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# DETECTING FEATURES OF NOVICE SCIENCE TEACHER THINKING

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Detecting Features of Novice Science Teacher Thinking" submitted by Peter M.K. Chin in partial fulfillment of the requirements for the degree of Master of Science.

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## ABSTRACT

There is a substantial research literature about the differences between "novice" and "expert" teacher thinking. The present study, based on the experiences of a student teacher in secondary school science, developed a way to detect features of a novice's thinking by examining the day-to-day events of his classroom. The novice (Don) was assigned to two cooperating teachers, Larry for biology and Diana for chemistry, in a large urban high school of about 2200 students. (All names in the study are pseudonyms, of course.)

The thrust of the argument is that an epistemological "bridge", in the form of a set of clues, is needed if an observer (say, a cooperating teacher) is to make reasonable inferences about features of a novice science teacher's thinking. Identifying and formulating those clues required a systematic examination of data associated with Don's teaching, in order to see how features of novice teacher thinking identified generally in the research literature manifested themselves in his particular case. Data were selected from a substantial collection of classroom transcriptions, recorded interviews, and Don's student teacher logbook.

The features of interest about novice teacher thinking were derived from an analysis of the literature, which generated four general themes representing a composite picture of novice teachers. These are as follows: (a) novices are unrealistically optimistic about the demands of teaching, (b) novices' subject matter knowledge is not entirely equal to the requirements of teaching, (c) novices lack sophistication in assessing classroom situations, and (d) novices perceive students from a perspective that is inadequate to the situation.

The researcher identified data showing how each of these themes manifested itself in Don's teaching, then developed clues for linking the actions to patterns of thinking. For each of the four themes, a clue to the "student view" of teaching (Don's) was paired with a "teacher view" clue. The themes were examined also in light of their pertinence to generic, or general pedagogical aspects of teaching versus aspects specific to teaching the subject matter of science, and each theme was considered to embody both a procedural component (<u>how</u>) and a declarative component (<u>why</u>).

In all, twelve clues were generated by this process -- six pertaining to a student view of teaching and a companion six for a teacher view. The study is regarded as potentially valuable for education, supervision, and induction of new science teachers.

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Finally, I would like to thank "Don", "Larry", and "Diana" for making this study possible.

This thesis is dedicated to

my father

ALLEN Y.L. CHIN

and to my mother

MARY W.M. CHIN

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## FOCUS OF THE STUDY

### Introduction

In the past decade a great deal of research has focussed upon identifying differences between novice and expert teachers -- both their knowledge base and their cognitive processes. The majority of such research has concentrated on non-subject-specific elementary school teaching. The knowledge about teaching which results from this approach is generic, suggesting that all subject areas share the same instructional concerns.

However, some researchers continue to approach research on teaching in secondary schools on the assumption that there are instructional concerns unique to the teaching of individual subjects. The assumption comes as no surprise to experienced teachers, of course. Recently, the most vocal advocate of renewed attention to subject-specific research on secondary school teaching has been Lee Shulman (1986, especially).

In detailing the breadth and depth of the knowledge base needed for teaching, Shulman (1986) began by acknowledging that the majority of novice secondary teachers

have completed a university major in their subject specialty, establishing a certain level of subject matter competence (i.e., knowledge within the discipline). He further contended that novices' (or student teachers') subject matter expertise must be modified into a form understandable to the students they will teach. Thus, he argued for the inclusion in educational research of studies within the "missing paradigm" of pedagogical content knowledge, which blends content (i.e., subject matter) knowledge with pedagogy. The term refers to the ways in which a teacher formulates and represents subject matter in order to make it comprehensible to others. Research in this paradigm is deliberately <u>not</u> generic.

The significance of the present study, about a novice teacher gaining experience in high school biology and chemistry teaching, can be seen partially in light of the present state of the art of research on teacher thinking. That is, the study adds to the growing body of novice teacher research situated in the context of secondary school science, and it acknowledges and reveals the importance of subject matter competence and subject-matter-specific knowledge. But there is another aspect of its significance. As discussed below, this is a study aimed at linking theoretical findings from teacher thinking research to the events of a novice science teacher's classroom, in order to relate such events to features of his thinking. This is of

epistemological significance, in that the study provides a means for inferring from events of practice what a novice is thinking, thus giving a sounder footing for the preparation and induction of new teachers.

## About the Study

This study concentrates on Don, a student teacher in a large urban senior high school (2200 students in grades 10-12), and his two cooperating teachers, Larry in biology and Diana in chemistry. (All names are fictitious in this study.) The period of time covered by the study is the seven-week "second round" of practicum, from early March until the end of April, in the professional year of Don's pre-service program. His first practicum experience, in the preceding fall, was in a junior high school (grades 7-9).

Before proceeding any further to describe the study, it will be helpful to clarify how the terms "novice" and "expert" are generally used in the research literature. Novices are defined either as students enrolled in a pre-service program, or as first-year teachers. They are commonly referred to as novices, novice teachers, student teachers, or beginning teachers. Experts are defined as experienced teachers who are recognized in some fashion as being outstanding examples of the profession, either through meeting specific criteria set out by the researchers or

being identified by school administrators. Many studies caution that experience does not necessarily equate to being categorized as an expert (Tobin and Fraser, 1987, e.g.). This is acknowledged as a weakness in the entire novice-expert line of research, in that it is difficult to find a clear demarcation between definitions of an experienced teacher and an expert teacher. Experience is clearly a necessary condition for developing expertise in thinking, but is not a sufficient condition.

## The Basic Conceptual Framework

To bypass the definitional difficulties found in novice-expert studies in general, this study is oriented around a fundamental distinction between what will be called a RELATIVELY NAIVE perception of teaching and a RELATIVELY DEVELOPED perception. The novice-expert literature is examined (Chapter 2) for its most informative findings, and four broad themes depicting the differences between novice and expert teacher thinking are used as a part of the conceptual framework for analyzing aspects of Don's teaching. The thrust of the study is to develop a systematic way to detect features of novice science teacher thinking, as these differ from the thinking of "experts".

An example, albeit trivial, will help to illustrate the distinction. Berliner (1986) conducted a study where the participants were briefly shown a slide of a classroom

situation. Novices typically responded that they had seen "a room of students sitting at tables", while experts elaborated that they had seen "a hands-on activity of some sort" or "a group of students maybe doing small-group discussions on a project as the seats are not in rows". Berliner concluded that while novices can report only the surface characteristics of classrooms, expert teachers have greater insight and inferencing abilities, and access their experiential knowledge base to report more than is directly visible in their efforts to make sense of what is occurring in the classroom.

The basic conceptual distinction between a relatively naive perception, referred to as a "student view of teaching", and a relatively developed perception, referred to as a "teacher view of teaching", is elaborated upon in two ways. First, because teaching strategies and techniques exhibited in a classroom are assumed to have a reasoned basis (Fenstermacher, 1986, e.g.), the notion of a perception of teaching is conceptualized as having two components: procedural knowledge of <u>how</u> to carry out the actions within a classroom, and declarative knowledge of <u>why</u> the actions within a classroom are being done in a particular way. Second, the framework accommodates issues within both the general pedagogical domain and the "missing" domain of subject-specific pedagogical content knowledge.

Influences on Novices' Views of Teaching

A novice's student view of teaching is conceptualized as being influenced by the accumulated information from several different sources, two in particular. First is the influence of observing teachers throughout one's own schooling experience (Lortie, 1975), which helps to inform a novice's procedural knowledge component. That is, a student teacher has spent thousands of hours in elementary, secondary and university classrooms as a student, and has therefore been exposed to a variety of teaching techniques and strategies -- the how of teacher knowledge. But as a student, one is not privileged to the declarative knowledge guiding the actions of the teachers one observes. Thus, the procedural knowledge that a novice initially brings to classroom teaching is conceptualized for the study as being uninformed (i.e., not well grounded in reasons).

A second influence comes from ideas about instructional techniques and pedagogical theory presented to novices in a variety of pre-service education courses. Such ideas help to develop novices' declarative knowledge about teaching, or what we might call educational theory. Due to lack of substantial practical experience, there is no reason to expect a novice to be able to link that declarative knowledge to his or her own classroom practice, however. Thus, the declarative knowledge that any novice initially

brings to classroom teaching is conceptualized for the study as being idealized.

## Correspondence Between Procedural and Declarative Knowledge Components

When novice teachers enter classroom teaching situations, it is common knowledge that they do not operate at the same level of proficiency as expert teachers. One way to account for these differences is to focus upon the correspondence between a teacher's declarative knowledge and procedural knowledge. It will be argued in more detail later (Chapter 3) that in experts the two knowledge components are generally in concordance, whereas in novices, there are often wide gaps between the two.

However, to say that novice teachers conceptualize the events in a classroom strictly from a student view of teaching is inappropriate. In some areas, especially in teaching those topics where they are confident and competent, novices are capable not only of knowing how to do it, but also why it is done in that way. By the same token, expert teachers placed in the situation of having to teach a new course exhibit many of the same deficiencies that are seen regularly in novices.

## General Pedagogical and Subject-matter-specific Domains

In the area of science education, obvious concerns about lesson presentation can be found in the sheer amount

and conceptual difficulty of the subject matter to be learned. Science teachers must evaluate the material and make decisions about teaching strategies to be used so that students have the best opportunity to learn. Thinking about science teaching thus includes such matters as understanding the subject matter, anticipating areas where students will experience problems or have misconceptions, and selecting the appropriate techniques (e.g., metaphors, examples, demonstrations, analogies, etc.) from one's repertoire (Shulman, 1987). This is essentially a restatement of the definition of pedagogical content knowledge.

Tamir (1988) re-emphasized the importance of subject matter knowledge, and further emphasized the importance of distinguishing pedagogical content knowledge from general pedagogical knowledge. General pedagogical knowledge includes knowledge about students, curriculum, instruction, and skills, for example, and such knowledge is the standard fare of many courses within pre-service teacher education programs. Topics include learning theories, Bloom's taxonomy of educational objectives, development of evaluation instruments, motivation theories, and classroom management techniques, among others.

Given this distinction, the conceptualization of a perception of teaching must be expanded to include both a general pedagogical domain pertaining to the aspects of teaching common to all classrooms, and a subject-matter-

specific domain pertaining to the aspects of teaching unique to each discipline. Procedural and declarative knowledge components characterize the actions and rationales for actions within each domain. This conceptualization will be developed further in Chapter 3.

## Methodology

Conducted at a large urban high school, the study involves the novice teacher, Don, and two experienced cooperating teachers, Diana and Larry, to whom he had been assigned. Don was selected by the researcher in consultation with the secondary science methods instructor on the grounds that he was interested in what he might learn by participating in the study, that he seemed to have a reasonable ability to discuss teaching, and that he was interested in the possibility of a joint placement in biology and chemistry. (Don's university science degree was in zoology, with a small number of courses in chemistry.)

Eight audio-taped "clusters" of data (four in biology and four in chemistry) were collected. Each cluster consists of a lesson taught by the novice and interviews involving: (a) the novice and the appropriate cooperating teacher, (b) the novice and the researcher, and (c) the cooperating teacher and the researcher. Weekly taping of

biology and chemistry clusters began in the third week of the seven-week student teaching round.

In addition to the eight tape clusters, several informal discussions between the researcher and the participants were audio-taped. The researcher also obtained a copy of Don's logbook which contained his lesson plans, his self-evaluations of the lessons, and the cooperating teachers' comments. (In this program, all student teachers are required to keep such a logbook.)

The researcher, a teacher at the same school, did not observe Don's teaching, did not participate in any of the interviews between Don and his cooperating teachers, and did not have a role in evaluating or otherwise officially commenting on Don's performance. The extent of formal interaction for purposes of this study amounted to a total of twelve interviews with Don; eight were about the lessons mentioned above, and the remaining four were more general in scope.

It is important to note that the study is <u>not</u> a summary of Don's experience in the four weeks spanned by the data collection. That is, this is <u>not</u> a case study documenting the experiences of one novice teacher. Rather, the novice's experiences are used as the data base for developing a series of "clues" that link novice teacher thinking to actual instances in classroom practice. The outcome of the study is the clues. Thus, instances from all of the data

are used on a highly selective basis, as required by the methodology described below.

The study is based on a research approach developed and described by Roberts and Russell (1975). The purpose of this technique is to relate theoretical distinctions to the actual events of science teaching, and in this case the point is to link what the novice does to what he thinks. In this approach a systematic conceptual framework is developed, based on the research findings available about novice teacher thinking. Next a "clue structure", or set of criteria for identifying instances, is formulated by examining Don's teaching to see how the theoretically established aspects of novice teacher thinking manifest themselves in his teaching and his comments about it. The outcome is a systematic set of attributes of practice which identify instances of the occurrence (or absence) of the features of teacher thinking represented in the conceptual framework. These attributes allow an observer of a novice science teacher's practice to answer the question, "If that is what a novice thinks, what does he/she do in the classroom to manifest that thinking?". The significance of such an outcome, especially for those interested in supervising novice science teachers, is to link theory about teacher thinking to the reality of student teaching situations. There is significance as well for other aspects of science teacher preparation.

The conceptual framework of this study is made up of two components which are developed and refined in Chapter 3. First, there are four major themes that emerge from the research literature (Chapter 2) depicting the differences between novice and expert teacher thinking. Second, as foreshadowed earlier, three dichotomies are stipulated: (a) student view versus teacher view, (b) general pedagogical domain versus subject-matter-specific domain, and (c) procedural knowledge versus declarative knowledge. These dichotomies guide the researcher in using the conceptual framework.

The clue structure, which is systematically developed in Chapter 4, is based on both components of the conceptual framework in the following manner. First, the four major themes arising from the novice-expert literature suggest four questions to ask about Don's teaching. Second, for each of the questions the researcher identifies its thrust within the two dichotomies of general pedagogical versus subject-matter-specific domain, and procedural versus declarative knowledge. Third, for each question an example from Don's teaching is analyzed in order to establish the salient clues indicative of the remaining dichotomy, namely a teacher view or a student view. Finally, another example of Don's teaching is presented and analyzed in order to validate the clues by trying them out on a different instance.

## Structure of the Thesis

This thesis is presented in five chapters. Following this chapter, Chapter Two presents a review of the relevant literature and Chapter Three develops the conceptual framework for the study. Chapter Four presents an analysis of the data, and the final chapter includes the conclusions, limitations and implications of the study.

## Summary

Two important strands of recent research about teacher knowledge inform the present study: the significance of subject-specific pedagogical content knowledge for teacher thinking, and the differences between novice and expert teachers in such areas as judgement, planning, and the decisions made in the teaching of lessons. The study merges aspects of these two strands in a conceptual framework used to develop a clue structure by which instances of teaching by a novice science teacher can be analyzed to link classroom actions to the novice's thinking.

The conceptual framework of the study accommodates the reasoned basis of teaching, including provision for detecting a relatively naive or a relatively developed perception of teaching, and the extent to which the reasons

inherent in such perceptions are actually informing classroom practice.

The significance of this study is threefold. First, it contributes to research on science teacher thinking, an area where little attention has been shown in science education research (cf. Roberts and Chastko, 1990). Second, teacher thinking research has predominantly been focussed on the generic features of elementary school teaching (see Clark and Peterson, 1986, especially), and this study is both subject-specific and secondary. Third, the outcomes of the study allow an observer to detect instances in actual science teaching discourse of characteristics of novice teacher thinking, which is potentially valuable for education, supervision, and induction of new science teachers.

# Chapter 2

## REVIEW OF RELATED LITERATURE

This chapter presents a review of literature that is relevant to this study, in three groups: (1) "Teachers' Knowledge Base" studies, (2) "Teacher Thinking" studies, and (3) "Novice Teacher" studies. The use of groupings attempts to separate the literature into manageable topics, but the groups are by no means mutually exclusive for two reasons. First, teachers' knowledge base studies and teacher thinking studies involve a variety of participants. Their primary focus may be experts, novices, or both. Second, it is obvious that a teacher's thinking is highly influenced by his/her knowledge base. Although novice teachers are the subjects of many of the studies contained in the first two groups, the third group is included in order to highlight the concerns and expectations of novices as they progress through their student teaching experiences.

### Teachers' Knowledge Base Studies

This first section begins with an overview of the seminal contribution of Lee Shulman's thinking in the

"Knowledge Growth in a Profession" project at Stanford University. Shulman is generally credited with successfully restoring to current educational research a systematic focus on the importance of what teachers know. This line of research is of obvious significance to the present study, in that analysis of the novice's (Don's) teaching intuitively suggested that careful attention be paid to his knowledge of biology and chemistry, and how that knowledge seemed to be affecting his teaching. The section also contains a synopsis of Tamir's (1988) elaboration of Shulman's work, and other studies which exemplify the so-called "missing paradigm" of research on what teachers know about their subject matter. There are surprisingly few such studies about secondary school science, but selected studies focussed on English teaching and mathematics teaching are included to provide illustrative examples of studies of teacher knowledge.

Shulman's "Model of Pedagogical Reasoning"

In an early paper about the significance of teacher knowledge, Shulman (1986) presented an argument that much of the research on effective teaching ignores what he calls the "missing paradigm" of studies on the importance of a teacher's subject matter knowledge. He acknowledged that this omission is due to the necessity that researchers narrow their focus in an attempt to simplify the

complexities of classroom teaching. He also pointed out that choices are involved, when focus is narrowed in research. His paper centred on how novice teachers draw upon their expertise in subject matter, when they teach. He clarified the focus on content issues being pursued in the "Knowledge Growth in a Profession" project as follows. (p.8):

> Our work does not intend to denigrate the importance of pedagogical understanding or skill in the development of a teacher or in enhancing the effectiveness of instruction. Mere content knowledge is likely to be as useless as content-free skill. But to blend properly the two aspects of a teacher's capacities requires that we pay as much attention to the content aspects of teaching as we have recently devoted to the elements of teaching process.

Shulman distinguished among three categories of content knowledge: subject matter content knowledge, pedagogical content knowledge, and curricular knowledge. These are now elaborated briefly. Subject matter content knowledge refers to the body of knowledge within the discipline that the teacher comprehends. There is an entailment that the teacher understands and appreciates the grounds upon which the knowledge is based. The inclusion of both the knowledge and the grounds recognizes the differences between the "substantive" and "syntactic" aspects of a discipline, as they have been called (Schwab, 1964).

Pedagogical content knowledge can best be described as "the ways of representing and formulating the subject that make it comprehensible to others". Included are such teaching tools as metaphors, analogies, illustrations,

examples, explanations, and demonstrations. As well, the teacher's pedagogical content knowledge includes knowledge of areas where students might have misconceptions or experience difficulty with the subject matter.

Curricular knowledge refers to the teacher's understanding of the variety of instructional materials available for teaching the subject matter in question. It also includes "vertical" knowledge of the "topics and issues that have been and will be taught in the same subject area during the preceding and later years of schooling", and "lateral" knowledge of related topics being taught in other subject areas.

Later, Shulman (1987) expanded the categories of a teacher's knowledge base to also include general pedagogical knowledge (principles and strategies of classroom management and organization), knowledge of learners and their characteristics, knowledge of educational contexts (including the character of communities and cultures), and knowledge of educational ends and values (and their philosophical and historical grounds). In the same paper he introduced a model of pedagogical reasoning and action as a means of explaining how teachers are able to tailor subject matter into a form that can be grasped by students, and then teach it. The model includes the processes of comprehension, transformation, instruction, evaluation, reflection, and new comprehension. Shulman cautions that

although the processes are presented in a sequence they are not intended to represent fixed stages. In fact, the processes may occur in any sequence, certain processes may not occur, or the processes can be truncated or elaborated.

Comprehension refers to the ideas that the teacher must understand before teaching them to students. Such understanding also includes knowing how the concepts relate to other concepts in the curriculum -- both vertically and laterally.

Transformation has four sub-processes: preparation, representation, selection, and adaptation. Preparation means examining and interpreting the material to be presented. Representation involves the teacher's review of the subject matter and subsequent selection of appropriate analogies, metaphors, etc., that will help the students to comprehend the material. Selection entails evaluating the material and deciding upon the appropriate teaching strategy to use. Adaptation is the tailoring of the material to the characteristics of the students.

Instruction signifies the actual teaching of the material and includes many aspects of pedagogy such as classroom management, organization, and effective interaction with students. Evaluation occurs throughout the lesson whenever the teacher gauges the level of understanding of the material as it is being presented. Evaluation also includes formal testing.

Reflection occurs when the teacher looks back at the teaching and subsequent evaluation in terms of the ends that were sought, and how well they were achieved. The teacher ultimately learns from the experience which results in new comprehension.

## Tamir's Elaborations of a Teacher's Knowledge Base

Tamir (1988) made three clear distinctions that differ from Shulman's conceptualization of a teacher's knowledge base as just discussed. First, Tamir takes issue with the categorization of subject matter content knowledge. He argues that it should be referred to as subject matter knowledge since the inclusion of the word "content" undermines the distinction between the "substantive" (content) and "syntactic" (process) components of knowledge in a given discipline.

Second, a teacher's pedagogical knowledge is clearly separated into general pedagogical knowledge and subject-matter-specific pedagogical knowledge. This distinction is helpful to teacher education since there is recognition that there are some elements of teaching which are generic, and others that should be addressed in specific subject area methods courses.

Third, Tamir expanded the concept of teacher's knowledge base in the areas of subject matter, general pedagogical knowledge, and subject-matter-specific

pedagogical knowledge to include more detailed distinctions. He separated all three forms into knowledge components and skill components, basing the distinction on Olson's (1973) clarification that "while knowledge may be transmitted in a variety of ways, including speech, print, pictures and films, skills can only be acquired by direct experience". For example, subject matter knowledge refers to the major ideas and theories of a discipline, while subject matter skills might be as specific as using a microscope.

As well, Tamir expanded the areas of general pedagogical knowledge and subject-matter-specific pedagogical knowledge to include elements dealing with the student, curriculum, instruction (teaching and management), and evaluation. Two examples will be helpful to illustrate the use of these additional distinctions.

First, in the area of general pedagogical knowledge about students, the knowledge component would include an understanding of Piaget's developmental levels, and the skills component would include how to deal with hyperactive students. Second, in the area of subject-matter-specific pedagogical knowledge of instruction (teaching and management), the knowledge component would include an understanding that typical laboratory classes consist of a pre-lab discussion, lab, and post-lab discussion, and the skills component would include how to teach students to prepare wet mount slides, for example.

Earlier Sightings of the Missing Paradigm

The following section reveals that although the concept of pedagogical content knowledge wasn't formally introduced by Shulman until 1987, the ideas associated with it were already being conveyed in earlier literature. Two studies are cited.

In curriculum research Ben-Peretz (1975) formulated the concept of "curriculum potential" as the independent teacher interpretations of curriculum materials that were not bound to the developers' intentions. She asserted that as opposed to being instruments of transmission, teachers "mold and change" every curriculum that is offered to them. These changes are made in order to tailor the materials so that they are more suited to the teacher's thinking about goals, student needs, and the realities of the classroom situation. Ben-Peretz concluded that rather than trying to make curriculum materials that are "teacher proof", it might be "better to provide teachers with curricular possibilities as a basis for choice and action".

Kilbourn (1982) presented an analysis of a teaching episode in biology which shows the interaction between subject matter issues and pedagogical issues. The data were collected during a clinical supervision cycle of a beginning teacher who had been assigned to a non-academic grade nine class. The lesson focussed on an exercise from the textbook dealing with form and function, the context being birds.

The students were required to match sketches of bird feet with sketches of bird beaks.

The transcript data revealed a lack of student understanding of the exercise since minimal information about the birds' feeding habits was supplied by the textbook. As a result, the students were "forced" to make judgements that required more information than was available. The teacher did little to "modify, change, and embellish curriculum materials" where change was needed. As well, the teacher made very few attempts to put the exercise in perspective for the students in terms of the scientific processes that were being emphasized, especially inferences from function to form. As a result, the author concluded that the lesson was "epistemologically flat". This foreshadows one aspect of pedagogical content knowledge which shows how teachers should/can anticipate where students may have misconceptions or experience problems with the subject matter.

The issues associated with both "curriculum potential" and "epistemological flatness" are attended to in Shulman's model of pedagogical reasoning and action, especially in the sub-processes of transformation.

## Illustrative Studies of Pedagogical Content Knowledge

Smith and Neale (1989) analyzed the subject matter knowledge of ten primary teachers enrolled in a summer

science program, learning about conceptual change. Through the use of questionnaires, video-tapes of classroom teaching, and audio-taped interviews, the researchers were able to detect the depth of the teachers' subject matter knowledge, pedagogical content knowledge, knowledge of students' misconceptions, and teaching strategies related to a unit dealing with light.

It was concluded that the findings of this study revealed many similarities to the work of Anderson and Smith (1985) and Leinhardt (1986) in that the teachers' knowledge of subject matter, their translation of the subject matter into appropriate lessons, their knowledge of likely student misconceptions about the subject matter, and their repertoire of teaching strategies for addressing student misconceptions, were "critical components in the changes they were able to make in their teaching".

Hashweh (1987) examined the effects of subject matter knowledge in the planning and teaching of biology and physics. Six experienced high school teachers (three in biology and three in physics) participated in a study and were asked to plan one lesson in the appropriate discipline in a simulated teaching experience. The teacher's knowledge of the topic was assessed beforehand in order to determine the effect that it would have.

Hashweh found that when teachers were knowledgeable about a topic, they also had better vertical and lateral

curricular knowledge. Knowledgeable teachers were also more likely to detect student misconceptions, interpret student comments, and exploit opportunities to pursue topic-related digressions. In some cases, teachers with less knowledge erroneously reinforced student misconceptions and criticized appropriate student responses. Happs (1987) reported similar results in a study of junior high teachers in Australia.

Grossman (1987) examined the role of subject matter orientation in the teaching of secondary English and concluded that novice teachers' beliefs about subject matter can greatly influence what they teach and how they will teach it. Thus, it becomes important for all teachers to reflect upon how their practice is influenced by their passions and beliefs about subject matter. Baxter et al. (1985) presented similar findings in a study of secondary school biology, as did a secondary mathematics study conducted by Marks (1987a).

Haymore (1987) focussed upon the difficulties encountered by a successful university student who was in the process of becoming a secondary math teacher. The study indicated that her difficulties were caused by shallow subject matter knowledge, undeveloped pedagogical skills, and limited pedagogical knowledge. The novice discovered that her expectations of teaching were quite different from the realities of the classroom, and she had great difficulty

in bridging the gap due to the previously mentioned weaknesses in her knowledge base. McDiarmid et al. (1989) reported similar findings in a study of different ways of representing subject matter.

Marks (1987b) presented an account of a novice secondary math teacher who possessed an expert subject matter knowledge base of mathematics (having progressed two years into a Ph.D. program in math), but was disillusioned with the erratic behaviour of students and their difficulties with what he perceived as very easy math concepts. This study suggested that highly trained subject matter experts are at risk for dropping out because the job of teaching involves more about students and teaching, than just knowing subject matter.

Summary

This section of the literature review has focussed on the aspects of a teacher's knowledge base, especially the missing paradigm of pedagogical content knowledge. Shulman's conceptions (1986, 1987) were presented and Tamir's (1988) research made refinements to them. As well, Ben-Peretz's (1975) and Kilbourn's (1982) studies, which pre-dated Shulman, conveyed many of the same ideas about the active role that teachers take when teaching subject matter to students.

Additional studies enhanced and reinforced the

importance of subject matter knowledge and general pedagogical knowledge, and how weaknesses in these areas are obstacles which any teacher must overcome. The literature expands our conceptions of teaching performance to include the intellectual capacity of the teacher to actively select, prepare and present curriculum materials, rather than maintaining a focus solely on classroom action.

## Teacher Thinking Studies

This section reviews the teacher thinking literature which operates on the fairly straightforward premise that the actions of teachers are affected by what they think (Yinger, 1987, e.g.). This line of research is consistent with the conceptualization of declarative and procedural knowledge, as developed in the present study.

Clark and Yinger (1977) cited that research on teacher thinking is a logical outgrowth of traditional teacher behaviour research. The authors acknowledge that the teacher behaviour approach, which focusses strictly on classroom actions, has contributed to our knowledge of what teachers and students do, but they argue that it is difficult to apply the findings to all classrooms.

They contended that teacher behaviour appropriate in one classroom, may be inappropriate in another, due to the unique combination of personalities, constraints, and

opportunities inherent in each classroom. They concluded that if we wish to apply the general case to specific situations, we must focus our emphasis on how teachers exercise judgement, make decisions and express their thoughts in their actions.

Because teacher thinking research has become more prevalent only recently in teacher education research, a computer search of the Educational Resources Information Center (ERIC) system yielded disappointing results. The system accesses the database on the basis of descriptor and identifier terms. "Descriptors" are terms which are widely used in research, while "identifiers" are assigned to novel terms which have not gained wide acceptance. Once an identifier becomes commonplace, it is re-categorized as a descriptor.

Using the descriptors "teacher-thinking", "science-teacher-thinking", "beginning-teacher-thinking", "student-teacher-thinking", and "novice-teacher-thinking", yielded no citations. The ERIC system did reveal twenty-three post-1987 articles using the identifier "teacher-thinking", but many of them were inappropriate to the study. As a result, the literature review of this section is comprised of relevant and related articles initially detected by cross matching "teacher" and "thinking", and through a subsequent search of related articles accessed by replacing the

descriptor "thinking" with "cognitive-processes" (e.g., science-teacher-cognitive-processes).

In their review of teacher thinking research, Clark and Yinger (1977) separated the literature into four areas: teacher planning, teacher judgement, interactive decision making, and teachers' implicit theories. These categories will serve as our guide for the rest of this section. The studies presented in each of these areas are significant to the study in two ways. First, they illuminate the dimensions of teacher thinking that influence classroom action. Second, they highlight the most salient differences between novice and expert teachers. These findings serve as the conceptual bases for this thesis.

## Teacher Planning

Teacher planning research focusses on describing teacher decision making in actual planning situations and is one of the central topics of research on teacher thinking (Clark and Yinger, 1987). Planning includes selecting appropriate strategies and sequencing the material such that the students can learn it. From another perspective, that of analytic philosophy, Hirst (1971) demonstrated that in order to be called "teaching" the activity must make clear to students what it is they are to learn, and ensure that it is within their ability level to understand it.

Two strong themes about planning are evident in the

literature. First, it can be seen that the quality of planning is highly dependent upon the teacher's pedagogical content knowledge, an area where novices are deficient. Second, planning not only attends to the sequencing of teaching, but also plays a role in the management of students. Thus, studies of classroom management and teaching routines are included as planning studies.

Ringstaff (1987) investigated the influence of subject matter knowledge on teacher planning in a study of a novice secondary English teacher who had been assigned one class of remedial math. When teaching outside his area of expertise, it was found that the novice was highly reliant upon the textbook, and rarely deleted, added, or reorganized the material. The class was set into a regular routine where the teacher would explain for twenty minutes, and then the students would work on questions in the book for the remainder of the class. If the students finished early, they were allowed to sit and chat.

His lack of knowledge of math subject matter manifested itself in that he taught by a very ends-oriented method of giving "rules without reasons". Several instances are cited where in a single paragraph, he corrected himself on the subject matter as many as eight times. This method of teaching is in stark contrast to the novice's "enthusiastic" teaching of English where he interacted more, asked as many

as fifty questions per lesson, supplied many personal anecdotes and analogies, and rarely lectured.

Borko et al. (1987) investigated novices' understandings of successful and unsuccessful teaching. Fourteen elementary school novices (seven considered to be "strong" and seven who were "weak") were required to maintain journals throughout their professional year program which included seven university courses and four student teaching experiences. It was found that strong novices reported planning as a useful tool for anticipating and solving instructional problems in advance of actually teaching the lesson, and cited planning as an opportunity for learning the subject matter. They were able to make general and specific references to instances that indicated student learning. In contrast, the weak novices made no mention of planning as a tool for solving instructional problems before they occur, and many were overwhelmed by the task of learning the subject matter. They were able to make only general references to instances that indicated student learning.

Gudmundsdottir and Shulman (1987) explored pedagogical content knowledge by comparing a novice and an experienced social studies teacher in a secondary school setting. Through the use of transcribed interviews and classroom recordings, observer's notes, and collected documents over a twelve-month period, the researchers reported several

conclusions. The expert and the novice both possess substantial subject matter knowledge in their disciplines since the expert is a history major and the novice has a major in cultural anthropology.

In terms of curriculum potential (Ben-Peretz, 1975), the expert teacher has a refined perception of the structure of the curriculum and is cognizant of the pros and cons of various teaching approaches. The novice "knows only one way, the way he uses", and is capable of only visualizing one unit as opposed to seeing the course as a whole. The authors agreed with Tabachnick and Zeichner (1984) who suggested that student teachers learn short term coping techniques that will get them through the next lesson. Gudmundsdottir and Shulman added that this is understandable in light of the fact that the novice lacks pedagogical content knowledge.

Borko et al. (1988) examined the lesson planning strategies of twelve prospective teachers, eight of whom were assigned to secondary schools. Each student teacher was observed on two consecutive days and was interviewed after each observation. Transcripts of the audio-taped open-ended interviews served as the primary data for the study. The data revealed that all of the student teachers addressed common issues in their planning such as subject matter, teacher activities and student activities. All of the student teachers mentioned building in flexibility to

allow for the unexpected, and also mentioned that they had contingency plans if difficulties arose.

The researchers also reported that subject matter knowledge and confidence with the material were associated with differences in planning and teaching. When student teachers had strong subject matter background and confidence in their knowledge of the course material, they planned in less detail and were more responsive to students while they were teaching. As well, the secondary student teachers were influenced by the extent to which the course subject matter and structure were determined by the curriculum guide.

Leinhardt and Greeno (1986) examined the cognitive skill of successful teachers and suggested that their knowledge of lesson structure and subject matter were fundamental. Four novices and eight experts in middle-school math participated in the four-month study which involved video-taped observations of teaching and audio-taped interviews regarding lessons.

The authors reported findings about opening homework reviews similar to those of Berliner (1986), but also presented illuminating findings regarding instructional methods and homework assigning. Expert teachers made use of guided practice (where students work on example questions to reinforce a new concept, while the teacher monitors progress, gives feedback to each question, and gives individual tutoring where warranted) and assigned homework

as long as a minimum of two questions had been attempted in class during guided practice. The novice teachers seldom used guided practice, usually jumping immediately from the presentation of the material into monitored practice (where the students individually work on problems while the teacher moves about the room and helps students). Homework was often assigned to finish an incomplete lesson, thus adding to the frustration level of the students and decreasing the chance that the homework would (or could) be completed for the next class.

Broeckmans (1986) examined the short-term developments in novice planning from an action-oriented perspective. Eighteen primary-school novice teachers participated in the study and were required to maintain pre-actional and post-actional self-reports about their lessons, and were also required to maintain anecdotal "observations" of their planning sessions. The research concluded that initial novice planning consisted of inspection and interpretation of the lesson assignment, exploration of the subject matter and related activities, selection of subject matter and related activities, filling in the lesson planning form, checking, revision, and preparation for teaching the lesson (which included memorizing some of the material, preparing "crib" sheets, gathering of necessary materials, and rehearsing).

Two major developments in the novices' planning that

were reported merit attention. First, reductions of the planning process occurred, in the sense of condensing the steps or doing several steps simultaneously. This was attributed to the fact that the novice was adding to a growing repertoire of activities and strategies, and was becoming more comfortable with the material. Second, the novices began inserting "controls" into lesson plans to avoid previously experienced discipline problems or to capitalize upon student interests. They were beginning to see how the management of students can be influenced by planning.

Borko and Livingston (1989) investigated the planning, teaching, and post-lesson reflections of three novices and their expert cooperating teachers in secondary school mathematics. Participants were observed on consecutive days for one week of instruction, and were interviewed prior to and immediately after each lesson.

The experts were found to operate on several levels of planning including daily, unit, and year planning. Although none of the experts had written lesson plans, they were able to provide mental plans for their lessons. These mental lesson plans included an identification of the specific subject matter and its sequence, but did not include details related to pacing, timing, or the number of examples that would be presented. In the lesson presentation, the experts were able to address problem areas and provide examples to

reinforce concepts and skills. Post-lesson reflections usually focussed upon student understanding of the material and rarely mentioned student behaviour and classroom management.

Novices had written and mental plans of their lessons with built-in flexibility related to pacing, timing, and number of examples to use, but their planning usually extended only a few lessons ahead. Their planning was usually time-consuming as they searched for ways to present the subject matter most effectively. The novices admitted that they were unable to predict where in the curriculum the students would have problems, and had difficulty getting back on track after a student asked a question. Their post-lesson reflections focussed upon student participation and involvement, and the effectiveness and clarity of the teaching.

Berliner (1986) found that expert teachers effectively utilized well-practiced routines in the classroom. For example, in the study of opening homework reviews, expert teachers were found to take one-third less time than novices. As well, the expert was "able to pick up information about attendance, about who did and did not do the homework, and to identify who was going to need help in the subsequent lesson". In contrast, the novice was not able to determine who had the homework done, had difficulty with taking attendance, and asked ambiguous questions which

led to inadequate assessment of the difficulty level of the homework.

Wragg (1985) reported results from a massive five-year study which analyzed over one thousand lessons of secondary school teachers and novices. It was found that in classroom management, student teachers initially make little use of eye contact and non-verbal posturing or gesturing, and rely heavily on voice to attract the students' attention. Experienced teachers use elaborate mannerisms, exhibit confident voice articulation, and make noticeable use of their eyes.

Teacher Judgement

Teacher judgement plays a primary role in the selection of instructional activities relative to student ability, and in predicting student cognitive and affective achievement (Clark and Yinger, 1977). This area of the literature yielded the fewest articles, but four are of interest to this study. The first two studies investigated the basis on which expert teachers made judgements, and the latter two studies investigated both novices and experts. Two salient themes emerge from the articles. First, expert teachers have deeper understandings of the issues on which judgements are based. Second, experts draw upon their classroom experiences and have vivid depictions of "typical" students.

Hofer (1986) investigated how teachers process

information to reach a prognosis on the future achievement of a pupil. Twenty-five teachers representative of all educational levels were asked to appraise information about a fictitious student and to predict the student's performance on an upcoming exam. The cards supplied only the name of the student and an assessment of the student's ability and effort.

The interview data revealed that more than half the teachers reported that they had imagined their own pupils in an attempt to compensate for the minimal information that they had been supplied. This is supported by Calderhead (1988) who reported that teachers abstract "typifications" of what children and classes are like.

Morine-Dershimer and Joyce (1979) conducted a study as part of the South Bay Study, which required ten teachers at the school to perform a "pupil sort" activity. After teaching two new lessons to their students, the teachers were asked to sort their students into groups based upon something that they had observed about the pupils during the lesson. This process continued until the teacher exhausted all possible reasons for different groupings. The teachers were asked to perform the "pupil sort" at five different points throughout the school year.

The researchers concluded that the most frequently used bases were student personality and student participation.

Other bases for pupil sorts included student ability, achievement, peer relationships, and progress.

A second procedure was also administered in this study where the teachers were asked to predict student year-end reading achievement. This procedure was administered in September and November and the teachers' rankings were compared to the students' actual performance on the year-end standard achievement tests. The results revealed that the teachers were most accurate with their predictions of successful students but were less accurate when discriminating between average and below-average students. Leinhardt (1983) conducted a similar study that required novices and experts to judge students' potential achievement on an exam. It was revealed that experts had much more understanding of how and why they made their assessments.

Carter et al. (1987) investigated fifteen novices, eighteen experts (in secondary math or science), as well as twenty-one postulants (subject matter experts with a desire to teach but with no formal training). In a simulated teaching task, the participants were presented with a scenario where they were to take over a class five weeks into the school year, and were given forty minutes to prepare and write lesson plans for the first two days of instruction. The subjects were supplied with the grades the students had achieved to this point, the seating plan of the class, corrected tests and assignments, the textbook the

previous teacher was using, and student information cards which contained anecdotal comments written by the previous teacher.

Subsequent to their forty-minute planning session, the subjects were asked to "recall general and specific information about the students, and to make generalizations about instruction, management, and classroom organization" based on the information that they had been provided. Not surprisingly, there was greater similarity between novices and experts than postulants and experts, but some of the differences between novices and experts are worth noting.

Experts had richer rationales than novices in their unwillingness to focus on the student information cards in their planning. Experts were hesitant to judge students based upon the comment on the information cards because they were more concerned with the logistics of getting the students involved, setting the tone, establishing the rules, and sharing their personal philosophy with the students. Novices were hesitant to judge the students because they "didn't want to be biased", or they felt that negative statements may have been the result of "personality conflicts".

Even though the class had been operating for five weeks, expert teachers viewed the takeover as a "new beginning" where it was imperative to establish new routines, get to know the students, and assess what they

already know about the subject matter. The experts felt that review sheets were necessary in order to elicit from the students what they already knew, and how well they actually knew it. Novices did not share the same sense of "new beginning" and their suggested methods for assessing what the students had already covered were superficial. Novices were more likely to ask the students where they left off, and then proceed with a quick lecture-type review of the material. The review would place much more emphasis on providing the students with information than with eliciting information from them.

Calderhead (1983) investigated the differences in cognitions of experienced teachers, student teachers, and probationer teachers (in their first year of teaching after completing the pre-service program). The eighteen participants (six from each grouping) were video-taped while teaching and were interviewed using stimulated recall techniques at various times during the course of the school year.

He suggested that "beginning teachers appear to lack the conceptual structures, or have simple, undifferentiated structures, with which to make sense of classroom life, and do not extract the same kind or level of meaning as experienced teachers". Experienced teachers who have taught the same age group for a number of years have acquired enough knowledge about pupils in general, that they already

"know" their new class even before they meet them. They are quickly able to make general assessments about particular pupils in terms of general ability, classroom behaviour, and sociability. Experienced teachers are also able to diagnose student strengths and weaknesses, and are cognizant of the precise difficulties that the students may encounter in a particular lesson.

Calderhead concluded that beginning teachers (both student teachers and probationer teachers) start out with very little of any of these types of knowledge. These weaknesses contribute to many of the difficulties that beginning teachers face. For example, lesson planning and presentation may be hampered by their lack of knowledge concerning what students already know, what can be expected from the students, and how they might respond to different activities. Thus, they have difficulty anticipating where students will have problems and are more likely to "react" to student difficulties, whereas experienced teachers are more likely to anticipate pupil difficulties and address them before the students encounter them.

## Interactive Decision Making

Interactive decision making refers to the decisions that are made by the teacher during the act of teaching. The teacher is seen as a decision maker who is constantly monitoring the progress of the class, making decisions,

altering lessons while teaching, utilizing built-in contingencies in the lesson plan, and observing the effects that these actions are having on the students (Clark and Yinger, 1977). All of the studies pertaining to this area of research are dependent upon the teacher's self-report after the lesson has occurred. Stimulated recall interviews (video or audio) are the most prevalent form taken by the data from the self-reports. As well, Yinger (1986) reported that models (Peterson and Clark, 1978; Shavelson and Stern, 1981) of teacher interactive decision making have been developed with the premise that teachers become involved in decision making only when the lesson is perceived as going poorly.

Research in this area is still in its infancy as researchers try to document the scope of the reasons behind the decisions that are made while a lesson is in progress. The most important finding that emerged from this section is that novice teachers have great difficulty attending to the "cues" that are indicative of the need to make changes in a lesson. Even though novices have built-in contingencies for lesson plans, they rarely deviate from the actual lesson plan.

Bromme (1987) explored how teachers perceive and explain student understanding in the classroom. The nineteen teachers who volunteered for this study, taught grade 5, 6 or 7, and had an average of eight years of

teaching experience. Lessons were observed and interviews were audio-taped. The teachers was asked whether there were particular events that occurred while teaching, that informed them that the students were understanding or misunderstanding the material.

The answers to the questions were transcribed and the data were analyzed. The main reasons for altering a lesson were problems detected in students' difficulties with subject matter activities and their insight into the subject matter. The most commonly cited causes of the problem were pacing (23%), instructional quality (10%), quality of teacher planning and knowledge (10%), and difficulty of the task (10%). Whitfield (1975) investigated the nature of on-the-spot decisions that teachers make while a lesson is in progress. It was concluded that novices have fewer options available to them when it is perceived that the lesson must be altered.

Housner and Griffey (1985) described the decision making process employed by experienced and inexperienced teachers as they taught lessons in physical education. Eight experienced teachers (with five or more years) and eight novice teachers participated in the study where they taught two lessons and were subsequently interviewed using a video stimulated recall technique.

The researchers concluded that experienced teachers possess a repertoire of strategies for managing students and

facilitating their psychomotor performance which enabled the teachers to alter their lessons to address student needs and address individual performance. Novice teachers possessed a more limited repertoire and focussed their attention on the interest level of the class to insure that classroom management was maintained.

Galluzzo (1984) used an information processing model to examine the thoughts of student teachers during the act of teaching. Ten elementary school novices participated in the study where lessons were video-taped and video-stimulated recall interviews were conducted. The researcher concluded that the most prevalent concerns identified by the novices were pupil learning (23.4%), pupil attitudes (23.4%), and learning activities (20.2%). Little mention was made of modifying lessons in progress, which suggests that novices are relatively inflexible in their ability to move away from the "lesson-as-planned".

Roberts (1991) examined how novice science teachers made sense of observed lessons where the teacher deviated from the announced lesson plan. They had some difficulty in understanding how a lesson can be altered in mid-stream, believing that the teacher had included the change in his lesson plan somehow. They showed some awareness of gross indicators that the lesson did not go well, but experienced difficulty coming to grips with more subtle indicators. Morine-Dershimer (1991) concurred that research must develop

mechanisms for improving novices' awareness of pupil responses in relation to whether alterations to the lesson are needed.

MacDonald (1990) reported similar findings and suggests that experienced teachers see changing lessons "on the fly", in response to student "triggers", as a characteristic of any lesson. They are more knowledgeable than novices in the subject matter and the particular topics which will be problematic for students, and also have specific knowledge of the students in their charge.

Teachers' Implicit Theories

Since much of a teacher's judgement and decision making follows from the teacher's interpretation of his or her own experience, it is important to study how teachers make sense of their world. Research into the culture of teaching has evoked many concepts that attempt to capture the essence of teacher interpretation. Many researchers have argued that a teacher's beliefs need to be understood before more work on teacher thinking can be pursued (Munby, 1982; Nespor, 1987; Brousseau et al., 1988, e.g.).

Recent research has focussed upon teachers' practical knowledge using images and narrative to express a teacher's biography. The teacher's knowledge is practical since it arises from reflection on action in the classroom (Yinger, 1986). The most important finding that is revealed by the

literature is that expert teachers' conceptions of classroom teaching are quite complex and are highly influenced by their years of experience. Novices lack this experience, and thus, their "simplistic" conceptions of teaching are mainly informed by their years as students in the classroom.

Cornett et al. (1990) investigated the use of personal practical theories (i.e., a systematic set of beliefs which guide the teacher from prior life experiences and classroom experiences) and their influence upon a first-year secondary science teacher's curricular and instructional actions. A series of twenty lessons were observed and both formal and informal interviews were audio-taped.

The researchers presented seven personal practical theories that appeared to guide the teacher's practice. In fact, prior to the investigation, the teacher had not systematically articulated these beliefs. The theories pertained to: visual learning, talking in kid's terms, science learning is fun, higher level learning, very disciplined class, reinforcing concepts, and helping students save face.

Calderhead and Robson (1991) presented a study to show the usefulness of "images of teaching" in describing how knowledge about teaching was held. Twelve primary novice teachers participated in the study and were monitored throughout their first year of a B.Ed. course. Each novice was interviewed four times throughout the year, was asked to

observe video-tapes of teaching and comment on what he or she liked or disliked, and prepared a lesson plan for an imaginary class.

The study revealed that many of the novices' prior experiences as students in the classroom were elements of their images. Several novices recalled negative images of former teachers and were convinced their own teaching would not be like that. As well, they were able to recall positive attributes of many former teachers and hoped to incorporate those characteristics into their own teaching. The researchers also discovered that novice teacher images were relatively inflexible and narrow in focus.

Examples that illustrate the inflexibility warrant our attention. First, the novices seemed to lack knowledge about children, curriculum, and alternative teaching strategies. Second, they had difficulty in suggesting how the video-taped teacher presentation could have been done differently. This was perceived by the researchers as a difficulty in taking the context and the students into account. Finally, it was detected by the researchers that when the novices observed lessons which were good, they would replicate the lesson. Unfortunately, their modelling of the lesson was done with very little adaptation despite the fact they were dealing with a class that was different from the one they had seen.

Peterson and Comeaux (1987) investigated teachers'

schemata for classroom events and suggested that novices and experts differ in their recall, representation, and analyses of problem situations. Ten expert secondary social studies teachers and ten novices completed three ability tests, and watched three videotapes of classroom scenes which had been role-played by the actual members of the classroom. Each participant was interviewed separately about the three video-tapes, and the interview was audio-taped and transcribed.

It was found that experienced teachers had significantly higher vocabulary scores which are indicative of verbal ability. In the interviews, experienced teachers not only had better recall of classroom events, but they also made significantly more statements about the video-tapes which could be categorized as higher-level analysis. As well, the experienced teachers were able to provide more justifications for their comments and provided more elaborate answers to questions about the video-tapes.

Strahan (1989) examined the cognitive differences between experienced and novice teachers through the use of semantic ordered trees which represented their views of instruction. Ten experienced middle-school teachers and seven novices who had not attempted student teaching were asked to create semantic ordered maps about instruction. All participants were interviewed about their semantic maps, and were also required to write reflective compositions.

It was found that experienced teachers constructed semantic ordered trees that were more complex than those of novice teachers. Although both groups used many similar terms, the experienced teachers ordered the terms into more "chunks", and created more linkages between the chunks. As well, experienced teachers expressed more student-centred views about teaching. Their higher order system of classification reflected results similar to those of Berliner (1986). Other researchers in this area focus upon the importance of metaphors (Munby, 1986; Russell et al., 1988, e.g.) and concept mapping (Elbaz et al., 1986, e.g.).

Steinberg et al. (1985) examined four novice teachers' beliefs about student ability in high school math. All four novices cited similar rationales about student ability. They believed that some people have "mathematical minds" while others have mental blocks towards it, and that the students with mental blocks or "humanities mode" thinking would never be able to grasp it. All four novices attributed student failure to causes that are outside of a teacher's control, and had not given much consideration to the possibility that student failure may be related to teaching techniques or the difficulty of the material.

Jordell (1987) examined the socialization of beginning teachers in terms of structural and personal influences. It is suggested that the interaction of these influences help "new teachers develop practice-generated theories in their

daily interactions in the classroom, and these theories guide their teaching". The structural influences occur at the classroom level (the influence of students), the institutional level (curriculum and administrators), and the societal level (economic, political, and social structure). The personal influences which inform the teacher's classroom practice originate from their experiences in the teacher education program, and their own experiences as pupils in the classroom.

Goodman (1988) reported the findings of an ethnographic study of pre-service teachers' professional perspectives. The principles of "ethnographic semantics" were used to identify the meaning that the participants gave to their verbal expression. The research suggested that novices create practical philosophies of teaching by integrating the two major perspectives of teaching as "problem control" and "facilitation of children's growth".

Problem control included perceptions of getting student cooperation, hoping to be seen as the teacher in the room, and having control over the classroom environment (not just the children in it). Facilitation of children's growth included perceptions of individualization and recognition of responsibilities to enhance a child's self-concept.

Goodman concluded that the practical philosophies were informed by a set of "guiding images" which are expressed verbally, but are really rooted visually "based upon their

past experiences as pupils, their present experiences in their teacher preparation program, and their future expectations of themselves as regular teachers". The research suggests that the novices' "intuitive screens" (a term similar to schema, but metaphorically implying a "boundary" that is open to external stimuli) give them an orientation point from which to interpret ideas presented to them in their education courses. Thus, the alteration and/or reinforcement of their prior perspectives resulted from their responses (both intellectually and emotionally) to the people, settings, ideas, and experiences that they encountered in their pre-service program.

Summary

The literature pertaining to teacher thinking reveals a variety of issues which teachers address in the classroom. The studies presented illuminate the thinking that guides teacher actions in such areas as planning, judgement, and interactive decision making. As well, emerging literature pertaining to teachers' implicit theories highlights the different approaches being used to identify how teachers make sense of their own teaching. It is apparent from the literature that there are major differences between novices and experts in all areas of teacher thinking.

## Novice Teacher Studies

The literature pertaining to novice teachers focusses on studies that explore how student teachers learn to teach and how they generally orient themselves to the processes of becoming members of the profession. This includes how novices perceive the student teaching situation and how these perceptions change as the student teaching progresses. This group of studies illuminates some of the factors which inform and influence novice teacher thinking.

Fuller and Bown (1975) explored the experiences of becoming a teacher and learning what is included in a teacher's "life space". They identified the university faculty educators, cooperating teachers, peers, parents, and students as the major influences which impact the novice. Fuller and Bown suggested that learning to teach involves three stages: the survival stage, the mastery stage, and the pupil concerns stage. In the survival stage, the novice is concerned with such issues as class control, knowing the material, and being liked. In the mastery stage the novice tries to perform well in spite of the numerous pressures associated with the preparation of lessons. In the pupil concerns stage the novice has settled into "stable" routines and can now shift his/her focus towards the cognitive, social, and emotional needs of pupils.

Judith Shulman (1987) described the changes in a novice

secondary English teacher's perceptions of learning to teach by tracking a novice through her first ten-week term of student teaching. The study generated data through the use of a participant observer who watched classes (which were either audio-taped or video-taped), conducted interviews with the novice and with other school personnel, and examined classroom handouts, assignments, unit plans, and other documents which were of value.

The researcher determined that the novice progressed through three distinct stages: (a) observer role, (b) trial and error, and (c) consolidation and integration. During the first four weeks as an observer, the novice teacher was both bored and discouraged, and was also highly critical of the cooperating teacher's management and instructional techniques.

After assuming the role of the teacher in the fourth week, the novice began to express concerns about discipline and lesson planning. These concerns were prevalent for the duration of the term. She wanted to try new strategies, but lacked confidence in her ability to plan effectively and control students. When lessons did not go well, she was quick to put blame on the students rather than examining whether the lessons were well planned.

By the eighth week, the novice began to enjoy teaching and was becoming more competent in preparing lessons which were relevant and contained realistic goals. The novice was

also becoming much more confident in her teaching ability. She had established several routines which the class adjusted to, and was beginning to manage the class without having to resort to yelling (such as by saying "excuse me, I can't hear"). By the end of the term, she realized that classroom management and well-planned lessons were related, and that unsuccessful classes could be the result of poorly organized lessons. Studies conducted by Russell (1988), Feiman-Nemser (1983), Feiman-Nemser and Buchmann (1987), and Busher et al. (1988) contain many examples which are similar to Shulman's findings.

Calderhead (1987) tracked ten primary-grade student teachers through a one-year teacher training course and explored the interpretive frameworks used by the novices in their thinking about their classroom practice within the school-based experience. The data were collected using semi-structured interviews, observations of lessons, and field notes. The researcher concluded that, in general, the novices passed through three phases: (a) the "fitting in" phase, (b) the "passing the test" phase, and (c) the "opportunity to experiment" phase.

In the "fitting in" phase, the novices experienced considerable anxiety as they less than willingly adopted behaviours and routines that the cooperating teachers expected from them. The "passing the test" phase was characterized by the novices' perception that their

classroom performance and results were being assessed by the cooperating teachers. Thus, in this phase, the novices "tuned in" to those behaviours and actions which signalled competence to the cooperating teacher. In the "opportunity to experiment" phase, competence had been demonstrated and the cooperating teachers reduced the amount of time they spent supervising in the room so that the novices could discover their own teaching styles.

Regardless of the terminology being used, the studies that have just been presented show many similarities in their reports of how novices progress through the student teaching experience. The following two studies focus upon the expectations that novices bring to the student teaching experience.

Weinstein (1988) investigated pre-service teachers' expectations about the first year of teaching. A 33-item questionnaire pertaining to expectations about the first year of teaching was administered to 118 students who had just completed their course work and were about to begin their student teaching. The questionnaire outlined the most common concerns of first year teachers such as instruction, organization and management, and interpersonal relations.

The results indicated that although novices recognize the difficulties of work load, classroom discipline, and lack of materials, they underestimate the difficulty that first year teachers have with motivating students,

organizing classroom activities, relating to parents, and dealing with individual differences. The author concluded that novice teachers have an "unrealistic optimism" in that they believe that teaching will be less problematic for them than for their peers. Since the novices have not yet been subjected to the "reality shock" of classroom teaching, the novices' concerns focus "more upon impact than on survival".

The author suggested four factors that contribute to the unrealistic optimism of the novice teachers. First, teacher education programs lack many of the characteristics present in other professional preparation programs such as rigorous admission requirements and stringent certification boards. Second, Lortie (1975) suggested that all novices have experienced the "apprenticeship of observation" leading to the belief that having been students equips them for being teachers.

Third, teacher preparation courses have been guilty of "dumbing down" the work of teaching by conveying to novices that student learning is non-problematic as long as certain effective methods are used. Fourth, in the absence of a "publicly recognized knowledge base for teaching", novices believe that personality is the main determinant of success. Many novices equate their effectiveness as babysitters or camp counsellors to their future effectiveness as teachers.

Bolin (1988) presented a case study involving one student teacher and presented the findings on the basis of

journal entries and interviews. The study focussed upon the meaning that the student teacher perceives from the student teaching experience. The student teacher viewed teaching as "something that you do" and was disgruntled with having to meet observation requirements. This attitude was tempered by his growing realization that teaching is more complex than it initially looks. He was quite eager to attempt new strategies, but was less thoughtful about the principles or rationales behind them. Bolin concluded that there is a renewed appreciation of using journals as a supervisory tool, and that journals may also be a very powerful tool for developing more thoughtful and reflective teachers.

Summary

The literature presents a strikingly consistent portrayal of the different stages that novices progress through during student teaching. These studies are valuable in that they highlight some of the most important concerns that student teachers have during their practice teaching. As well, they depict the expectations that novices have before they begin student teaching and suggest possible influences that have informed these expectations.

## Conclusion

The review of the related literature has been most illuminating to this study. The knowledge base studies acknowledged the importance of research in the "missing paradigm" of pedagogical content knowledge. The teacher thinking studies highlighted the issues and intricacies involved in planning, judgement, and interactive decision making. Studies of teachers' implicit theories showed an important influence on how teachers make sense of what occurs in the classroom. The novice teacher studies depicted the perceptions and expectations of novices as they enter student teaching.

The literature review informs the conceptual framework of the study in two ways. First, the knowledge base studies support the dichotomy of general pedagogical versus subject-matter-specific domains, and the teacher thinking studies intuitively inform the teacher view versus student view dichotomy. Second, the studies presented characterize the various and numerous differences between novice and expert teachers. For the sake of conciseness, these differences have been consolidated into four major themes that depict how novices are different from expert teachers. Although they will be discussed in more detail in Chapter 4, it is helpful at this time to briefly identify the four major themes.

First, the literature generally reports that novices tend to have unrealistic optimism in that they believe that teaching will not be problematic for them. Second, the literature reveals apparent weaknesses in the breadth and depth of subject matter knowledge and subject-matter-specific knowledge that novices possess. Third, some studies conclude that novices lack depth in their rationales for classroom actions. Fourth, the literature reports that novices' perceptions of students in classroom situations are influenced by their own experiences as students.

# Chapter 3

## CONCEPTUAL FRAMEWORK

### Introduction

The reader will recall that the purpose of this study is to formulate a systematic method for detecting features of novice science teacher thinking about classroom teaching events. The purpose of this chapter is to develop and present the conceptual framework which guides that method.

The conceptual framework is comprised of two components. First, the researcher has stipulated already that the analysis will proceed respecting three dichotomies: (a) distinguishing a "student view" of teaching from a "teacher view", (b) viewing teaching situations according to general versus subject-matter-specific characteristics, and (c) identifying the procedural and declarative aspects of teaching acts (i.e., the how and the why). The teacher thinking literature intuitively informs the first and third dichotomies, while the knowledge base studies establish the basis for the second dichotomy.

Second, the review of research reported in Chapter 2 can be summarized according to four themes, giving a composite view of differences found between novice and

expert teacher thinking. These themes are the basis for four questions which constitute the second part of the conceptual framework.

## Four Themes from the Literature

From the research literature it is possible to formulate a composite picture of the differences between novice teachers and expert teachers. These are summarized here in rather stark terms as a generalized description of a population, not a characterization of any individual.

### Unrealistic Optimism

First, some researchers conclude that novice teachers tend to have unrealistic optimism in that they believe that teaching will not be problematic for them. That is, they see classroom teaching as something that "just happens" rather than something that is carefully planned. Other studies reveal a lack of breadth and depth in general pedagogy, evidenced by a limited repertoire of effective routines and classroom management techniques. Finally, many studies conclude that even when they encounter unanticipated problems, novices tend to be hesitant to deviate from a pre-determined lesson plan.

Knowledge of Subject Matter

A second theme is found in studies about the breadth and depth of novices' subject matter knowledge. Whenever there is weakness in subject matter knowledge there is inevitably a concomitant weakness in the novices' subject-matter-specific knowledge about teaching (i.e., the ways in which a teacher transforms subject matter into a form that students can comprehend). In such instances, planning is highly reliant upon the curriculum guide, the required textbook, the cooperating teacher, or even notes taken by novices when they were students in the same subject. Some studies found that novices are not very proficient at anticipating areas where students will have difficulty, and even when they do anticipate, novices have few strategies to address the student problems.

Analysis of Classroom Situations

Third, some studies have concluded that novices lack depth in the rationale for their actions in the classroom. That is, the principles guiding their instructional decisions are not clearly developed or articulated. What this means is that novices' understanding of problems in the classroom is superficial, compared to that of experts.

Undeveloped Perceptions of Students

Fourth, in general, novices' perceptions of students in classroom situations are highly influenced by their own experiences as students in the classroom, and by what they have learned in their pre-service training. When such reference points conflict with novices' actual classroom teaching experiences, frustration can ensue as to why their classes are not measuring up to their idealized images.

Contradictory Examples

The four previously mentioned broad themes depict many of the obvious general differences between novices and experts in an apparently dichotomous fashion. More specifically, they give the impression that novices can be characterized one way and experts can be characterized in a different way. This impression does not acknowledge that in some instances, novices are similar to experts, or vice-versa.

Two examples highlight the potential for apparent contradictions within the dichotomous approach. First, in some instances, the novice's background knowledge on a particular topic is very strong, including awareness of related strategies, anecdotes, analogies, and metaphors. For this particular topic, their confidence and competence allows them to teach in a fashion that is contradictory to the general characteristics of novices.

Second, previously identified expert teachers may be implementing a new course, be assigned to teach an out-of-area subject, or be placed in a situation where the students are markedly different (perhaps in age, ability, or temperament) from those they have been familiar with. In these situations, expert teachers are unfamiliar with the new material, have some difficulty anticipating where students will have problems, and have a limited repertoire of appropriate strategies to address the problem areas.

In fact, this description is strikingly similar to one of the themes describing novices. Borko and Livingston (1989) suggest that "any teacher will think and act like a novice, to some extent, the first time he or she attempts to teach a particular body of knowledge". The systematic approach to characterizing the distinctions between novices and experts that follows, accommodates these apparent contradictions.

## Visualizing the Dichotomies of the Conceptual Framework

As suggested immediately above, the straightforward dichotomy "novice versus expert" is too simplistic to serve as an analytical device for the purposes of this study. That is, novices sometimes think and/or act like experts and vice-versa. The present section is devoted to an

elaboration of the more complex approach taken by the researcher.

Components of a Perception of Teaching

The basic distinction for this study, as pointed out already, is that between a relatively naive and a relatively developed perception of teaching. The relatively naive perception is referred to as a "student view of teaching", and the relatively developed perception is referred to as a "teacher view of teaching".

Figure 1 shows four analytical categories which comprise a perception of teaching. Because a teacher's actions within the classroom are assumed to have a reasoned basis, a perception of teaching is conceptualized as being composed of procedural knowledge of how to carry out the actions associated with teaching, and declarative knowledge of why actions in the classroom are being done in a particular way. A perception of teaching operates in two different domains: the domain of general pedagogical knowledge (i.e., the generic aspects of teaching), and the domain of subject-matter-specific knowledge (i.e., the aspects of teaching unique to each discipline).

Figure 1

The components of a perception of teaching

A view of teaching (either a student view or a teacher view) is defined as consisting of the following categories (examples are included for clarification):

**Procedural subject-matter-specific knowledge:**

Knowing how to carry out content related actions in the classroom such as teaching students how to prepare wet mount slides in biology.

**Procedural general pedagogical knowledge:**

Knowing how to carry out actions common to all classrooms such as routines and discipline.

**Declarative subject-matter-specific knowledge:**

Knowing the rationale for classroom actions specific to the subject matter such as understanding where students have covered similar material in previous years. For example, showing how the process of meiosis in cell biology is the basis for the concepts found in Mendelian genetics.

**Declarative general pedagogical knowledge:**

Knowing the rationale for all other classroom actions such as understanding how excessive and extreme disciplining can cause the classroom climate to deteriorate.

## Recasting Expert and Novice Thinking

Expert teacher thinking is conceptualized, according to the categories of Figure 1, as that of a person who has refined and consistent declarative and procedural knowledge in both subject-matter-specific and general pedagogical domains. Thus, expert teacher thinking is marked by the

making of sound, reasoned decisions about how to present a lesson, and also by a large selection of teaching strategies with which to carry out the lesson.

In novice teacher thinking, by contrast, procedural and declarative knowledge in both general pedagogical and subject-matter-specific domains is conceptualized as being superficial, compared to that of experts. There is good reason for this. Procedural knowledge has been based upon watching the actions of teaching from the receiving side, not the delivery side of the classroom. As a result, the novice's initial procedural knowledge is a small repertoire of teaching strategies that have been gleaned from his/her memory of what teachers did. It is conceptualized as being uninformed because as a student in the classroom, the novice has been privy only to the visible actions of teaching and not the "invisible" thinking that has informed practice.

Within the procedural subject-matter-specific domain, novice teacher thinking is characterized by a comprehension of the subject matter which is not yet solidly grounded enough that the novice can appreciate the difficulties in its presentation. Utilizing the textbook, curriculum guide, cooperating teacher, or even his/her old notes aids the novice, but does not inform the novice's thinking as to the reasons that a particular sequence is chosen. For example, a novice may rely upon the sequence of material presented in a textbook, but he/she could well be unaware of the

rationale for the sequence (such as the need in many cases in science teaching to provide concrete examples before making a shift to abstract topics).

Within the procedural general pedagogical domain, novice teacher thinking and teaching often incorporates and mimics the routines and strategies of the cooperating teacher, again for good reason. Not only have those techniques been seen to be successful in managing a classroom, but also the nature of the student teaching situation requires that the cooperating teacher evaluate the novice.

In novice teacher thinking, declarative knowledge within the subject-matter-specific and general pedagogical domains, informed by the novice's pre-service education courses, is conceptualized as being idealized. Subject-matter-specific methods courses stress the importance of using a variety of teaching strategies and techniques in order to help students understand the subject matter. As well, general pedagogical theories about teaching are presented to the novice in a variety of education courses. Due to the lack of substantial practical experience, novice teacher thinking cannot be expected to exhibit strong connections between theory and practice.

Visualizing Novice Teacher Thinking

Establishing a dichotomous comparison between a "student view of teaching" and a "teacher view of teaching" rather than simply between "novice thinking" and "expert thinking" has been justified already. Context is simply too important for determining how a given teacher will think about a teaching situation; no teacher is a "novice thinker" or an "expert thinker" in all situations, in other words.

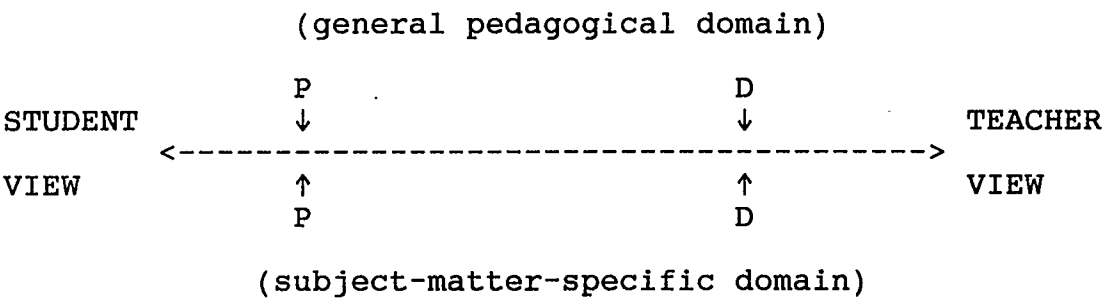
Figure 2 is the first of a series of visual representations intended to assist in clarifying the way this analysis proceeds. In these visuals, "student view" and "teacher view" are placed at the ends of a conceptually polarized continuum. The markers above the line represent the procedural and declarative components of general pedagogical knowledge, while the markers below the line represent the procedural and declarative components within the subject-matter-specific domain.

Figure 2 is a visual representation of novice teacher thinking in general. The distance between P and D, the procedural and declarative components of the novice's knowledge, captures the point that procedural knowledge is uninformed by reasons, in novice teacher thinking, and that declarative knowledge is idealized (i.e., not informed by practice). Due to the influences of pre-service education courses, D is relatively well informed and thus appears towards the teacher view end of the continuum. P, relying

heavily on memories as a student, quite naturally appears towards the student view end.

Figure 2

Novice teacher thinking




The four themes about novice teacher thinking from the research literature can also be "seen" on this visual. First, the literature reported unrealistic optimism and a lack of breadth and depth of knowledge about effective routines, classroom management techniques, and teaching strategies. This is analytically represented by the location of P (procedural knowledge) at a spot which associates it with a student view of teaching, in both the general pedagogical domain (specific to routines and classroom management), and in the subject-matter-specific domain (specific to teaching strategies). Second, the location of P in the subject-matter-specific domain captures the reported weakness in subject matter knowledge, and the concomitant weakness in subject-matter-specific knowledge.

The other two characteristics of novice teacher

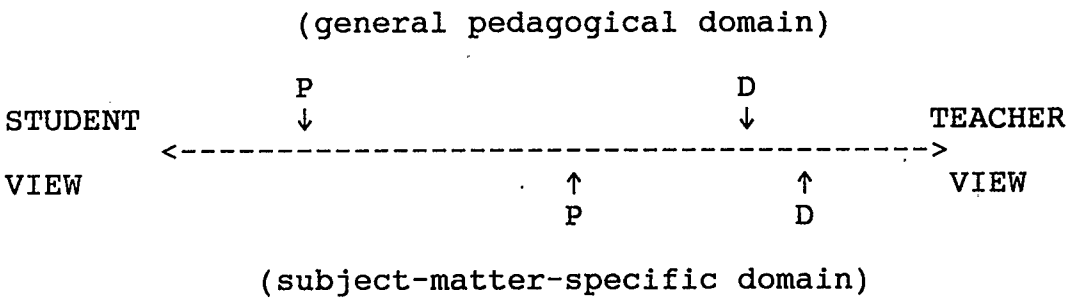
thinking are represented by the locations of P and D relative to each other. It was reported that novice teacher thinking lacks depth about the rationale for actions in the classroom. This is captured by the separation of P and D. As noted earlier, novices' perceptions of students in classroom situations are highly influenced by their own experiences as students, and by what they have learned in their pre-service training. Hence P is toward the "student view" end of the continuum. But the analytic representation of idealized pre-service "theory" would place the declarative (D) component of novice teacher thinking near the level of expert thinking, since novices can state the appropriate theoretical reasons for actions. That they have difficulty embodying such theory in their own practice keeps P near the student view, yet D is more in the realm of a teacher view (but definitely lower than the location where the D representation of expert teacher thinking would be).

In some areas, novice teacher thinking may also exhibit characteristics more similar to a teacher view of teaching, where procedural knowledge informs, and is informed by, declarative knowledge (P and D would come closer together). For example, in some areas a novice's subject matter understanding might be comprehensive enough that he/she can see particular topics about which students will experience problems or have misconceptions, and can access appropriate metaphors, analogies or explanations in order to facilitate

the students' learning. In such a case, a novice teacher would have a better than usual understanding of the reasons for sequencing the material in a certain way, since it is familiar. Clearly this is a matter within the subject-matter-specific domain, and Figure 3 represents it by showing P and D much closer together than in Figure 2, with D closer to a teacher view as well.

Figure 3

Novice teacher thinking in a strong subject matter topic




Visualizing Expert Teacher Thinking

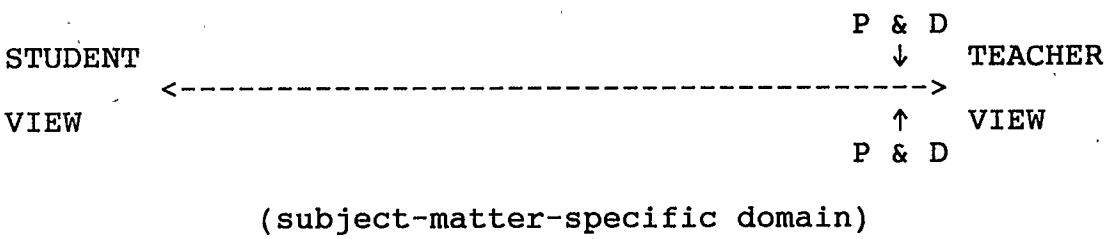
Earlier it was noted that expert teacher thinking can, in some situations, display some of the characteristics of novice teacher thinking. The situation cited was that expert teacher thinking resembles a teacher view in one subject area, but resembles some elements of a student view when the individual is placed in situations of teaching new subject matter or unfamiliar kind of student, for instance.

Let us consider this anomaly by first considering

expert teacher thinking in the setting where the expert is competent, i.e., within his/her strong subject area, and teaching students of the type that he/she is accustomed to. Figure 4 shows P and D, the procedural and declarative components, grouped together to illustrate that in expert teacher thinking, each component informs and is informed by the other. This is shown to be the case in both the general pedagogical domain and the subject-matter-specific domain.

Figure 4

Expert teacher thinking

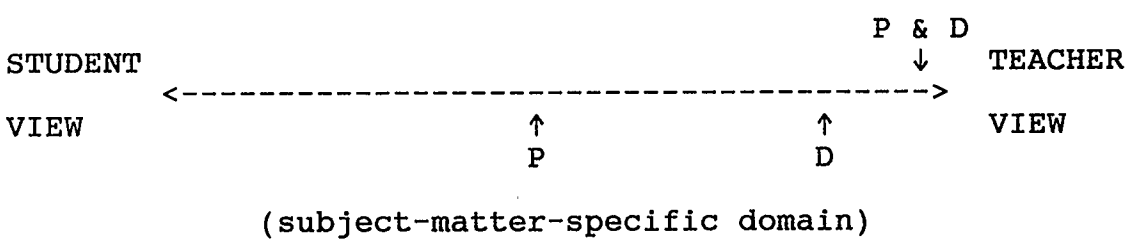



What about expert teacher thinking when the teacher is teaching a subject outside his/her normal subject area, for example? The teacher's general pedagogical knowledge remains unchanged in the new situation, but Figure 5 captures three changes in the subject-matter-specific domain. First, P and D are separated, because they do not inform each other as well as before. Second, D has been moved slightly away from the teacher view end of the continuum to display the point that the teacher will

experience difficulty in determining what the students ideally need to know. Third, the procedural component of knowing how to best make the subject matter comprehensible to the students has been shifted. This marker has not reached the extreme (student view) end of the continuum due to the recognition that an expert teacher will utilize his/her experience with other subjects in an attempt to anticipate what students might find difficult, although he/she lacks the necessary subject-matter-specific strategies to address them.

Figure 5

Expert teacher thinking in an unfamiliar subject area




When expert teachers are assigned to teach new courses, their subject-matter-specific knowledge levels resemble those of novices who are strong in a particular topic. Chastko (1990) explored the substance and quality of discussions between novices and experts and found that in the situations where the expert was teaching a newly

implemented Science-Technology-Society (S-T-S) course, novices and experts were highly collaborative in attempting to make sense of the material. In this instance, their lack of procedural knowledge was their commonality for collaboration.

If the novel teaching situation of the expert is compounded by being assigned to teach students who are markedly unfamiliar (e.g., in age, ability, or temperament), the markers within the general pedagogical domain would also be altered in a similar fashion. This is due to the recognition that an expert's traditional ways of dealing with students must be altered in order to successfully manage them. For example, a teacher who has usually taught high school chemistry cannot use the same repertoire of classroom management techniques when teaching junior high students.

## Constructing the Conceptual Framework

In order to contextualize the conceptual framework within the actual events of Don's teaching, part of the conceptual framework must delineate the parameters of what constitutes significant data. This is accomplished by the development of four questions which capture each of the four themes depicting major differences between novices and

experts identified in the literature. The four questions of the conceptual framework are as follows:

1. How does a novice science teacher manifest the unrealistic optimism that he/she already knows how to teach?
2. When a novice science teacher makes a subject matter error, what can be inferred about the novice's thinking?
3. How does a novice science teacher's assessment of classroom problems (e.g., lesson flow, discipline) suggest a rudimentary level of analysis?
4. How does a novice science teacher's performance reveal a relatively undeveloped perception of students in classroom situations?

The questions are framed to target pertinent data about Don's teaching. As well, each of the three stipulated dichotomies is engaged for each question as follows. First, an instance of data is classified as either in the general pedagogical domain or the subject-matter-specific domain dichotomy of teacher thinking and/or action. Second, procedural knowledge and/or declarative knowledge components are identified. Procedural components can be detected directly from Don's classroom practice, and declarative components can often be detected from interview and logbook data, in which he gives reasons for the actions identified. Finally, the analysis seeks to identify clues to both a student view and a teacher view about the instance being examined. The student view clue is based on Don's teaching, and the teacher view clue is "hypothetically" developed using the cooperating teachers' (Diana's and Larry's)

comments where possible, but otherwise inferring the clue from the literature and/or the general lore of the science classroom.

## Summary

The conceptual framework forming the basis for this study incorporates two components. The first, a set of four general themes about novice science teacher thinking, comes directly from the research literature pertinent to the study. The second component arises from the researcher's methodological stance, and consists of three stipulated dichotomies which shape the way that the data will be analyzed. The two components have been presented and woven together in this chapter.

The chapter also introduced and developed a highly methodological point: an alternative is needed to the simplistic view that novices and experts have characteristic thinking patterns associated with all teaching situations. The alternative is presented by developing a series of visual representations, each of which encapsulates all three of the dichotomies of (a) student view versus teacher view, (b) general pedagogical domain versus subject-matter-specific domain, and (c) procedural versus declarative knowledge components of teacher knowledge. Variations in novice and expert thinking are shown using those visuals.

# Chapter 4

## ANALYSIS AND CLUE DEVELOPMENT

This chapter has two purposes. The first is to demonstrate how the four composite characteristics of novice teacher thinking, as identified in the research literature, can manifest themselves in a novice's actual teaching. Excerpts from Don's teaching, from his logbook, and from various discussions with his cooperating teachers and the researcher constitute the data on which this illustration is based. The second purpose is to develop and refine "clues" which permit an observer of a novice's science teaching to link events of teaching to the four problem areas incorporated in the conceptual framework presented in the previous chapter. Here are the questions once again.

1. How does a novice science teacher manifest the unrealistic optimism that he/she already knows how to teach?
2. When a novice science teacher makes a subject matter error, what can be inferred about the novice's thinking?
3. How does a novice science teacher's assessment of classroom problems (e.g., lesson flow, discipline) suggest a rudimentary level of analysis?
4. How does a novice science teacher's performance reveal a relatively undeveloped perception of students in classroom situations?

The chapter proceeds in four sections, each devoted to one of those questions. Each section briefly reviews the research basis for the question presented in Chapter 3 and frames the question within two of the dichotomies associated with the conceptual framework of the study. (1) Is this issue more in the realm of general pedagogy, or is it subject-matter-specific to science teaching? (2) How does the issue lend itself to considering both procedural and declarative components of the novice's knowledge? An illustrative example (e.g., an episode of teaching discourse, logbook comments) is then presented showing the manifestation of the particular aspect of novice teacher thinking embodied in the question, and the salient clue is identified which links the classroom events in the data to the thinking.

The clue which answers each question about novice science teacher thinking directly is associated with a "student view of teaching", but the reader will recall that the other half of the dichotomy is called a "teacher view". Since both Diana and Larry are recognized by school administrators as experts, where possible the "teacher view" clue is inferred from their logbook commentary and interview transcriptions. Where this is not possible, the "teacher view" clue is hypothetical.

Finally, in each section a second example is presented to validate the clues by trying them out on a different

instance. This is illuminating in two ways. First, it shows how the clues link additional instances of classroom events to Don's thinking, which is a kind of corroboration of the clues. Second, it allows one to infer whether Don's thinking and/or performance changes from the time period of the first instance to that of the second, which is a kind of tracking of the novice. (Some sections deviate slightly from this plan by presenting more than two examples.)

## I. Unrealistic Optimism

### Discussion

This section is based on the generalized theme in the literature to the effect that novices tend to believe teaching will not be problematic for them, that in a sense they already know how to teach. Two other findings are associated with the theme. Contrary to the novices' view, investigators have reported on their limited repertoire of effective routines and classroom management techniques, and a general hesitance to deviate from a pre-determined lesson plan even when unanticipated problems develop. While an observer can know that a novice's repertoire is limited, compared to the regular demands of teaching situations, the novice doesn't know this, which is at least a partial explanation for unrealistic optimism.

Is this a problem in general pedagogical knowledge, or

is it subject-matter-specific to science? Surely the research findings about routines and classroom management are common to all subject areas. But lesson planning inevitably is subject-matter-specific, and the illustration of this issue in Don's teaching, together with associated clue development, will have to take account of the science teaching context.

How does the problem lend itself to the identification of both declarative and procedural knowledge components? With respect to the former, novices have received instruction in pre-service education courses about the importance of lesson planning and changing pace, for instance. As well, they have been taught about a variety of teaching strategies, routines, and techniques for managing the classroom. All of this is in the abstract (so to speak), though, and their procedural knowledge about teaching probably overshadows it. That is to say, in their roles as students in the classroom and practicum observers, novices have spent thousands of hours watching teachers perform during what Lortie (1975) calls their "apprenticeship of observation". They have watched the actions of teachers in seemingly effortless displays of classroom teaching, but have not been privy to the thinking and detailed planning necessary for a class to run smoothly. In fact, many novices are quarrelsome about having to do detailed lesson plan assignments in pre-service education

courses, since they believe "real" teachers don't do such a thing. Finally, a subject-matter-specific point is that novice science teachers have most recently been exposed (in university-level science courses) to a style of teaching appropriate to highly motivated, advanced students in the sciences, whereas the situations for which they are learning to teach are quite different.

Illustration of the Theme in Don's Teaching

An excerpt of Don's teaching in a grade 11 biology class follows. It is important that the reader be oriented in advance to his intent for the lesson; here is a portion of the lesson plan which pertains to this excerpt, taken from his logbook.

* * * * * * * * * * * *

Logbook Entry 1

OPEN DISCUSSION

What is man's role in the ecosystem?
What do we do?
How do we affect the environment?
-Pesticides (why do we use them)
-Pollution
-etc.

Raise awareness of our effect on the planet.

* * * * * * * * * * * *

Unrealistic optimism is suggested already in the brevity and vagueness of the plan. That is, there are no substantive indications of what the dimensions of the discussion might be, and no hint of what student responses

could be expected as a result. The researcher has ample evidence that Don was TAUGHT how to make more adequate lesson plans, but this nevertheless is the plan he entered in his logbook. Here is how that portion of the lesson went.

* * * * * * * * * * *

Excerpt 1
Biology Lesson: Environment
(Grade 11, April 3, 1990)

S = unidentified student
[2 letters] = first two letters of identified student's name

1 Don: Let's talk about some of the effects that we have on our surroundings ... what are some of the things that we do to our planet (long pause) ... do we just sit here and eat and everything is left (inaudible) ... is going on ... Greg do you think so?

2 Gr: No, not really.

3 Don: OK, well what are some of the exceptions to that then?

4 Gr: Ah ... like acid rain ... and that stuff?

5 Don: OK, acid rain ... good ... so what's the general term for acid rain, carbon dioxide ...

6 S: Pollution.

7 Don: Pollution ... good ... now a lot of people think that pollution is not a problem ... it's not affecting me that much, so I'll just go along and live my life how I want to, and let my kids deal with it ... but there tends to be a problem with that ... and that is that the more advances that are made in science, the faster our pollution problem is growing ... OK ... what kind of pollutions are there ... Craig ... can you give me one?

8 Cr: Air pollution.

9 Don: OK ... air pollutants, air pollutants are very important, what are some of the sources of air pollutants ... Steve?

10 St: Factories.

11 Don: Factories is a big one ... what's another one ... Brad?

12 Br: Car exhaust.

13 Don: Car exhaust ... exactly, it's a really big one ... what is the chemical that is put into the air from things like factories and car exhaust ...

14 S: (several students respond making all of the responses inaudible)

15 Don: OK, there's nitrous oxides, sulfur dioxides, carbon dioxide is a big one ... with all these going into the atmosphere what tends to be the problem with all the pollutants in the air?

16 S: (several students respond)

17 Don: OK, one I heard was ozone ... all the birds die? ... yeah I guess that birds could die off ... well what's that mean ... why is our ozone so important, ... Janice?

18 Ja: It protects the earth from harmful rays.

19 Don: It protects ... I guess it protects the earth ... but it protects us too ... right? ... if there was no ozone ... we wouldn't be able to go outside for very long, we'd always have to keep covered up because of the radiation from the sun. The ozone, ... you can think of it as a filter, it filters out the ... radiation from the sun, so ... mostly heat energy ... and wavelengths of light get through that plants and things can use ... so what would happen if there wasn't an ozone layer?

20 S: Everything would start to die.

* * * * * * * * * * *

The logbook indicates that in order to raise awareness of our effect on the planet, Don planned an "open

discussion" using three questions to get the discussion going. From Excerpt 1, it can be seen that by utterance 3 Don has already expended his three questions. It is almost as if Don assumed that by identifying and asking these questions, nothing else would be needed to make the discussion go -- i.e., it would go on "autopilot". The same impression is conveyed by the unvarnished use of the two words "pesticides" and "pollution" as guides for the rest of the plan. Part of the unrealistic optimism is the brevity of the plan, the other part is the expectation that students can carry the load of the discussion unaided.

Clue Development

The development of the student view and teacher view clues for this theme will be focussed in the area in which we have been afforded insight -- namely, the nature of planning necessary for discussions.

From a student view, as suggested by what Don has done, the only requirement for a discussion is to have a few introductory general questions to get it going. The discussion, it is assumed, will propel itself along in the desired direction until it is successfully completed. From this perception, it is not surprising that the teacher may express frustration when the discussion doesn't unfold by itself.

How do expert teachers consider this issue? In order

to develop the teacher view clue, two excerpts from post-lesson interviews will be presented. First, Excerpt 2 is a portion of the post-lesson interview between Don and Larry, as Larry suggests ways to improve discussions.

* * * * * * * * * * *

Excerpt 2
Post-Lesson Interview
Novice (Don) and Cooperating Teacher (Larry)
(April 3, 1990)

1 Don: I felt like I was dragging and dragging the information out of them ... so rather than keep letting them develop the ideas, I kind of jumped in and gave them the information.

2 Larry: Yes.

3 Don: I guess, there are times when you do that ... but I guess with something as everyday as the concern over the environment and ecology ... that maybe there was an opportunity to allow them to give a little more information.

4 Larry: Yeah ... I think that you might want to try to ... and again ... with a discussion ... when you're trying to generate a discussion, what you want to do with them is try to think of ... well ... I can ask what, or how, or where, or why, and you'll typically get from the students pretty short one word answers or little phrases.

5 Don: Yes.

6 Larry: If you can challenge them with some really specific examples, then move from a specific example, which they will have some opinions on, to a general case ... a lot of what you were doing was asking a general question, and they made general comments, but I'm not sure that they know how to apply it to a specific situation. Do you know what I mean?

7 Don: I think so.

8 Larry: So you try and maybe devise a few little specific scenarios, get them to develop and discuss them,

> and even play the bad guy a little bit ... you know, say ... hey, I'm a big developer and I want to come in here and build a 5 million dollar plant that will make dioxins ... what's your first reaction? NO ... they don't want you to ... but then you say, but hold it, I've got a whole lot of things to offer here, and I can guarantee that these things are going to be safe because I have access to the technology ... and all of a sudden more and more of them are going to start buying into it. Some of them are just anti-everything ... but at some point in your mind you say ... OK, let's have a vote ... and maybe the vote now turns out 50-50. But that gets them more involved in it ... you kind of write the script and they play out the arguments.

* * * * * * * * * * * *

Larry has stressed the importance of creating specific scenarios where the teacher plays the "devil's advocate". This helps to focus the students' responses and also shows them the multiple dimensions to environmental problems. This excerpt is typical of how cooperating teachers help their student teachers in terms of suggesting alternative methods for generating better discussions. Excerpt 3 shows a portion of discourse between Larry and the researcher as they draw upon their own experiences as veteran classroom teacher to mutually address issues important to carrying out a discussion.

* * * * * * * * * * * *

Excerpt 3
Post-Lesson Interview
Researcher and Cooperating Teacher (Larry)
(April 5, 1990)

1 R: ... and it's not that the kids don't want to partake, it's just that they don't know where you're going with the question ... since it's

so wide open.

2 Larry: Yeah.

3 R: Like ... "What's in the air?".

4 Larry: That's right, where do we start ... and often by the preamble that he has ... as most people do when they ask a question like that ... you have a specific answer in mind.

5 R: Right.

6 Larry: ... and often to the student's chagrin a little bit ... when they didn't respond in kind to what he was looking for ... he would take over the discussion and give the answer that he was looking for. At that point it stops being a discussion and it becomes ... again ... the provider of all knowledge ... and a student teacher has to be willing to risk a certain amount of class time to get where they want ... if you want to call it a true discussion.

7 R: ... and risk a certain amount of yourself, and your knowledge. Rather than just telling it to them, you have to tease it out of them.

8 Larry: That's right, and one of those things that I think beginning student teachers don't have ... is the skill to play a little dumb ... that's a very difficult thing to do in front of the classroom.

9 R: Right, after all, the last thing that they want to do is be seen as not knowing the content, even if it's just a teaching strategy.

10 Larry: Yeah ... to be able to say ... gee ... I don't understand this, can you explain that a little bit more? or I don't know where you're going with this ... it gives the "mistaken" appearance that you don't know the material.

11 R: Right.

12 Larry: So the game playing is usually on a fairly linear level for the student teacher ... he wants to be up there ... and still wants to appear to be all knowledgeable.

* * * * * * * * * * *

Both Larry and the researcher concur that one way of encouraging more class participation in a discussion is to "play dumb". By not admitting to the students that one understands the student responses, the teacher forces the students to qualify their statements, thus expanding student input beyond one-word answers. Both Excerpts 2 and 3 serve as the basis for developing the teacher view clue.

From a teacher view, planning for discussions includes being aware of the possible answers that students will give, and being able to guide the structured discussion towards its intended objectives by framing specific questions and if appropriate, by designing specific scenarios. As evidenced by Excerpts 2 and 3, student participation in the discussion is vital, even if it means that the teacher "plays dumb" or plays the "devil's advocate" in order to get a response from the students. Figure 6 serves as a summary of these clues.

Figure 6

Unrealistic optimism

QUESTION FROM THE CONCEPTUAL FRAMEWORK:

How does a novice science teacher manifest the unrealistic optimism that he/she already knows how to teach?

ANSWER:

In this instance the clues to the differences between novice and expert thinking are in the way they plan, specifically for discussions, and their expectations about the role students play in the discussion.

| STUDENT VIEW (CLUE 1-A) | TEACHER VIEW (CLUE 1-B) |
|---|---|
| A planned discussion is comprised of a few general questions to initially get the discussion going. | A planned discussion is comprised of specific questions that will guide the discussion to its intended goals. |

| STUDENT VIEW (CLUE 2-A) | TEACHER VIEW (CLUE 2-B) |
|---|---|
| In classroom discourse there is heavy reliance on the students to carry the flow of the discussion unaided. | In classroom discourse there are deliberate strategies to assist the students to participate such as: designing specific scenarios, "playing dumb", and playing the role of "devil's advocate". |

Validation of the Clues

In order to validate these clues, the researcher reviewed excerpts from discussion lessons later in Don's student teaching round. The discourse that follows is from a lesson that occurred more than three weeks later. Don's intent can be surmised from the pertinent portion of the lesson plan.

* * * * * * * * * * * *

Logbook Entry 2

What determines the size of a population?

- can probably draw this discussion out to get to the environment.
- will get a variety of answers:
  e.g.: limiting factors
  competition
  food and space availability

* * * * * * * * * * * *

Unrealistic optimism is still suggested by this lesson plan. In this case, Don stated some of the expected answers the students would supply. The comment that he can "probably draw this discussion out to get to the environment" illuminates the intended goal of the discussion, but the plan lacks any specific questions to guide the discussion. Here is how that portion of the lesson went.

* * * * * * * * * * *

Excerpt 4
Biology Lesson: Populations
(Grade 11, April 26, 1990)

1 Don: What kinds of things determine the size of a population?

2 S: Abiotic factors?

3 Don: OK, that's one (writes it on the board). What kind of abiotic factors have we talked about?

4 S: Water and soil.

5 Don: What are some of the other ones that we've talked about?

6 S: Light.

7 S: Water.

8 Don: Good (writes them on the board). Any others?

9 S: Soil.

10 S: Temperature.

11 Don: Yes. How does something like soil affect the population size? (no response) ... How is soil going to affect the population size?

12 S: Of what?

13 Don: Let's say plants. How is the soil going to affect plant populations? Laura?

14 La: Pardon me?

15 Don: How is the soil going to affect the size of the population of a plant?

16 La: Well ... it depends what kind of soil it is and how the nutrients and everything are.

17 Don: OK, nutrients ... there's something else. What else does the soil hold?

18 S: Water.

19 Don: Water. The ability to hold water (writes notes on the board). How does pollution affect the soil? Donna?

20 Do: Pardon?

21 Don: How does pollution affect the soil?

22 Do: Well ... it gets into the soil and the pollutants get into the cells and starts killing the plants.

23 Don: OK, what about pollutants in the air?

* * * * * * * * * * *

The lesson plan for Excerpt 4 is remarkably like the lesson plan for Excerpt 3. Therefore, clue 1-A seems to be a valid detector. In this case, it continues to detect a student view (unrealistic optimism) three weeks later. As well, the discourse in Excerpt 4 shows heavy reliance on the students, as in Excerpt 3, so clue 2-A also continues to detect the student view, and is also a valid detector.

## II. Subject Matter Knowledge

### Discussion

This section is based on the theme in the literature regarding the breadth and depth of novices' subject matter knowledge. Teaching difficulties associated with inevitable gaps in any novices's understanding of subject matter knowledge, or just plain weakness of background, might cause problems of several kinds. The literature suggests that a novice's lesson planning might therefore be more time consuming and difficult for two reasons. First is the recognition that the novice may be learning the subject matter at the same time as planning to teach it. Second, a weakness in subject matter knowledge is associated with a weakness in subject-matter-specific knowledge. Thus, a novice's ability to transform the subject matter into a form that students can comprehend is hampered in planning tasks such as developing appropriate metaphors and analogies, assessing students' prior knowledge, and detecting students' misconceptions about the subject matter.

This problem clearly is predominantly subject-matter-specific, but as we shall see, it is more complex than just "knowing your stuff".

The problem lends itself to the identification of both declarative and procedural components. Declaratively, novices "know" from pre-service education courses that it is

important to get students to think for themselves and take an active role in their classroom learning, rather than giving them all the answers. The teacher's presentation of the subject matter is supposed to foster such goals, they know. But procedurally (that is, in terms of what they do), novices are influenced by the fundamental survival concern of appearing to be credible to their students. In the artificial situation of student teaching, all novices have been forewarned (especially by their peers) that students will test their authority in terms of "knowing your stuff". There is very likely also recollection of this point from their own schooling, where they perceived their "good" or credible teachers as subject-matter-competent.

Illustration of the Theme in Don's Teaching

The discourse that follows is an excerpt of a lesson pertaining to abiotic environmental factors where the students are asking questions which the novice admittedly did not anticipate.

* * * * * * * * * * *

Excerpt 5
Biology Lesson: Abiotic Factors
(Grade 11, April 19, 1990)

1 Don: Remember ... what organism is in association with the plants ... actually lives within the plants and is responsible for nitrogen fixation?

2 S: Bacteria.

3 Don: What is it called where the bacteria live? Root ... they live in root ... Lana? Root ...

4 La: I don't know.

5 Don: The question was ... what is the name of the structures where the bacteria live in the plant?

6 S: They swell up, right?

7 Don: They swell out ... right ... the plant tissue swells.

8 S: Nodules.

9 Don: What's that?

10 S: Nodules.

11 Don: Right ... nodules ... the nitrogen fixation takes place in the root nodules ... so this is very easy for the plants because the nitrogen is taken in, and the nitrate produced by the bacteria is in the system already. So it's a very advantageous situation ... acid rain alters the pH of soil ... we've already mentioned that acid rain has a pH of about 4.5 ... and this would be considered another limiting factor ... because we all know that plants have optimal conditions in which they want to grow ... and if the pH isn't just right, they're not going to grow ... they're not going to reach the expectations.

12 S: What is the ideal pH of soil for plants?

13 Don: I'm not sure ... exactly what the number is, but neutral is 7.0 and the ideal is just under that. Maybe about 6.0 or so.

14 S: What exactly does pH mean?

15 Don: Well, pH is percent ... percent hydrogen ion ... I believe ... OK? A very low pH is acidic ... like a pH of 1.0 is very, very acidic. The hydrochloric acid in your stomach, or your stomach acids, whatever they may be, have a pH of about 2.0 and that helps you digest things. On the other extreme, a pH of 14.0 is as high as they go, and they're considered bases. With pH you can have an acid burn if it's a strong acid, or you can have a base burn.

16 S: I know pH has to do with shampoo.

17 Don: Right, pH balanced shampoo for your hair, yeah ... but plants ... I think they are around 6.0 or 6.5, or so ... fairly close to neutral but slightly acidic ... just like our blood is slightly acidic, ... oh ... no ... slightly basic, 7.39 or something like that ...

* * * * * * * * * * * *

In post-lesson discussions, Don's stated that he had assumed that the students knew about the pH scale from previous courses in science. In fact, the concept of pH is a major component of Chemistry 30, a course which many of these students would not take until the next year. He was not only surprised that they didn't know it, but perceived a situational demand of having to explain it to the students. Since Don had not anticipated the question, he qualified to the students that he was not sure, but then proceeded to give a very specific answer.

Several errors in accuracy were presented in the excerpt. First in utterance 11, the students have the understanding that acid rain refers to rainfall at pH 4.5, but in actual fact, acid rain is defined as any rainwater with a pH of 5.6 or less. Second in utterance 15, pH actually refers to the "potenz" or logarithmic concentration of hydrogen ions, rather than the percent of hydrogen ions. Third, Don's statement "whatever they may be" in reference to stomach acids erroneously suggests that the stomach contains several types of acids in addition to hydrochloric acid.

In utterances 13 and 17, Don inadvertently propagates and reinforces a major misconception about plants. He suggests that all plants grow in an optimal pH range of 6.0 to 6.5, when in fact, each plant has a unique optimal pH. For example, pine trees ideally grow in acidic soils typical of forests, and wheat ideally grows in alkaline soils typical of prairie regions.

Clue Development

The development of the student view and teacher view clues for this theme focusses upon the situation where a student's question results in an erroneous teacher answer.

From a student view of teaching, the novice sees a student question as a situational demand for an answer. The logic is that in order to appear credible, the novice must answer all questions (or at least appear to know the answer). One of the ramifications of this logic is that the teacher's responses may contain erroneous information.

From a teacher view, a question asked in class can be dealt with in a number of ways. For example, the teacher may ask for more clarification from the person asking the question, answer the question, deem the question irrelevant or inappropriate to answer at this particular time, throw the question back to the students to answer, or even respond that he/she doesn't know the answer. The decision takes into account such factors as student motivation and

interest, time constraints, and whether the question enhances or detracts from the lesson. Figure 7 serves as a summary of these clues.

Figure 7

Subject matter knowledge

QUESTION FROM THE CONCEPTUAL FRAMEWORK:

When a novice science teacher makes a subject matter error, what can be inferred about the novice's thinking?

ANSWER:

In this instance, subject matter errors are most evident in the novice's responses to student questions. The clues to the differences between novice and expert teacher thinking are in the way they perceive student questions.

| STUDENT VIEW (CLUE 3-A) | TEACHER VIEW (CLUE 3-B) |
|---|---|
| When a student asks a question during a lesson, the teacher always answers it (even if he/she is not sure). | When a student asks a question during a lesson, the teacher uses various techniques, maybe answering the question or maybe asking a student to answer it. If the teacher decides that the question will not be responded to, he/she may or may not reveal a reason. |

Validation of the Clues

The following excerpt from Don's teaching follows a lesson in which he had established the definitions of herbivore, carnivore, and omnivore, as they relate to the trophic levels within a food chain.

* * * * * * * * * * *

Excerpt 6
Biology Lesson: Trophic Levels
(Grade 11, April 3, 1990)

1 Don: Who can think of a couple of organisms that are omnivorous?

2 S: Us.

3 S: Humans.

4 Don: Us, we're one ... Misty?

5 Mi: Can I ask you a question?

6 Don: Sure.

7 Mi: The carnivores, they just eat meat ... they don't eat plants ... is that what it means?

8 Don: Right ... carnivore means meat eater.

9 Mi: That's all they are, they don't eat plants at all ... right?

10 Don: Well ... some do ... like ... maybe we could say that ... take for example ... we have a plant, our second feeding level is an insect, the insect feeds on the plant ... and a mouse may eat the insect ... so the mouse could eat the insect, or the mouse could eat the plant ... now an insect is kind of a wishy-washy example of something ... of a meaty animal I guess ... but it's definitely not a plant.

11 Mi: So what's the difference between carnivores and omnivores then?

12 S: Isn't that an omnivore then?

* * * * * * * * * * *

This portion of dialogue is a typical example of situations in which students ask subject-matter-related questions. In utterances 7 and 9, Misty is attempting to get clarification on the differences between carnivores and

omnivores. When she wanted reaffirmation that carnivores don't eat plants, Don's response "well ... some do" in utterance 10 was incorrect. Utterances 11 and 12 are indicative of the fact that the students were still unclear about the definitions. In fact, there is a repeat of the same concern that was being raised before the teacher presented his explanation.

Two important findings are evident in this excerpt. First, even on points of clarification, Don chose to answer the questions himself, rather than (for instance) checking the understanding of some other students by turning the question back on the class. Therefore clue 3-A is a valid detector and, in this case, continues to detect the student view.

Second, Don has made a subject matter error which contradicts the subject matter that he taught just previously. (In fact, when the researcher showed this transcription to Don his response was "I can't believe it!") So this is not simply a weakness in a novice's subject matter knowledge that becomes evident when he/she answers questions. Although research findings of studies in the missing paradigm exemplify the importance of a teacher's strong subject matter knowledge, it becomes apparent that there must be contextual factors such as the perceived situational demand for an answer, that contribute to the transmission of faulty subject matter.

Don's self-evaluation comments in his logbook pertaining to Excerpt 6 are most illuminating.

* * * * * * * * * * * *

Logbook Entry 3
(April 3, 1990)

I am surprised that this class is a little bit harder to carry on a conversation with considering that some of the students are very outgoing. This class was worse than Period 4 in that once it became difficult to pull information from the students, I turned to using their one word answers as a springboard to explaining what is going on in the world.

I need to concentrate on:

1. Phrasing and rephrasing of questions.
2. Ability to turn questions back onto the students.
3. Ability to recognize when I am using the students as a springboard and be able to stop this pattern and have the students be responsible for much more of the information in the discussion.

* * * * * * * * * * * *

Don's logbook self-evaluation comments present two important findings. First, Don has been critical of the discussion-oriented lesson and was quite surprised that the outgoing students didn't "carry" the discussion. Even when reflecting, Don operates from a student view indicated by clue 2-A.

Second, Don comments that he must concentrate upon "turning questions back onto the students", which is one of the possibilities of clue 3-B. The teacher view clue is indicative of an expert teacher, where the procedural and declarative knowledge inform each other. Thus, even though

clue 3-B is procedural (i.e., the visible actions), the declarative component (i.e., the teacher thinking) is also in concordance.

This example shows that Don implicitly recognizes "why" he should not answer all questions, but has difficulty with "how" to do it in the classroom. This is a concrete example of the point made in Chapter 3 that in novice teacher thinking, declarative subject-matter-specific knowledge can be similar to that of a teacher view, but procedural subject-matter-specific knowledge on the same point can be similar to a student view (refer to Figure 2). In this specific instance, Don's declarative knowledge does not inform his procedural knowledge, and he recognizes this.

Recognizing the declarative characteristics of the teacher view clue does not equate to procedurally operating from it. Logbook entry 3 pre-dates Excerpt 5 by sixteen days. This illustrates that even though Don recognized that he wanted to improve in how he dealt with student questions, he was procedurally doing the same as before.

## III. Making Sense of Classroom Life

### Discussion

This section focusses on the theme perhaps best represented in Calderhead's (1983) assessment to the effect that novices appear to have simple structures with which to

make sense of classroom life and that they do not extract the same kind or level of meaning from events as experienced teachers do.

Since the term "classroom life" encompasses all aspects associated with teaching, the problem must be manifested in both the general pedagogical and subject-matter-specific domains. With respect to the former, novices must assess the quality of student behavior and the classroom climate, for example. Within the subject-matter-specific domain novices must make sense of how students are comprehending the subject matter. Consequently each domain will be addressed separately resulting in the development of clues 4 and 5.

Declaratively, novices have been exposed to many issues pertinent to lesson planning and classroom management in their pre-service courses that help to inform them of what a good lesson presented in a well-managed classroom looks like. Procedurally, due to a lack of classroom experience, and influenced by unrealistic optimism, novices have difficulty providing reasons for problems that occur in lessons, or explaining the causes and remedies for problems with discipline.

III-1. Making Sense of Problems in Lessons

Don's way of making sense of problems in lessons he taught is based on whatever is available as data pertaining

to the lesson in question. In some cases, problems were evident in lessons that had not been audio-taped; there, Don's logbook self-evaluations and the cooperating teacher's comments are the data base. In other cases the lesson in question was audio-taped, so a broader data base is used.

Illustration of theme III-1 in Don's teaching. Following are two examples of situations where problems became evident in lessons taught by Don. The first is from a chemistry lesson dealing with nomenclature of ionic and molecular substances.

* * * * * * * * * * *

Logbook Entry 4
March 7, 1990 - Chemistry 10

**Don's self-evaluation comments**

I was somewhat put off that some students had no idea how to do the worksheet after I had spent all class on it, but there were only a few of these. Sometimes I need to be more explicit in giving out instructions for a worksheet because I had to interrupt the class twice to make some instructions more clear.

**Diana's comments**

Some adjustment needed to the sequencing so that students know straight away that there are both ionic and molecular compounds and how to distinguish between them. (Remember: someone asked "What is an ionic and molecular compound?)

Were the students clear about the criteria being used to distinguish between ionic/covalent bonds? It may be better to classify as ionic or molecular compounds.

* * * * * * * * * * *

Don's comments reveal his frustration that the students were saying that they did not know how to do the questions

on the worksheet. Since the instruction had already taken place, Don surmised that perhaps his verbal instructions about the assignment were not as clear as they could have been. Diana's comments suggest that perhaps Don had not been totally explicit with the students as to the criteria for identifying ionic and molecular compounds. Diana recognizes that the key to nomenclature is to properly categorize the compound as ionic or molecular so that the proper naming rules can be used. She was concerned that Don did not make the logical provision necessary for students to accomplish the task.

The second example is taken from a biology lesson in which Don was introducing a new topic dealing with viruses.

* * * * * * * * * * *

Logbook Entry 5
March 19, 1990 - Biology 10

**Don's self-evaluation comments**

This class went okay but I sure felt as if I was doing a lot of the work. The students kept asking questions which was a good sign, but they were all over the place and I wasn't sure how to tie everything back together.

**Larry's comments**

Take care, when trying to generate a discussion, you have to get the students more involved. You are doing a lot of the discussing. It will feel really risky and threatening but let the students carry more of the load. This may require some well prepared questions to get their responses started, and to keep them on track. Getting students into a thoughtful discussion is sometimes difficult, but always requires active pursuit and teacher stimulation.

* * * * * * * * * * *

Don's lesson plan called for the students to access their background knowledge about viruses and to develop the notes through a discussion. The following is the pertinent lesson plan entry regarding the discussion.

* * * * * * * * * * *

Logbook Entry 6

Call on background knowledge of viruses.
There are a lot of viruses that infect man. Give me some examples.

This will be an open discussion on some of the viruses that are brought up by the students.

In the discussion some main points to get across are:

- viruses are host-specific
- viruses are not affected by antibiotics
- viruses are defensible by vaccines
- discussion of immune response

* * * * * * * * * * *

Although this situation is indicative of unrealistic optimism (clue 1-A) since the lesson plan does not provide a series of questions to guide the discussion to the main points, this example is being used in the context of making sense out of classroom events.

In this case, Don is concerned about "carrying too much of the load" in the discussion, and worries about how to tie together the varied student responses. Larry agrees with Don, but is suggesting that the preparation of good discussion questions will invite more student involvement and will better control the direction of the discussion so that the student responses are more focussed.

In both examples it is apparent that Don's assessment of problems in lessons is different from those of the cooperating teachers. Don appears to view the problem in terms of what the students did (or did not do), while the cooperating teachers focus on aspects of Don's lesson presentation that could have been improved.

Clue development for theme III-1. The development of the student view and teacher view clues for this theme centres on the assessment of problems that have occurred in lessons.

From a student view, as suggested by Don's self-evaluation comments, once a lesson has been planned, the responsibility for the success or failure of the lesson is determined by the students. When problems in lessons occur, Don initially attributes the cause to the students' shortcomings. Even when he recognizes that the presentation of lessons could have been altered, Don's suggestions for remediation remains at a superficial "quick fix" level such as being sure to have the students' attention before giving instructions.

From a teacher view, as suggested by Diana's and Larry's comments, when problems in a lesson occur, the initial focus of attention is the lesson plan itself. The teacher examines the sequence and substance of the lesson in order to establish whether logical provision was made so

that the students could realize the teacher's expectations. Figure 8 serves as a summary of these clues.

Figure 8

Making sense of problems in lessons

QUESTION FROM THE CONCEPTUAL FRAMEWORK:

How does a novice science teacher's assessment of problems in lesson flow suggest a rudimentary level of analysis?

ANSWER:

In this instance the clues to the differences between novice and expert thinking are found in what they attend to as the source of the problem.

| STUDENT VIEW (CLUE 4-A) | TEACHER VIEW (CLUE 4-B) |
|---|---|
| Problems in a lesson are attributed to the students' shortcomings. If necessary, minor "quick fixes" can help to keep the students on track. | Problems in a lesson are attributed to flaws in the lesson plan. The sequencing is examined in order to detect where the breakdown in logical provision occurred. |

Validation of the clues. In order to validate these clues, two examples will be presented. The first is an excerpt of classroom dialogue where a problem becomes evident while a quiz is being marked in class. Before the excerpt is presented it will aid the reader to see the actual questions of the quiz.

**********

1. List three reasons why water is necessary for life.
2. List three reasons why soil is important in the ecosystem.

3. List three reasons why light is important to plants.
4. List three reasons why light is important to animals.
5. List three ways in which temperature affects organisms.

**********

The quiz questions appear to be very open-ended which can result in a plethora of diverse responses. If a teacher were to mark them it would be difficult since there are so many plausible answers. In this case, Don is attempting to mark the quizzes in class. Here is a portion of dialogue showing how it went.

* * * * * * * * * * *

Excerpt 7
Biology Lesson: Abiotic Factors
(Grade 11, April 19, 1990)

(Don is marking a quiz that had just been completed by the class. The quiz is based on the assigned reading in the textbook)

1 Don: Three reasons why light is important to plants ... OK ... strictly related to plants here ... Donna?

2 Do: Photosynthesis, chemosynthesis and growing?

3 Don: Photosynthesis ... yes, I agree with it ... that's one, I don't think chemosynthesis ... no ... and you said growing? ... that was the third one?

4 Do: Yes.

5 Don: No ... just photosynthesis ... the other ones we talked about already are ... light affects plant distribution, light is important in heating the earth ... we all know that plants like it hot to grow ... and finally, light triggers flowering in plants ... budding and things like that ... any questions? (several hands go up) ... holy smokes,

I'm really surprised by all the problems ... Leslie?

Le: It helps plants get bigger?

Don: Yeah ... well that's photosynthesis.

S: Light affects where trees are distributed?

Don: Yeah ... that's distribution.

S: (inaudible)

Don: No, they are the same.

S: (inaudible)

Don: One mark.

S: It's important for chloroplasts and chlorophyll in the plant?

Don: Half a mark.

S: It affects how plants grow?

Don: Yes, that's distribution.

(This continues with 10 more questions before Don moves on to the next question to mark)

* * * * * * * * * * *

A predictable pattern evolved in the marking of the quiz. After each answer was given, several students asked Don how many marks to give for the answers that they were marking. After marking one more question on the quiz, Don became frustrated and told the students that he would mark the remaining questions and then instructed the students to hand all of the quizzes in. The following excerpt is from the post-lesson discussion between Don and Larry.

* * * * * * * * * * *

Excerpt 8
Post-Lesson Interview
Novice (Don) and Cooperating Teacher (Larry)
(April 19, 1990)

1 Larry: Well, what did you think of the class?

2 Don: I realized that I had some problems with that quiz in the last class ... I was surprised that the problems were more obvious in this one ... and I kind of got frustrated ... and it wasn't that some of the answers were broad ... the thing that started to get on my nerves was ... you know, I'd say distribution and someone would ask ... well what about distribution?

3 Larry: Yeah.

4 Don: And it kept happening and happening ... and threw me off, and I realized that I was getting frustrated and said to myself ... try and relax.

5 Larry: Yes ... I think you did the right thing ... since you weren't making any progress towards where you wanted to go. When designing quizzes like that when you want the class to mark them, try and make them as specific as possible ... you know ... marking multiple choice in class is quite easy because it's either right or wrong ... but as soon as you get away from that to any degree at all, then it throws in all kinds of problems.

* * * * * * * * * * *

Excerpt 7 is indicative of clue 4-A, and illustrates a student view of evaluating problems in a lesson. Don suggested that the problems that occurred in the marking of the quiz were the result of the students not paying attention to the answers. He cited a specific example found in Excerpt 7 (utterance 8) where a student asked whether a certain answer was acceptable. Don contended that had the student been listening, he would have realized that his

question had already been answered. He made mention of the broadness of the answers but discounted that as the main cause of the problem.

Larry suggested that the problems with marking the quiz were caused by the nature of the questions that were being marked. Larry suggested that if a quiz is going to be marked in class, the questions must lend themselves to specific answers.

To illustrate the second example, the following logbook entry was taken from a self-evaluation of a chemistry lesson that occurred in the final week of Don's student teaching round.

* * * * * * * * * * *

Logbook Entry 7
Don's self-evaluation comments
April 23, 1990 - Chemistry 10, Period 1

I was really surprised to see how much trouble this class had. I felt that I started by explaining what was to be done, and afterwards, everybody was asking questions that were about what I had just discussed. It took almost everyone the full sixty-five minutes to finish the lab.

I start to wonder that it must be me. Some had a few questions and some were totally lost. This sounds like a normal distribution, but there were only two groups who knew what they were doing right from the start. I didn't think that I needed to, but for tomorrow's lab (with period 3), I need to take more time to explain what is happening in the lab. I will also do a demo of what they are to do in the lab.

* * * * * * * * * * *

This self-evaluation of problems with a lab activity is indicative of clue 4-B, and illustrates a teacher view of evaluating problems in a lesson. Don judged that the lab

activity did not go very well, and it became apparent to him that the class had not received enough of a pre-lab before attempting the activity. The same lab activity was going to be done by a different class the next day, and Don had already made plans to provide better logical provision to the students, including more explanation and a demonstration.

This example illustrates that, in this instance, Don has shifted to a teacher view of evaluating problems in a lesson. Thus, both the student view clue and the teacher view clue have been demonstrated to be valid detectors.

III-2. Making Sense of Problems in Classroom Management

The previous clues were situated in the subject-matter-specific domain and focussed upon how novices make sense of problems that occur in lessons, and how to alleviate them. The next set of clues is situated in the general pedagogical domain, concentrating on how novices deal with discipline problems in the classroom. Although lesson flow problems have been separated from discipline problems, it is acknowledged that in some situations, discipline problems arise as a result of problems inherent in the planned lesson.

Illustration of theme III-2 in Don's teaching. Novices are well aware of the fact that students will test them in

their ability to control a class. This is compounded by the certainty that their student teaching evaluations are detrimentally impacted if they manage classes poorly. Thus, the ability to effectively manage the classroom is one of the most important aspects of teaching that novices are concerned with, as evidenced by the following self-evaluation comments.

* * * * * * * * * * *

Logbook Entry 8
Don's self-evaluation comments

March 9, 1990 - Biology 10, Period 8

> This lesson did not flow quite as smoothly as I had anticipated. A major reason for this was because I had to keep up with discipline which took some concentration away from the lesson itself. There were a number of students that insisted on talking to their neighbors.

March 14, 1990 - Biology 10, Period 7

> This class was fairly frustrating for me (and I think the students as well). The class was fairly rowdy which put me off (i.e., I found it frustrating). Unfortunately the rest of the class seemed to be fairly regimented and probably tedious. I can't let this type of thing bother me or I will be ineffective at times.

March 20, 1990 - Biology 10, Period 8

> This class was very talkative today. I had to stop several times to get their attention. Finally, I moved Jim to the corner of the room, and when this did not work, I asked Bill to leave and wait in the hall for me.

* * * * * * * * * * *

These comments about classroom discipline are typical of those found in the earlier portions of the logbook. When

the classroom is not conforming to the Don's expectations, he becomes quite agitated and authoritative. In the following excerpt, Larry reminds Don that one must be careful when dealing with discipline problems.

* * * * * * * * * * *

Logbook Entry 9
March 9, 1990 (Larry)

> It is a good idea to establish your authority and expectations in the classroom, but do not become too much of a heavy ... remember, it is these same students who have to feel comfortable to contribute to your classroom presentations.

* * * * * * * * * * *

Larry sensed that Don expected the students to pay absolute attention for the entire lesson. Larry recognized the potential damage to the classroom climate if the expectations for decorum were not reasonable. Within two weeks of these warnings, the students in period 8 had become quite rebellious, and the atmosphere in the classroom had deteriorated significantly. Don and Larry discussed the issue of reasonable discipline and how it is related to classroom climate.

Don began to realize that trying to keep the students "under his thumb" was not an effective way to control a classroom because "I keep becoming more serious and then the kids start to revolt, and then I become more serious and I get in this spiral that's going down". The nature of the following three logbook comments illustrates Don's attempts

at becoming comfortable with a more reasonable approach to discipline.

* * * * * * * * * * *

Logbook Entry 10
Don's self-evaluation comments

March 27, 1990 - Biology 10, Period 8

> This was the class in which I try to be a little more light hearted and not trying to control everybody. I had to make a conscious effort not to squelch some talking back and forth among the students. I have to make sure that I know where to draw the line and say "this behaviour is not acceptable". I feel that I'm struggling in finding that line.

March 29, 1990 - Chemistry 20, Period 1

> I really like this class. There is a nice mixture of kids in the class including a few characters. The only downfall here is that once they get chatting it's hard to get them back sometimes. I was a little more harsh than I wanted to be in getting them back from doing a worksheet, although I don't think that it was anything that the students would take offense to.

April 3, 1990 - Chemistry 20, Period 3

> This class sure is full of a bunch of characters. Sometimes though, they push it. I enjoy the class because they are a good natured group but I have to be able to draw the line in a firm yet nice way.

* * * * * * * * * * *

The amount of overt classroom control in all of the classes Don taught was reduced, and resulted in improved classroom atmospheres.

Clue development for theme III-2. The development of the student view and teacher view clues for this theme is focussed on assessments of classroom discipline. It is

acknowledged that appropriate levels of classroom discipline are difficult to assess and articulate since they vary from teacher to teacher. The focus of these clues is not to explicate the grounds for a teacher's discipline level, but it is to illustrate that those grounds do exist.

From a student view, the level of classroom discipline is a function of several influences such as classroom climate, mutual respect, and maintenance of a learning environment, but there are no definitive boundaries that establish what is not appropriate behaviour. Thus, from a student view, the need for consistency in classroom management has not been established.

From a teacher view, the level of classroom discipline is also guided by the same influences noted above, but the individual influences are more meaningful to an expert teacher. More specifically, expert teachers have clear conceptions of the type of learning environment that they want to create and are aware of the ramifications of unreasonable discipline levels (whether they be too strict or too lenient). Although expert teachers vary in respect of what they deem as appropriate levels, their commonality is that they all have a clear conception of when a student has overstepped the boundaries. Figure 9 serves as a summary of these clues.

Figure 9

Making sense of classroom management

QUESTION FROM THE CONCEPTUAL FRAMEWORK:

How does a novice science teacher's assessment of discipline problems suggest a rudimentary level of analysis?

ANSWER:

In this instance the clues to the differences between novice and expert thinking can be found in the consistency of classroom disciplining.

| STUDENT VIEW (CLUE 5-A) | TEACHER VIEW (CLUE 5-B) |
|---|---|
| When a reasonable level of behaviour is exceeded, the teacher does not consistently take effective actions to maintain an appropriate level of classroom decorum. | When a reasonable level of behaviour is exceeded, the teacher consistently takes effective actions to maintain an appropriate level of classroom decorum. |

Validation of the clues. In order to validate the clues, two examples will be used. In the first example, the following logbook comments are presented. These comments continue to depict Don's indecision regarding classroom management.

* * * * * * * * * * *

Logbook Entry 11
Don's self-evaluation comments

April 3, 1990 - Chemistry 10, Period 3

> I am undecided on whether or not I should continually try to cut down on some of the talking that goes on in class. I feel like it's coming to the point where they are taking it for granted that they can speak out when they want to. I may have to become a little more strict in this sense.

April 17, 1990 - Biology 10, Period 8

> Period 8 were their normal selves. I was surprised at how well behaved they were but I'm starting to tighten up the freedom that they have. I felt that they haven't minded this becoming more strict but I don't know if I'd want to push it any further for now.

April 19, 1990 - Biology 10, Period 7

> I'm having a hard time keeping my patience with a few of these students because they are so immature. I'm not sure if I should become more strict to try and regain some control, or if I should avoid pushing them.

* * * * * * * * * * * *

These examples from Don's self-evaluations are indicative of clue 5-A, suggesting a student view regarding classroom management. Don is questioning whether the students are "getting away with" too much, but is also indecisive about whether to become more strict in the classroom. This problem manifested itself throughout the entire student teaching round.

For the second example, note the following logbook comments from both cooperating teachers. These comments indirectly validate the teacher view clue.

* * * * * * * * * * * *

Logbook Entry 12
Cooperating Teachers' Comments

March 28, 1990 - Larry

> If you feel that some of them are taking advantage, don't be afraid to bring them back into line.

March 29, 1990 - Diana

> Don't worry about the noise level. They tend to be chatty but quickly get back on task.

April 3, 1990 - Diana

> Chris is still turning around too much. Cathy, Keith, and Leslie tend to chat a lot instead of working.

* * * * * * * * * * * *

The cooperating teacher comments above have been presented for two reasons. First, they illustrate how both Diana and Larry are trying to help Don formulate his own level of appropriateness by relaying their own assessments. Second, it can be inferred from the comments that both Diana and Larry have clearly delineated levels of appropriate behaviour for themselves. Diana's comments indicate her own perceptions of acceptable noise levels and acceptable behaviors in the classroom. Larry's comment, which is intended to support Don, implicitly suggests that Larry perceives that the students have overstepped the boundaries and are taking advantage of Don. This data indirectly confirms the detection ability of the "hypothetically generated" teacher view clue.

## IV. Perceiving Students in Classroom Situations

### Discussion

As Lortie (1975) has suggested, all teachers have been through an "apprenticeship of observation" which influences their perceptions of school, teaching, and students. Specific to this study, Don graduated from high school six years ago and went directly into a university science

program. After completing a Bachelor of Science degree, he enrolled in a Bachelor of Education after-degree program which is composed of ten full courses. Prior to entering the professional year, he was involved in a volunteer teaching program and was assigned to a local high school in which he spent approximately six hours per week. Most of this time was spent observing lessons and aiding students during lab sessions. In terms of his apprenticeship, Don still possesses fairly clear memories of high school.

It is apparent that this theme spans both the general pedagogical and subject-matter-specific domains since actions and rationales for action within these areas are highly influenced by the teacher's perceptions of students in classroom situations. This study will address this theme within the context of the science classroom.

Declaratively, novices have received instruction about the characteristics of students. In pre-service education courses they have been exposed to many of the attributes of students including information about cognitive abilities, developmental levels, learning disabilities, and behavioural problems. Procedurally, novices are informed by their own recollections of being students in school, and by their association with similar-age students that they know through non-school contexts. Even while observing classroom teaching as part of their student teaching requirements, the actions and discourse of students seem familiar.

Illustration of the Theme in Don's Teaching

The following is an excerpt of interview dialogue related to Don's first impressions of teaching high school students, taken from one of the first interviews between Don and the researcher.

* * * * * * * * * * *

Excerpt 9
Novice (Don) and Researcher

1 R: You were saying that there were some things that you didn't expect ... why didn't you expect them before?

2 Don: Well, I think it comes from my pre-set notion of school especially when I was going to high school. I went to high school at Prairie Composite and I guess I would be classified as being fairly keen and being interested in what was going on in the classroom. Well the big shocker was that it doesn't seem like a lot of the students in the classroom ... in some of my classes here ... have that interest ... so more emphasis is placed on the teacher to motivate the students.

3 R: So you're saying that a lot of your shock in terms of what you didn't expect was based on your own high school experience?

4 Don: Yeah, exactly ... I was thinking that ... well, this was the way high school was for me ... and before I started teaching ... I would think that if that's the way high school was for me ... then it would be fairly close to that when I'm teaching ... although it was kind of a rude awakening here ... that it's not always the same.

* * * * * * * * * * *

Don recaptures the first weeks of student teaching and tells how he was shocked that high school students today are not the same as when he was in high school. This shock became apparent to Don only after he actually began teaching

high school students. The reader will recall that Don spent numerous hours observing high school classrooms during the observation phase of the practicum and during his volunteer teaching experiences. These recent experiences still did not prepare him for the realization that students "are different now".

Clue Development

The development of the student view and teacher view clues for this theme centres on how novices' perceptions of students in classroom situations seem to influence their teaching performance.

From a student view, classes that are being taught are compared with the comparable class that the teacher was enrolled in as a student. More specifically, a teacher will compare a Biology 30 class with his/her own recollections of what it was like when he/she took Biology 30 as a high school student.

From a teacher view, if a class is not performing to the expected level of achievement (for example), the basis for such a decision is determined by comparing the class with other comparable classes. More specifically, a teacher will compare a Biology 30 class with other sections that they are teaching, or with previous Biology 30 classes that they have taught in recent years. Figure 10 serves as a summary of these clues.

Figure 10

Perceiving students in classroom situations

QUESTION FROM THE CONCEPTUAL FRAMEWORK:

How does a novice science teacher's performance reveal a relatively undeveloped perception of students in classroom situations?

ANSWER:

In this instance the clues to the differences between novice and expert thinking are in the comparison basis they use to make statements about students and classes.

| STUDENT VIEW (CLUE 6-A) | TEACHER VIEW (CLUE 6-B) |
|---|---|
| Judgements about the characteristics of a group of students are made on the basis of comparing the group to "what it was like when I was a student". | Judgements about the characteristics of a group of students are made on the basis of comparing the group to comparable groups from the current year or from recent years. |

Validation of the Clues

To validate the clues, two examples will be presented. Pertaining to the first example, the discourse that follows deals with Don's method for assessing the students' prior knowledge.

* * * * * * * * * * *

Excerpt 10
Novice (Don) and Researcher

1 R: In terms of assessing students' prior knowledge, how do you go about it?

2 Don: Could you be a bit more specific?

3 R: It goes hand in hand with anticipating student responses ... how do you perceive where the students are in regards to what they know and what they don't know?

4 Don: At this point in time ... all I have to base it on is my own experiences of when I was in high school ... and obviously once I start getting to know the students a little bit ... which ones are more keen ... I can use them as a gauge.

* * * * * * * * * * * *

This excerpt is indicative of clue 6-A, and illustrates a student view of high school students in classroom situations. In order to assess what students know and what they don't know about the topic, Don is relating back to his own high school student experiences. He tries to recall how much he knew about the subject when he was a student in the exact same situation, and uses this to establish the parameters of the students' prior knowledge.

To begin the second example, the following logbook entry self-evaluation, from a biology lesson taught during Don's final week, is presented.

* * * * * * * * * * * *

Logbook Entry 13
Don's self-evaluation comments
April 23, 1990 - Biology 10

Both classes went well. I felt that the variety in method for teaching (i.e., overhead, boardwork, handout, discussion) allowed me to cover more material than I usually would (especially with period 8). I felt that the students grasped a great deal of this information.

The review went well in period 7. It was too bad that I did not have more time for this. The period 8's struggled with this because they did not take it seriously. The questions that they came up with were fairly poor and unchallenging compared to the period 7 class. This reflects the type of class period 8 is (with a low degree of

maturity). I will need to keep the variety going for period 8 (with busy work) but am more able to try different things with the period 7's.

* * * * * * * * * * * *

This excerpt is indicative of clue 6-B, and illustrates a teacher view of high school students in classroom situations. Don recognized that the period 8 class was different from the period 7 class. The evidence for this statement is not Don's comparisons of the period 8 class with recollections of his own biology 10 class in high school, but is the result of comparing the two classes to each other. He cites the quality of the questions that were asked as his evidence. Of all of the areas investigated through the questions of the conceptual framework, this one is most affected by increased experience in the classroom.

An additional avenue that could have been explored is the reasons why Don depicted period 8 as low in maturity. Was this assessment being made on the basis of comparisons to other classes, or to his recollections of his own schooling? The answer to the question would further reveal whether he was operating from a student or teacher view.

## Summary

Chapter 3 developed a conceptual framework to account for the four major differences between novices and experts that appeared in the teacher thinking literature in Chapter 2. The present chapter has bridged the gap between the

theoretical findings represented in the conceptual framework on one hand, and actual science classroom teaching events, on the other. The bridging is provided by "clues" which permit one to link classroom actions to either a teacher view or a student view of teaching.

Twelve clues were developed in all. They are reproduced all together at this point, to provide a collective sense of the findings of the study.

| STUDENT VIEW | TEACHER VIEW |
|---|---|
| CLUE 1-A | CLUE 1-B |
| A planned discussion is comprised of a few general questions to initially get the discussion going. | A planned discussion is comprised of specific questions that will guide the discussion to its intended goals. |
| CLUE 2-A | CLUE 2-B |
| In classroom discourse there is heavy reliance on the students to carry the flow of the discussion unaided. | In classroom discourse there are deliberate strategies to assist the students to participate such as: designing specific scenarios, "playing dumb", and playing the role of "devil's advocate". |
| CLUE 3-A | CLUE 3-B |
| When a student asks a question during a lesson, the teacher always answers it (even if he/she is not sure). | When a student asks a question during a lesson, the teacher uses various techniques, maybe answering the question or maybe asking a student to answer it. If the teacher decides that the question will not be responded to, he/she may or may not reveal a reason. |

| CLUE 4-A | CLUE 4-B |
| --- | --- |
| Problems in a lesson are attributed to the students' shortcomings. If necessary, minor "quick fixes" can help to keep the students on track. | Problems in a lesson are attributed to flaws in the lesson plan. The sequencing is examined in order to detect where the breakdown in logical provision occurred. |
| **CLUE 5-A** | **CLUE 5-B** |
| When a reasonable level of behaviour is exceeded, the teacher does not consistently take effective actions to maintain an appropriate level of classroom decorum. | When a reasonable level of behaviour is exceeded, the teacher consistently takes effective actions to maintain an appropriate level of classroom decorum. |
| **CLUE 6-A** | **CLUE 6-B** |
| Judgements about the characteristics of a group of students are made on the basis of comparing the group to "what it was like when I was a student". | Judgements about the characteristics of a group of students are made on the basis of comparing the group to comparable groups from the current year or from recent years. |

The clues demonstrate in one instance, the case of Don, how differences between expert and novice teacher thinking can manifest themselves in a student teaching setting. As such, they can serve as a diagnostic tool for cooperating teachers to establish the "mindset" of a novice, and to track a novice's progress throughout a student teaching round. By inferring the general characteristics of the novice's thinking from his/her classroom performance, logbook entries, and responses in interviews, the cooperating teacher can fashion feedback which takes into account the findings of research in this area.

# Chapter 5

## CONCLUSIONS, LIMITATIONS, AND IMPLICATIONS

The thrust of the argument in this study is to demonstrate the development of a systematic way to detect features of novice science teacher thinking. There is a growing body of research literature which portrays various aspects of the novice teacher's sensemaking, usually as "deficiencies" when compared to expert teacher thinking (however "expert" is defined). The context in which these research findings count, and can make a difference, is a practical one: teacher education, especially the practicum or student teaching component.

When an observer (say, a cooperating teacher) watches a novice teach, the deficiencies depicted in the research literature can provide useful background as a basis for feedback to the novice, but how does one know the deficiency when one sees it? That is, how do deficiencies in a teacher's thinking manifest themselves in teaching acts? The researcher has pursued that issue in the context of one novice science teacher's experience.

Thus the importance of answering the epistemological question "How do you know it when you see it?" has provided

the impetus for the present study. This closing chapter reviews the study and its conclusions, and identifies and discusses limitations. Finally, implications are suggested for further research and practice.

## Review of the Argument

### Components of the Conceptual Framework

Organizing a fairly diverse literature into a conceptual framework to guide analysis of teaching discourse and other data sources associated with student teaching (logbook, interviews) involved two major steps. First, the researcher stipulated that three distinctions would frame the data analysis. (a) The literature inherently conveys a comparison between two views of teaching: a relatively naive view and a relatively developed view. These are identified for the study as a "student view" and a "teacher view" of teaching. (b) Recognizing a standard distinction from analytic philosophy of education, actions in the classroom are taken to be guided by a reasoned basis. That is, a perception of teaching is defined as including both procedural (knowing how) and declarative (knowing why) knowledge components. (c) The framework acknowledges a distinction in the literature between generic aspects of teaching (applicable to all subject areas) and aspects unique to a given subject area (science, in this case).

Second, a review of the pertinent research literature yielded four general findings which constitute a composite picture of novice teachers. (None of these is too surprising.) They are unrealistically optimistic about the demands of teaching; their subject matter knowledge is not entirely equal to the requirements of teaching, either in depth and breadth or in form; they lack sophistication in assessing classroom situations; and they perceive students and teaching from a perspective that is inadequate to the situation.

## Characteristics of the Literature

Three areas of literature have been examined: knowledge base studies, teacher thinking studies, and novice teacher studies. The first area includes exemplary studies of what Shulman referred to as the "missing paradigm" of educational research. Such studies demonstrate how and why teachers' subject matter knowledge and subject-matter-related knowledge are important components of their thinking. Unfortunately, there are few studies that explore these issues within a secondary school science context.

The second area of the literature, known as the teacher thinking research, contains for the most part studies conducted in elementary school contexts. Even within the few secondary school studies, science teacher thinking received little attention. This area of the literature

highlights several differences between novice and expert teachers. Even though the studies individually focus only on certain aspects of teacher thinking, they are important to the present study in their cumulative contribution to a composite picture.

The third area of the literature illuminates the concerns and expectations of novices as they progress through student teaching. These findings are helpful with their general depiction of the stages novices progress through, but lack specific detail concerning the events of the classroom as novices experience them.

The literature informs the conceptual framework by characterizing novice teachers and the deficiencies that are evident when they are compared to expert teachers. What the literature does not do, is provide a comprehensive mechanism for detecting how these differences manifest themselves in a novice's teaching.

## Analysis and Clue Development

As noted earlier, four major themes depicting differences between novice and expert teacher thinking were identified. These were translated into question form, making the answers to the questions "clues" for detecting instances of classroom events linked to characteristics of thought. The four questions, which guided the selection of data about a novice teacher (Don), are as follows:

(1) How does a novice science teacher manifest the unrealistic optimism that he/she already knows how to teach?

(2) When a novice science teacher makes a subject matter error, what can be inferred about the novice's thinking?

(3) How does a novice science teacher's assessment of classroom problems (e.g., lesson flow, discipline) suggest a rudimentary level of analysis?

(4) How does a novice science teacher's performance reveal a relatively undeveloped perception of students in classroom situations?

Each question has two answers (a "student view" clue and a "teacher view" clue). In examining data about Don's teaching, the researcher asked two prior questions (also dichotomous), about the orientation of the "theme" question as relating to general pedagogy or specific to science, and about the possibility of discerning both declarative and procedural knowledge components. The results, as presented in Chapter 4, are twelve clues (six of student views and a parallel six of teacher views). Most importantly, the clues constitute a tool that allows an observer to identify specific instances of possible ways that features of novice teacher thinking manifest themselves in a novice's teaching.

## Conclusions

The most straightforward conclusion about this research is that it is **possible** to detect instances of the general research findings about teacher thinking in concrete, day-

to-day events of a novice science teacher's experience. This is not a trivial conclusion. That is, the present state of the art of research on teacher thinking is such that generic findings are mixed with findings specific to subject areas (science among others). Hence it is not clear, often, how one is to "apply" the research, or see its usefulness, in the important practical context of student teaching.

Second, the six pairs of clues are intuitively satisfying, in that they capture the differences in teachers' understanding which can be developed only through experience.

And third, the clues satisfy the epistemological requirement giving impetus to the study, namely finding a way to answer the question "How do you know it when you see it?". One unanticipated finding is that the clues can be used as a diagnostic tool to track the development of a novice. That is, it can be seen that early in the student teaching round, student view clues pertaining to all four questions of the conceptual framework were frequently detected in Don's teaching. Later, some instances indicative of a teacher view could be detected. Significant shifts towards a teacher view were most noticeable in the evaluation of problems in a lesson, and in his perceptions of students in classroom situations. As noted earlier, this

development does not necessarily indicate "expert" teaching even though it shows that Don learned from experience.

## Limitations

This study necessarily focusses on only certain aspects of the complexities of learning to teach. This obviously presents some limitations which could be addressed in subsequent research. First, the researcher utilized four questions, representative of four major themes that emerged from the literature detailing the differences between novice and expert teachers. That literature is growing rapidly, and it is acknowledged that other researchers potentially may consolidate the literature differently -- either now or in a future study.

Second, although the four questions attempt to depict a composite picture, it is acknowledged that they may not be totally inclusive of all of the differences that exist between novices and experts. This is a limitation of the existing literature.

Third, another limitation of the novice-expert literature is the lack of clear criteria for distinguishing "expert" teachers from teachers who simply have more experience than novices. For all of the themes, experience is clearly a necessary component for a novice to learn how to teach. But to teach in an "expert" way, what else is

required? The literature is not forthcoming on this matter, and any study of this sort is therefore necessarily limited.

Fourth, the study involved only one novice teacher. The clues that emerged are significant, and link thinking to action for any novice who manifests the deficiencies in the same way as Don. However, there are many ways in which any of the characteristics of novice science teacher thinking could manifest itself. For example, Don manifested subject matter problems through a situational demand to answer all questions. Other novices may not exhibit this clue but, for example, they may constantly respond "I'm not sure", "I don't know", or "I'll get back to you on that tomorrow", as the researcher has seen other student teachers do. Thus, further studies involving more novices would result in the development of an enriched structure of possible clues about the questions in the conceptual framework.

Fifth, in hindsight, it would have been helpful to gather more information about Don's educational history. That is, the researcher did not investigate the extensiveness of Don's subject matter background, sometimes making it difficult to infer clearly about his thinking in this area. This problem was not anticipated. In the case involving the misinformation about carnivores (Excerpt 6), for example, Don was very surprised about what he said after being informed of the error. This reveals that the error wasn't the result of weak subject matter knowledge, but was

probably due to the novelty of teaching and the perceived situational demand to answer questions. By contrast, in the case of the "ideal pH of soil for plants" (Excerpt 5), the errors appear to be genuine subject matter mistakes.

Finally, the teacher view clues were generated from applicable data obtained by interviews involving the cooperating teachers, in some cases, and were developed hypothetically in others. Although they appear to be logically plausible, they have not been tested using data about actual expert science teachers.

## Implications for Further Research

This study has been an attempt to provide a systematic method of detecting instances of teaching, involving a secondary science novice teacher, that are indicative of a student view or teacher view of teaching. In addition to those suggested by the limitations section, such work has implications for further research as additional research questions arise. First, it would be interesting to see what the clues would look like in other areas of secondary school teaching such as mathematics, English, and social studies. Surely the subject-matter-specific domain clues would be affected by the unique nature of each discipline, but how different would they be? This could be extended into seeing how the clues would look in secondary school non-academic

classes such as Alberta's Science 14 or Math 15, or how they would look in a junior high school setting. The general pedagogical domain clues might be affected by the nature of the students unique to those contexts, but again one wonders how different they would be.

Second, how would "regular" teachers -- not novices or experts -- look if this methodology were used on their teaching and thinking? The clues are designed to depict novices and experts, but within the continuum, would "regular" teachers actually fall somewhere in the middle?

Third, how do novices make the shift from a student view to a teacher view? Instances were detected, but it is beyond the scope of the study to explain them. What are the factors involved in causing the shift? For instance, is there a minimum of experience necessary for this learning? Does coaching help? Are novices able to articulate the shift, or even become aware that they have made the shift? These are tantalizing questions.

Finally, if there is low concordance between a novice's procedural and declarative knowledge, what are the factors that contribute to this discrepancy? In novices, much of this can be attributed to the novelty of the situation or the evaluative nature of student teaching. When it happens in other teachers, can they account for the discrepancies between what they believe and what they do?

## Implications for Practice

There are several implications that the results of this kind of study can have for practice, specifically dealing with teacher education programs. First, the six pairs of clues provide a diagnostic tool by which cooperating teachers can detect the view of teaching from which a novice is operating. This is potentially a satisfying and effective outcome, since it helps to inform cooperating teachers about the mindset of the novices, and it is also useful in tracking the development of novices as they progress through the student teaching round. (This would be an interesting study in itself.) Another potential benefit is that utilizing such a clue structure would increase the commonalities between the university-based teacher education program and the school-based practicum.

Second, the results of the study can be used as a reflective tool within a pre-service education program through providing a basis for discussing and exposing the basis for the student view of teaching. Rarely do teacher education programs take into account the prior conceptions of teaching, learning, students, and subject matter that student teachers initially have (Barnes, 1989). If student teachers are confronted with understanding their own pre-conceptions of teaching, they might be empowered to realize that their experience is limited and biased, and might also

become aware of what has been called the "familiarity pitfall" (Feiman-Nemser and Buchmann, 1983).

Third, the clues can be helpful to novice teachers by supplying them with a basis with which to reflect. Using the clue structure as a guide, novices can evaluate the development of their own teaching. As well, the teacher clues also direct novices towards the goals to which they are aiming for.

Finally, the results of the study can be incorporated into a practicum setting to expedite the shift from a student view to a teacher view of teaching. It must be cautioned that rather than merely focussing upon improving the actions of novices, improvement of the cognitive aspects must not be neglected. In order to improve novices' concordance between procedural and declarative knowledge, one possibility is to utilize cooperating teachers in a reflective practicum. This situation requires cooperating teachers to make explicit both the procedures and actions that they engage in as well as the rationale for doing them (Erickson and MacKinnon, 1991). This improves the quality of novices' student teaching experiences since it moves beyond merely "showing and telling", by requiring cooperating teachers to reveal the declarative knowledge that guides their procedural knowledge.

# BIBLIOGRAPHY

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Anderson, C., & Smith, E. (1985). Teaching Science. In V. Koehler (Ed.), The educator's handbook: A research perspective (pp. 80-111). New York: Longman, Inc.

Barnes, H. (1989). Structuring knowledge for beginning teaching. In M.C. Reynolds (Ed.), Knowledge base for the beginning teacher (pp. 13-22). Toronto: Pergamon Press.

Baxter, J., Richert, A., & Saylor, C. (1985). Science group: Content and process in biology. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Ben-Peretz, M. (1975). The concept of curriculum potential. Curriculum Theory Network, 5(2), 151-159.

Berliner, D. (1986). In pursuit of the expert pedagogue. Educational Researcher, 15(7), 5-13.

Bolin, F.S. (1988). Helping student teachers think about teaching. Journal of Teacher Education, 39(2), 48-54.

Borko, H., Lalik, R., & Tomchin, E. (1987). Student teachers' understanding of successful and unsuccessful teaching. Teaching and Teacher Education, 3(2), 77-90.

Borko, H., & Livingston, C. (1989). Cognition and improvisation: Differences in mathematics instruction by expert and novice teachers. American Educational Research Journal, 26(4), 473-498.

Borko, H., Livingston, C., McCaleb, J., & Mauro, L. (1988). Student teachers' planning and post-lesson reflections: Patterns and implications for teacher preparation. In J. Calderhead (Ed.), Teachers' professional learning (pp. 65-83). London: Falmer Press.

Broeckmans, J. (1986). Short-term developments in student teachers' lesson planning. Teaching and Teacher Education, 2(3), 215-228.

Bromme, R. (1987). Teachers' assessments of students' difficulties and progress in understanding in the classroom. In J. Calderhead (Ed.), Exploring teachers' thinking (pp. 125-146). London: Cassell Educational Limited.

Brousseau, B.A., Book, C., & Byers, J.L. (1988). Teacher beliefs and the cultures of teaching. Journal of Teacher Education, 39(6), 33-39.

Busher, H., Clarke., S., & Taggart, L. (1988). Beginning teachers' learning. In J. Calderhead (Ed.), Teachers' Professional Learning (pp. 84-96). London: The Falmer Press.

Calderhead, J. (1983). Research into teachers' and students' cognitions: Exploring the nature of classroom practice. Paper presented at the annual meeting of the American Educational Researchers Association, Montreal.

Calderhead, J. (1987). Cognition and metacognition in teachers' professional development. Paper presented at the annual meeting of the American Educational Research Association, Washington, D.C.

Calderhead, J. (1988). The development of knowledge structures in learning to teach. In J. Calderhead (Ed.), Teachers' Professional Learning (pp. 51-64). London: The Falmer Press.

Calderhead, J., & Robson, M. (1991). Images of teaching: Student teachers' early conceptions of classroom practice. Teaching and Teacher Education, 7(1), 1-8.

Carter, K., Sabers, D., Cushing, K., Pinnegar, S., & Berliner, D.C. (1987). Processing and using information about students: A study of expert, novice, and postulant teachers. Teaching and Teacher Education, 3(2), 147-157.

Chastko, A.M. (1990). Communicating about teaching during changes in science curriculum policy. Paper presented at the annual meeting of the Canadian Society for the Study of Education, Victoria.

Clark, C.M., & Peterson, P.L. (1986). Teachers' thought processes. In M.C. Wittrock (Ed.), Handbook of research on teaching (3rd ed.), (pp. 255-296). New York: Macmillan Co.

Clark, C.M., & Yinger, R.J. (1977). Research on teacher thinking. Curriculum Inquiry, 7(4), 279-304.

Clark, C.M., & Yinger, R.J. (1987). Teacher planning. In J. Calderhead (Ed.), Exploring teachers' thinking (pp. 84-103). London: Cassell Educational Limited.

Cornett, J.W., Yeotis, C., & Terwilliger, L. (1990). Teacher personal practical theories and their influence upon teacher curricular and instructional actions: A case study of a secondary science teacher. Science Education, 74(5), 517-529.

Elbaz, F., Hoz, R., Tomer, Y., Chayot, R., Mahler, S., & Yeheskel, N. (1986). The use of concept mapping in the study of teachers' knowledge structures. In M. Ben-Peretz, R. Bromme & R. Halkes (Eds.), Advances of research on teacher thinking (pp. 45-54). Lisse: Swets and Zeitlinger B.V.

Erickson, G.L., & MacKinnon, A.M. (1991). Seeing classrooms in new ways: On becoming a science teacher. In D.A. Schön (Ed.), The reflective turn: Case studies in and on educational practice (pp. 15-36). New York: Teachers College Press.

Feiman-Nemser, S. (1983). Learning to teach. In L.S. Shulman & G. Sykes (Eds.), Handbook of teaching and policy (pp. 150-170). New York: Longman Inc.

Feiman-Nemser, S., & Buchmann, M. (1983). Pitfalls of experience in teacher preparation. (Occasional paper No. 65). East Lansing, MI.: Michigan State University, Institute for Research on Teaching. (ED 237504).

Feiman-Nemser, S., & Buchmann, M. (1987). When is student teaching teacher education? Teaching and Teacher Education, 3(4), 255-273.

Fenstermacher, G.D. (1986). Philosophy of research on teaching: Three aspects. In M.C. Wittrock (Ed.), Handbook of research on teaching (3rd ed.), (pp. 37-49). New York: Macmillan Co.

Fuller, F.F., & Bown, O.H. (1975). Becoming a teacher. In K. Ryan (Ed.), Teacher Education (pp. 25-52). The seventy-fourth yearbook of the National Society for the Study of Education, Part II. Chicago: University of Chicago Press.

Galluzzo, G.R. (1984). A study of student-teacher thinking. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Goodman, J. (1988). Constructing a practical philosophy of teaching: A study of preservice teachers' professional perspectives. Teaching and Teacher Education, 4(2), 121-137.

Grossman, P.L. (1987). A tale of two teachers: The role of subject matter orientation in teaching. Paper presented at the annual meeting of the American Educational Research Association, Washington, D.C.

Gudmundsdottir, S., & Shulman, L. (1987). Pedagogical content knowledge in social studies. Scandinavian Journal of Educational Research, 31(2), 59-70.

Happs, J.C. (1987). "Good" teaching of invalid information: Exemplary junior secondary science teachers outside their field of expertise. In K. Tobin & B.J. Fraser (Eds.), Exemplary practice in science and mathematics education (pp. 69-70). Perth, Australia: The Authors.

Hashweh, M.Z. (1987). Effects of subject matter knowledge in the teaching of biology and physics. Teaching and Teacher Education, 3(2), 109-120.

Haymore, J. (1987). From successful student to frustrated student teacher: A case study of Sharon, a beginning math teacher. Stanford University: Knowledge Growth in a Profession Project.

Hirst, P.H. (1971). What is teaching? Journal of Curriculum Studies, 3(1), 5-18.

Hofer, H.M. (1986). Forming judgements in the classroom: How do teachers develop expectations of their pupils' performances?. In M. Ben-Peretz, R. Bromme & R. Halkes (Eds.), Advances of research on teacher thinking (pp. 113-121). Lisse: Swets and Zeitlinger B.V.

Housner, L.D., & Griffey, D.C. (1985). Teacher cognition: Differences in planning and interactive decision making between experienced and inexperienced teachers. Research Quarterly for Exercise and Sport, 56(1), 45-53.

Jordell, K.O. (1987). Structural and personal influences in the socialization of beginning teachers. Teaching and Teacher Education, 3(3), 165-177.

Kilbourn, B. (1982). Curriculum materials, teaching, and potential outcomes for students: A qualitative analysis. Journal of Research in Science Teaching, 19(8), 675-688.

Leinhardt, G. (1983). Novice and expert knowledge of individual student's achievement. Educational Psychologist, 18(3), 165-179.

Leinhardt, G. (1986). Math lessons: A contrast of novice and expert competence. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Leinhardt, G., & Greeno, J.G. (1986). The cognitive skill of teaching. Journal of Educational Psychology, 78(2), 75-95.

Lortie, D.C. (1975). Schoolteacher: A sociological study. Chicago: University of Chicago Press.

MacDonald, D. (1990). Altering lessons "On the fly": An aspect of science teacher practice. Paper presented at the annual meeting of the Canadian Society for the Study of Education, Victoria.

Marks, R. (1987a). Problem solving with a small "p": A teacher's view. Paper presented at the annual meeting of the American Educational Research Association, Washington, D.C.

Marks, R. (1987b). Those who appreciate: The mathematician as secondary teacher. Stanford University: Knowledge Growth in Teaching Project

McDiarmid, G.W., Ball, D.L., & Anderson, C.W. (1989). Why staying one chapter ahead doesn't really work: Subject-specific pedagogy. In M.C. Reynolds (Ed.), Knowledge base for the beginning teacher (pp. 193-205). Toronto: Pergamon Press.

Morine-Dershimer, G. (1991). Learning to think like a teacher. Teaching and Teacher Education, 7(2), 159-168.

Morine-Dershimer, G., & Joyce, B. (1979). An introduction to the South Bay study. In McNair, K. & Joyce, B., Teachers' thoughts while teaching: The South Bay study, part II. (Research series No. 58). East Lansing, MI.: Michigan State University, Institute for Research on Teaching. (ED 191797).

Munby, H. (1982). The place of teachers' beliefs in research on teacher thinking and decision making, and an alternative methodology. Instructional Science, 11(3), 201-225.

Munby, H. (1986). Metaphor in the thinking of teachers: An exploratory study. Journal of Curriculum Studies, 18(2), 197-209.

Nespor, J. (1987). The role of beliefs in the practice of teaching. Journal of Curriculum Studies, 19(4), 317-328.

Olson, D.R. (1973). What is worth knowing and what can be taught? School Review, 82(1), 27-43.

Peterson, P.L., & Clark, C.M. (1978). Teachers' reports of their cognitive processes during teaching. American Educational Research Journal, 15(4), 555-565.

Peterson, P.L., & Comeaux, M.A. (1987). Teachers' schemata for classroom events: The mental scaffolding of teachers' thinking during classroom instruction. Teaching and Teacher Education, 3(4), 319-331.

Ringstaff, C. (1987). Teacher misassignment: The influence of subject matter knowledge on teacher planning and instruction. Paper presented at the annual meeting of the American Educational Research Association, Washington, D.C.

Roberts, D.A. (1991). What counts as an explanation for a science teaching event? Teaching Education, 3(2), 69-87.

Roberts, D.A., & Chastko, A.M. (1990). Absorption, refraction, reflection: An exploration of beginning science teacher thinking. Science Education, 74(2), 197-224.

Roberts, D.A., & Russell, T.L. (1975). An alternative approach to science education research: Drawing from philosophical analysis to examine practice. Curriculum Theory Network, 5(2), 107-125.

Russell, T. (1988). From pre-service teacher education to first year of teaching: A study of theory and practice. In J. Calderhead (Ed.), Teachers' professional learning (pp. 13-34). London: The Falmer Press.

Russell, T., Munby, H., Spafford, C., & Johnston, P. (1988). Learning the professional knowledge of teaching: Metaphors, puzzles, and the theory-practice relationship. In P.P. Grimmett & G. Erickson (Eds.), Reflection in teacher education (pp. 67-89). Vancouver: Pacific Educational Press, The University of British Columbia.

Schwab, J.J. (1964). Structure of disciplines: Meanings and significances. In G.W. Ford & L. Pugo (Eds.), The structure of knowledge and the curriculum (pp. 1-30). Chicago: Rand McNally and Company.

Shavelson, R.J., & Stern, P. (1981). Research on teachers' pedagogical thoughts, judgments, decisions, and behavior. Review of Educational Research, 51(4), 455-498.

Shulman, J. (1987). From veteran parent to novice teacher: A case study of a student teacher. Teaching and Teacher Education, 3(1), 13-27.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), 4-14.

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1-22.

Smith, D.C., & Neale, D.C. (1989). The construction of subject matter knowledge in primary science teaching. Teaching and Teacher Education, 5(1), 1-20.

Steinberg, R., Haymore, J., & Marks, R. (1985). Teachers' knowledge and structuring content in mathematics. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Strahan, D.B. (1989). How experienced and novice teachers frame their views of instruction: An analysis of semantic ordered trees. Teaching and Teacher Education, 5(1), 53-67.

Tabachnick, B.R., & Zeichner, K.M. (1984). The impact of student teaching experience on the development of teacher perspectives. Journal of Teacher Education, 35(6), 28-36.

Tamir, P. (1988). Subject matter and related pedagogical knowledge in teacher education. Teaching and Teacher Education, 4(2), 99-110.

Tobin, K., & Fraser, B.J. (Eds.). (1987). Exemplary practice in science and mathematics education. Perth, Australia: The Authors.

Weinstein, C.S. (1988). Preservice teachers' expectations about the first year of teaching. Teaching and Teacher Education, 4(1), 31-40.

Whitfield, R.C. (1975). Teaching as decision-making for and in the science room. In P.L. Gardner (Ed.), The structure of science education (pp. 155-167). Victoria, Australia: Longman Australia Pty Limited.

Wragg, E.C. (1985). Training skilful teachers. Teaching and Teacher Education, 1(3), 199-208.

Yinger, R.J. (1986). Examining thought in action: A theoretical and methodological critique of research on interactive teaching. Teaching and Teacher Education, 2(3), 263-282.

Yinger, R.J. (1987). Learning the language of practice. Curriculum Inquiry, 17(3), 293-318).