in something else?

20. Bryan: Underwater mountains.

21. T: O.K., Stuart.

22. Stuart: He said it.

23. T: O.K. Yesterday David was talking about something, ah David and Jim were talking about a time when the continents were together. Now they're not together any more. What do we call that? What is that all referring to?

24. Jeff: Continental . . .

25. T: Continental?

26. Chris: Drift.

27. T: Right. We'll be studying this in more detail. We'll be having film strips about it. Basically it is the idea that the continents were all together and they floated apart. And what happens when sometimes these continents bang into each other? Or these whole plates. There are actually ten plates, three underwater and three above water, or I'm sorry, seven above water.

After our meeting in which the teacher explained to me what patterns he had identified, I undertook my own search for patterns and found myself coming up with quite different ones, no doubt in part because I was analyzing only a portion of the entire lesson. I identified the following patterns, among others.

> With the exception of entry 16, teacher talk is much longer than student talk, and the teacher's response in entry 17 begins "Well, not exactly." I wondered what effect this might have on students' willingness to talk at any length.
>
> Between entries 1 and 17, the teacher asks questions, elaborates correct answers, decides what will be asked next, and selects illustrations. Where audible, the students' responses are brief.
>
> In entries 3, 19, and 23, the teacher calls for names.
>
> Entries 9, 11, and 13 involve the concept of "pressure."

Other readers will see other patterns; this is as expected, and is a strength of the technique. Sharing the patterns one sees can enable individuals to understand each other better. In this particular situation I found myself sensing that the teacher and I seemed quite far apart in the patterns we noticed. The teacher did seem to be making progress toward an analytic perspective on his teaching, but I began to doubt that we would find an issue to which philosophical analysis could usefully be applied.

Our training program had used an "Intentions-Behavior-Effects" view of communication to assess the significance of any pattern: How did a pattern of behavior compare to the teacher's intentions, and what effects

did the pattern of behavior have on students? I found that this teacher was assessing patterns somewhat differently, judging a pattern as "good" if it had its intended effect for a long period of time. The theme seemed to be one of doing better what was already being done, rather than identifying alternatives to present teaching practices.. Since I also knew that this teacher was inclined to focus on "questioning," while I was personally inclined to look at issues such as "authority" and the "nature of science," I decided not to push for continued work with this teacher. He seemed content to work on his own goals and I could see no long-term value in demanding that he consider mine. He is pleased to have mastered the basic technique of pattern analysis, and he knows how to reach me if so inclined at a later date. I am pleased to have evidence about his response to pattern analysis.

If I were asked to specify the point at which the process of applying philosophical analysis "broke down," I would probably place it at the stage of identifying what it is that concerns the teacher, which philosophical analysis might address. Very bluntly, in this case the answer came up, "Nothing." Pattern analysis proved very helpful as a "getting to know each other" preliminary, and it could have brought the area of potential analysis into sharper focus. After some type of philosophical analysis have been carried out, we could have used pattern analysis to study the actual effects of any changes the teacher had achieved.

Designing Alternative Teaching Strategies

My third and fourth issues of inservice strategy can be treated somewhat more concisely. As a third question I would ask, "Do the results of philosophical analysis permit the science teacher to design alternative practices?" This question serves as a reminder that doing philosophical analysis of science education practices is not an end in itself, and hence demands that the results be in a form which has clear implications for alternative practices.

To illustrate this point I will summarize my own first attempt at philosophical analysis to indicate how the results pointed to changes

in practice.[12] Single observations of a dozen different science teachers had left me with the overall impression that students were being asked to accept and use scientific laws without adequate opportunity to understand them completely. Peters' distinction between rational and traditional attitudes toward authority[13] (implicit in my second question of strategy) seemed helpful. As a clue structure, I used Toulmin's concept of an "argument-pattern" for all rational arguments[14], stipulating that all elements of the argument-pattern must be provided correctly by the teacher to convey a rational attitude toward authority to his students.

Analysis of three "disturbing" episodes of the teaching I had observed (and which had been recorded and transcribed) revealed incomplete arguments in each instance, with the teacher's "authority of position" presumably carrying the class over the omissions. One teacher moved from application of a law to an exercise which stressed students' simply stating the law being applied; another teacher shifted from demonstrating a law to asserting it; a third reduced a demonstration of a law to a circular argument. In each instance these results imply specific changes a science teacher could attempt to make, were he agreed that it was desirable to convey a rational attitude toward authority.

As a general rule, I would recommend that all attempts to draw from philosophical analysis to examine practice should include efforts to express the results in a manner useful to the design of alternative practices.

Meeting the Challenge of Change

My fourth question of strategy is general to all inquiry which identifies desirable changes in teaching practice: "Is the teacher prepared to deal with responses which changes in practice will generate?" Prior to actually making changes in practice, it is likely that teacher and researcher have been the principal participants in the use of philosophical analysis. When the teacher reaches the stage of actually modifying his teaching, he automatically begins to involve his students and, less directly, his colleagues in the school.

In simplest terms, a change is a stress, and in a psychological version of Le Chatelier's principle in chemistry, the system responds to reduce the stress. (In introducing change, the teacher is in the fascinating position of being both internal and external to the classroom "system.") Students are likely to react in ways which encourage the teacher to act as he did previously. If he has normally settled for short responses but begins to request longer ones, he may find he still gets short ones and disturbances break out while he waits for or tries to elicit longer ones. Also, if a teacher begins to move away from norms adhered to by most other teachers in the school, he may find his colleagues discouraging his changes. I recently noticed a corridor in a school where most teachers leave their classroom doors open when they teach; if there is unusual noise in any room, it is expected that the teacher in that room will close his door rather than permit noise in the corridor. What chance of success has a strategy which calls for a group of students to use the corridor for any purpose?

Sarason has described such elements of the "culture of the school" and assessed the culture's influence on change,[15] providing us with a realistic guide to the challenge of change. It seems pointless to ask a teacher to undertake significant change without an opportunity to become acquainted with this type of educational literature, which has grown as curriculum developers have probed more deeply into implementation "non-events" and other forms of "failure."

Conclusion

In this paper I have described and illustrated four issues which can guide inservice work with a teacher to apply philosophical analysis to science teaching. The issues are sequential: Has the teacher developed an analytic perspective on his teaching? Has philosophical analysis been applied so that the teacher can accept the results on rational authority? Do the results of analysis suggest alternative teaching practices? Is the teacher prepared for the challenge of introducing change?

The process of using philosophical analysis has been made substantially easier by including the technique of pattern analysis, a basic

element of clinical supervision. Pattern analysis helps one look more closely at present practices, to identify clearly the area of concern to which philosophical analysis can be applied. Pattern analysis can also help a teacher develop an analytic perspective on his teaching. Then, when one reaches the stage of making changes in practice based on the results of philosophical analysis, pattern analysis is very helpful in determining what changes were actually made and what effects the changes have on students.

In my introduction I suggested that using philosophical analysis to examine science education practices reduces the familiar gap between theory and practice because philosophical analysis cannot be so applied without addressing events of practice. It enables us to look more closely and systematically at our objectives, materials, and teaching acts. Later, I suggested that the "top-down" approach in which a researcher does philosophical analysis for a teacher and prescribes changes is inappropriate and ineffective. In concluding I would like to extend somewhat these comments on the relationship of researcher to teacher.

Recently we have seen impressive growth in the literature of curriculum implementation, a natural outcome of the earlier period of large-scale curriculum development in which science subjects figured so prominently. Some five years ago, Cohen pointed out some of the contradictions in the design of N.S.F. Summer Institutes and noted the almost complete neglect of the teacher's affective (as opposed to cognitive) concerns about the implementation of new science curricula.[16] McLaughlin has more recently made the issue even clearer, drawing upon a Rand Corporation study of educational innovation which concluded that "successful implementation is characterized by a process of mutual adaptation," in which both researcher and teacher modify to meet the characteristics of the other.[17] To those who impatiently complain that we cannot afford to allow teachers to "reinvent the wheel," McLaughlin responds that "a most important aspect of significant change is not so much the 'wheel' or the educational technology but the process of 'reinvention' or individual

development." "Even willing teachers have to go through . . . a learning (and unlearning) process in order to develop new attitudes, behavior, and skills for a radically new role."[18]

Hunt has argued from psychological premises that a view of "persons-in-relation" would be much more useful than the "theorist to teacher to student" view which has been traditional in education.[19] Hunt uses the vivid metaphors of "reading" and "flexing" to characterize both the researcher-teacher relationship and the teacher-student relationship, not as they are now but as they might become. If each "person-in-relation" can "read" and "flex" to the other, we have every reason to expect improved communication which results in improved educational practice.

The use of philosophical analysis is certainly subject to the points raised by McLaughlin and Hunt. As one who has used this approach to science education research, I find that it does lend itself to "mutual adaptation." The four questions of strategy which I have presented and discussed can serve as major guides to the "reading" and "flexing" required of researcher, teacher, and eventually students in the use of philosophical analysis to improve science education practices.

NOTES AND REFERENCES

1. The set of papers is titled "Philosophical Analysis and Science Education: A Fruitful Partnership." Other papers in the set are

   Douglas A. Roberts, "Systematic Analysis of Science Education Phenomena: Researching Where the Action Is"

   Hugh Munby, "Analyzing Science Teaching: The Quality of the Intellectual Experience and the Concept of Intellectual Independence"

   Graham W. F. Orpwood, "Analyzing Arguments for Objectives in Science Education"

   Brent Kilbourn, "Identifying World Views: Mechanism and Potential Consequences for Science Students"

2. For a detailed description of how philosophical analysis can be applied to science education practices, see Douglas A. Roberts and Thomas L. Russell, "An Alternative Approach to Science Education Research: Drawing from Philosophical Analysis to Examine Practice," Curriculum Theory Network 5, no. 2 (1975): 107-125. An earlier version of this paper was presented at the 47th Annual Meeting of the National Association for Research in Science Teaching, Chicago, April 16, 1974.

3. See, for example, William A. Reid and Decker F. Walker, eds., Case Studies in Curriculum Change: Great Britain and the United States, London: Routledge & Kegan Paul Ltd, 1975.

4. See, for example, Arthur Blumberg, Supervisors and Teachers: A Private Cold War, Berkeley, California: McCutchan Publishing Corporation, 1974.

5. David S. Ireland, "Teaching Strategies in Curriculum Implementation: A Study of the Use of Affective and Higher-Order Cognitive Objectives as the Focus for Training a Group of Teachers in Curriculum Implementation," a Grant-in-Aid Proposal submitted to and funded by the Ontario Ministry of Education, 1975.

6. Inquiries about the Ottawa Valley Teaching Project may be directed to The Ottawa Valley Centre, OISE, 60 Tiverton Drive, Ottawa, Ontario, Canada, K2E 6L8. David Ireland is the Principal Investigator.

7. The following books include explanations of pattern analysis:

   Morris L. Cogan, Clinical Supervision, Boston: Houghton Mifflin Company, 1973

   Robert Goldhammer, Clinical Supervision: Special Methods for the Supervision of Teachers, New York: Holt, Rinehart and Winston, Inc., 1969

   Ralph L. Mosher and David E. Purpel, Supervision: The Reluctant Profession, Boston: Houghton Mifflin Company, 1972

8. P. James Gaskell, "Patterns and Changes in the Perspectives of Student Teachers: A Participant Observation Study," unpublished doctoral dissertation, Harvard University, 1975.

9. P. James Gaskell, "Developing an Analytic Perspective in Student Teachers," a paper presented at the Annual Meeting of the Canadian Association of Professors of Education, Quebec, June, 1976.

10. The Ford Teaching Project in England reached a similar conclusion, using the term "self-monitoring teacher." See John Elliott, "Developing Hypotheses about Classrooms from Teachers' Practical Constructs: An Account of the Work of the Ford Teaching Project," Interchange 7, no. 2 (1976-77): 2-22.

11. See the reference in note 2 above, and the summary of one application on page 13 of this paper.

12. Thomas L. Russell, "Toward Understanding the Use of Argument and Authority in Science Teaching," Background Paper No. 7 for the Explanatory Modes Project, Toronto: Ontario Institute for Studies in Education, Department of Curriculum, 1973.

13. R. S. Peters, Ethics and Education, London: George Allen and Unwin, 1966, p. 240.

14. Stephen Toulmin, The Uses of Argument, Cambridge: Cambridge University Press, 1958, p. 97.

15. Seymour B. Sarason, The Culture of the School and the Problem of Change, Boston: Allyn and Bacon, Inc., 1971.

16. Ronald D. Cohen, "Problems of 'Retreading' Science Teachers, Part II," Science Education 56, no. 3 (1972): 417-421.

17. Milbrey McLaughlin, "Implementation as Mutual Adaptation: Change in Classroom Organization," revision of a paper presented at the Annual Meeting of the American Educational Research Association, Washington, D.C., March, 1975.

18. These quotations are from pages 15 and 8 of McLaughlin's paper.

19. David E. Hunt, "Theory-to-Practice as Persons-in-Relation," Ontario Psychologist, March, 1977.
See also David E. Hunt, "The Problem of Three Populations: Students, Teachers, and Psychologists," in Solveiga Miezitis and Michael Orme, eds., Innovation in School Psychology, Symposium Series/7, Toronto: The Ontario Institute for Studies in Education, 1977, pp. 51-58.