PEDAGOGICAL INQUIRY THROUGH GROUP INTERACTION: A CASE OF HIGH SCHOOL SCIENCE TEACHERS DOING ACTION RESEARCH

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Pedagogical Inquiry through Group Interaction: A Case of High School Science Teachers Doing Action Researc
(Under the direction of RUSSELL H. YEANY)

This dissertation is composed of five connected, although independent, papers on related aspects of Pedagogical Inquiry Through Group Interaction. The first two papers provide theoretical contributions to the understanding of the relationship between action and thought. "The Representation of Teachers' Mental World", reviews research methodologies and studies on teachers' implicit theories, beliefs and knowledge. This review highlights the basic epistemological assumptions and concepts used by researchers to represent teachers' mental world. The second paper, "Action, Thought, and Interaction Across Some Logical, Philosophical, Psychological and Social Psychological Approaches," reviews some of the most influential theories of action. These include Dewey's Philosophy of Inquiry, Practical Problem Solving, Soviet Theory of Activity, Genevan Constructivist Psychology, Symbolic Interactionism, and Action Science (Schon's Reflective Practitioner). This review attempts to delineate the basic concepts of action, thought and interaction set forth by these theories, and to synthesize the basic problems in conceptualizing the dynamic relationship between thought and action.

The next papers investigate three related aspects of the pedagogical inquiry undertaken by a group of action researchers, consisting of two high school science teachers and an outsider/researcher. "`Homework For Conceptual Change`: The Intellectual Journey of a Group of High School Science Teachers Doing Action Research," is the collective narration of what was learned during the action research process. This paper provides a space for teachers' voices and shows some of the main intellectual difficulties in inquiring into teachers' own pedagogical problems. "The Functional, Emotional and Symbolic Dimensions of Researcher's Interventions within Action Research" studies the researcher's role within action research, through analysis of researcher discourse. The influences on researcher interventions of the task and of the group participation structure are also investigated. The fifth and final paper, "Teachers' Pedagogical Inquiry through Group Interaction", studies the process, content, and structure of teachers' pedagogical inquiry conversations. The influence of interaction on changes in teachers' pedagogical inquiry is also discussed.

INDEX WORDS: Action Research, Collaborative Research, Teacher Inquiry, Pedagogical Problem Solving, Group Interaction, Group Dynamics, Small Group Problem Solving, Discourse Analysis, Conversational Analysis, Teacher Thinking, Teacher Thought Processes, Reflection, Teacher Change, Teacher Development, Science Teachers, Supervisory Conferences

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PEDAGOGICAL INQUIRY THROUGH GROUP INTERACTION:

A CASE OF HIGH SCHOOL SCIENCE TEACHERS

DOING ACTION RESEARCH

by

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DEDICATION

Aquest treball està dedicat a Rosa Sensat, Artur Martorell, Alexandre Galí, Marta Mata, Teresa Codina i Pilar Benejam, pedagogs que han inspirat i marcat el moviment educatiu a Catalunya.
(This work is dedicated to Rosa Sensat, Artur Martorell, Alexandre Galí, Marta Mata, Teresa Codina i Pilar Benejam, the educators who have inspired and shaped the development of education in Catalonia)

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CHAPTER 1

OVERVIEW OF THE RESEARCH

This dissertation is composed of five connected, although independent, papers on related aspects of Pedagogical Inquiry Through Group Interaction. social, professional and personal factors shaped the research question, and the methodology used to answer it. The work documented here begun in 1986, and was influenced by contemporary developments within the field of research on teaching. The 3rd Handbook of Research on Teaching (Wittrock, 1986) had just been published with a new section on teachers' thought processes was included. This publication presented, for the first time, teachers' thinking as a single, coherent area of educational research. That same year, Shulman (1986) presented a conception of teacher knowledge which strongly emphasized the role of subject matter knowledge in teaching. This work stemmed partly from public concern for the quality and professionalism in teaching (Carnegie Report, 1986; Holmes Report, 1986). Previous to this research, I had worked on several projects to influence teacher change in high school science and mathematics classrooms (Tobin, Espinet, Byrd & Adams, 1988; Tobin & Espinet, 1989; ibid., in press). Both the new ideas emanating from within the educational research community, and my own research, led me to formulate the initial question of the present dissertation: What is the development of teachers' content knowledge, pedagogical knowledge, and content pedagogical knowledge?

Personal values also influenced my research design and methodology. My profound respect for teachers and teaching prevented me from using research methodologies which alienate teachers from the research process and product. A non-negotiable condition was that teachers clearly benefit from their involvement with the investigation. The best context for this appeared to be collaborative work, in which teachers engaged in solving their own pedagogical problems. Through this inquiry process, teachers could create practical knowledge, and I was able to study teacher knowledge at work. If, at any time during the research, these two interests conflicted, I clearly prioritized the teachers' needs. My role became that of a faciliator and a researcher studying teachers' knowledge within the context of inquiry.

The five papers included in the present dissertation were written at different moments in the research process. The first paper (chapter 2), "The Representation of Teachers' Mental World," reviews research methodologies and studies of teachers' implicit theories, beliefs and knowledge. It was written at the beginning of the field work, as a tool for understanding how teachers' knowledge could be represented. This review revealed major differences in the basic epistemological assumptions and concepts used by researchers to represent teachers' mental world. Most of the studies on teachers' practical and personal knowledge reviewed showed that teachers themselves can generate the concepts guiding their practice, provided that they have an environment conducive to reflection and interaction. From this, I concluded that the investigation of teachers knowledge could best be done through a process in which teachers would articulate the concepts and theories guiding their practice. The teacher and the researcher would collaborate in the creation of practical theories through inquiry. This methodological review of studies on teachers' practical and personal knowledge sharpened my original research question and help me chose a methodology.

The second paper (chapter 3), "Action, Thought, and Interaction Across Some Logical, Philosophical, Psychological and Social Psychological Approaches," reviews several of the most influential theories of action. These include Dewey's Philosophy of Inquiry, Practical Problem Solving, Soviet Theory of Activity, Genevan Constructivist Psychology, Symbolic Interactionism, and Action Science (Schon's Reflective Practitioner). These theories were selected for review because of their strong impact on the development of the social sciences, and because they use human inquiry as a context for the study of action. The review compares the basic concepts of action, thought and interaction set forth by these theories, and highlights basic problems in conceptualizing the dynamic relationship between thought and action. This review was undertaken at the end of the research experience, once it became clear that study of teacher knowledge could not be conducted without a general consideration of action and interaction as they relate to thought.

The remaining papers investigate three related aspects of a group pedagogical inquiry undertaken by one experienced high school science teacher, one novice high school science teacher, and myself as an outsider/researcher doing action research. Different types of action research differ in their handling of relationships between teachers and researchers, in their methods of defining research problem, and in other methodological details. The pedagogical inquiry undertaken by the teachers and myself is best described as practical action research. The teachers chose the problems to be dealt with. The role of the researcher was to create the constraints of the experience; to facilitate reflection; to help teachers confront contradictions; and to provide ideas. Pedagogical inquiry included observations on changes attempted by all group members. This helped to provide a common basis of experience from which to reflect in subsequent meetings. The three final chapters constitute different studies based on the same experience of action research.

Chapter 4, "'Homework For Conceptual Change': The Intellectual Journey of a Group of High School Science Teachers Doing Action Research," narrates what was learned during the action research process. This chapter provides space for teachers' voices, and highlights the intellectual difficulties in constructing practical theories for specific aspects of teaching. This report was co-authored by the group members, and written right at the end of the action research experience. In fact, the last group meetings were devoted to sharing and discussing the written report. This report presents a social construction of a practical theory of teaching which developed in response to a specific problem set by the teachers. Reporting the results of the teachers' pedagogical inquiry as an intellectual journey shows the "craft" nature of teachers' practical knowledge. This paper represents the group's socially constructed answer to the initial question of this dissertation: How does teacher knowledge develop?

The final two chapters were written at the end of a two year-long process of data analysis and interpretation. At the end of the action research experience, all of us were ready to write about our struggles to understand and finding the best solutions for the selected problems. However, along the way, I had become interested in uncovering the role of interaction in pedagogical inquiry. Interaction now seemed the hidden means through which we were able to construct practical theories. I started a detached process of analyzing and interpreting the discourse within action research, once the experience was past. The general purpose of this investigation was to understand the role of interaction in pedagogical inquiry. The most important data were the transcripts of our group meetings. Analysis of the pedagogical inquiry discourse took two separate, complementary routes. The first focused on researcher/facilitator discourse and the influence of the group interactive environment on researcher intervention. The second was the analysis of group conversation and the influence of interaction on the teacher inquiry.

In Chapter 5, "The Functional, Emotional and Symbolic Dimensions of Researcher's Interventions within Action Research" I studied my role as researcher within action research, and analyzed my own discourse and the meaning I attached to it. The chapter begins with a functional description of researcher interventions, and their evolution during the action research. The second part describes the emotional and symbolic dimensions of researcher intervention during critical communicative events. This chapter attempts to set a precedent for future research studies, by focusing on the researcher's actions, meanings, and emotions. Sensitivity to the subjective world of researchers will become especially important, as collaborative educational research studies become more common.

The final chapter, "Teachers' Pedagogical Inquiry through Group Interaction", studies the process, content, and structure of the teachers' pedagogical inquiry conversations. While inquiry has traditionally been studied at the individual level, this chapter attempts to describe teacher inquiry within an interactive context. The data analyzed here was a subset of the total data collected. Only the transcripts of the meetings associated with the homework problem, reported in chapter 4, were used.

This chapter is composed of three parts. The first identifies pedagogical inquiry moves, as the proper units for the content analysis of pedagogical inquiry discourse. The second part describes the structure of pedagogical inquiry conversations. The last part describes those interactive events within conversations which induced change in the teachers' pedagogical inquiry.

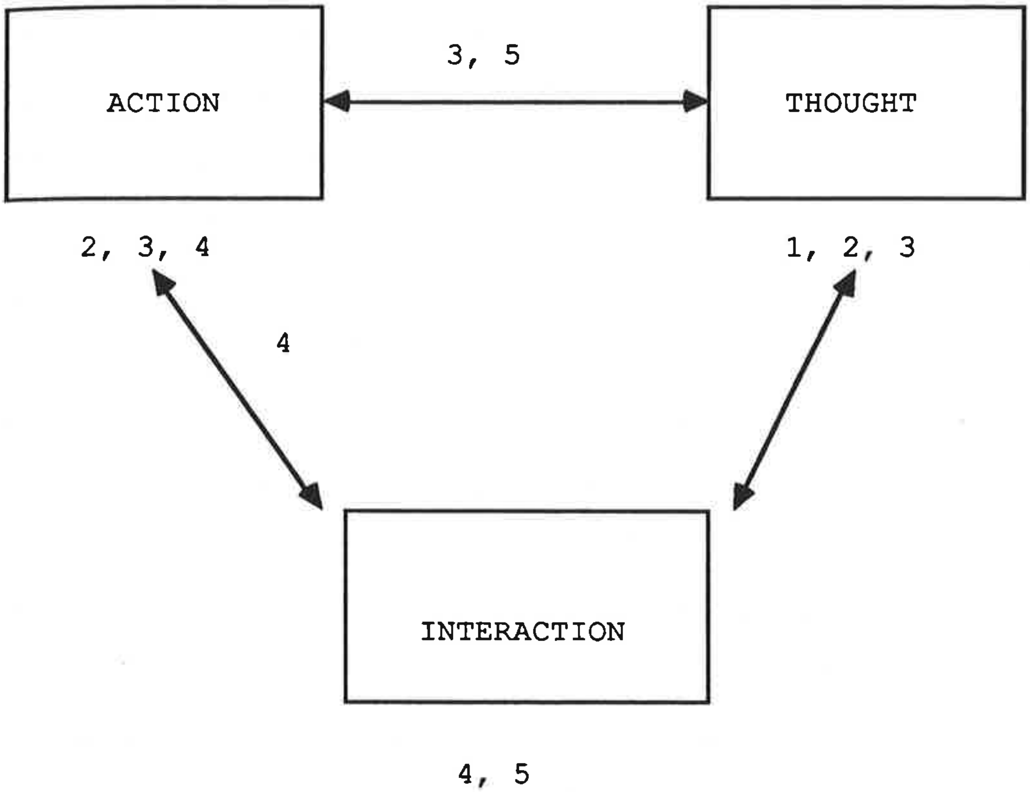
The five papers included in this dissertation contribute differently to our understanding of the act of teaching. This understanding must rest on the establishment of a relationship between the concepts of action, thought and interaction, as these concepts apply to teachers. For this, the phenomenological boundaries of the concepts of action, thought and interaction need to be described, as a prelude to their reintegration into a comprehensive theory of teacher action. The construction of such theoretical framework will be a long process, requiring efforts on many different fronts. The papers included as chapters 2 and 3 provide theoretical contributions to this project, while chapters 4, 5, and 6 attempt an empirical contribution (See Figure 1-1).

Chapter 2 reviews research studies of teachers' implicit theories, beliefs and knowledge. It contributes to the definition of a unit for the description of teacher thought, and shows the place of action within the representation of teachers' mental world.

Chapter 3 reviews theories of action, providing solid theoretical contributions to the identification of units of thought and action, and to the description of their relationship. All the theories reviewed explore the relationship between action and thought within the dynamic context of human inquiry. This context involves a subject reacting to a problem, task, or personal feeling of puzzlement. This is precisely the context chosen to develop the empirical contributions included in this dissertation.

Chapter 4 constitutes a socially constructed report on the pedagogical inquiry undertaken. It provides specific data from which to develop an understanding of the relationship between action and thought, as experienced by a particular group of pedagogical inquirers.

Chapter 5 is a systematic study of researcher interventions and their evolution as a consequence of group interaction. This analysis contributes to an understanding of the relationship between interaction and researchers' actions.



1. Contributions of chapter 2 ("The representation of teachers' mental world")
2. Contributions of chapter 3 ("Action, thought and interaction across some logical, philosophical, psychological, and social psychological approaches")
3. Contributions of chapter 4 ("Homework for conceptual change: The intellectual journey of a group of high school science teachers doing action research")
4. Contributions of chapter 5 ("The functional, emotional, and symbolic dimensions of researcher's interventions within action research")
5. Contributions of chapter 6 ("Teachers' pedagogical inquiry through group interaction")

Figure 1-1. The Contributions to the Understanding of Teachers' Action Thought, and Interaction.

Finally, Chapter 6 identifies units for the description of interaction, and shows how interaction influences teacher inquiry. This paper contributes to the understanding of the relationship between interaction, action, and thought as it occurs in pedagogical inquiry.

This dissertation's focus on interactive pedagogical inquiry ties in with recent professional, epistemological and research concerns within the educational community. Recent reports have stressed the need to develop an image of teachers as independent professionals (The Holmes Group Report, 1986; Carnegie Report, 1986). Teachers' pedagogical inquiry is one important activity characterizing teacher professionalism. Constructivism has become an increasingly acceptable alternative epistemology within the educational community (von Glasersfeld, 1984; ibid., 1987). Studies are being developed for the purpose of refining the basic concepts which would sustain a constructivist theory of teaching and learning. Historically, inquiry has been the context in which to study the development of intelligence and the construction of knowledge. Teachers' pedagogical inquiry provides the appropriate context for studying the construction of teacher knowledge.

Action Research, too, has developed as an alternative to the positivistic and interpretive paradigms within the educational research community (Elliot, 1988; Carr & Kemmis, 1988). Action research has mostly been used as a method for teacher growth and development. However, action research is also a valid form of educational inquiry, which needs to be better understood if it is to have some impact on teachers' practice.

CHAPTER 2

THE REPRESENTATION OF TEACHERS' MENTAL WORLD

PURPOSE

The literature on teacher implicit beliefs, theories and knowledge reveals the use of a wide variety of concepts and approaches. Researchers have used all of the following terms in describing the cognitive dimensions of teaching: perceptions, perspectives, views, ideas, concepts, conceptions, misconceptions, schema, knowledge structures, knowledge in action, principles of practice, beliefs, images, personal theories, practical philosophies, understanding, implicit theories, thought and thinking processes. The research frameworks include the sociology of education, symbolic interactionism, personal construct theory, linguistics, knowledge-in-action and phenomenology. This wide diversity of terms and approaches suggests that the area of teacher thought processes is an under developed and eclectic field of knowledge and that work is needed to clarify its philosophical and epistemological assumptions. This chapter reviews different approaches to syudying teachers' implicit theories, beliefs and knowledge. Careful consideration of these approaches will help determine whether their apparent discrepancies can be resolved and whether an emergent perspective is identifiable from which to construct a representation of teachers' mental world.

STRUCTURE AND APPROACH OF THE REVIEW

The papers reviewed here included journal articles, presentations at professional meetings (AERA, ISATT), dissertations, and non-published articles. The review considers in the following topics:

1. Methodologies used in studies of teacher thinking.
2. Studies of teachers' beliefs
3. Studies of teachers' perspectives
4. Studies of teachers' personal and practical knowledge.

The remaining sections center on four main issues. The first concerns the definitions of the concepts under study and the framework upon which they are based and the second concerns the social environment in which the teacher is being studied. Third, the individual researchers' conceptions of the nature, development, and use of teacher's knowledge is considered and, fourth, the scientific status of the research results is answered. Some of the researchers assumed that research findings on teacher thinking coule be widely generalized while others aimed to understand their thinking in particular situations and to capture their personal knowledge.

METHODOLOGY

The research methodology used in investigations into teacher thinking determines the extent and nature of the data collected. The different methods reviewed are organized on the basis of the researcher's involvement within the educational situation. The researcher's role in these studies ranges from that of an external non-participant to that of a potentially compromised participant.

Pencil and Paper Instruments: Surveys and Questionnaires

There are many instruments for identifying and measuring teachers' beliefs and principles (Confrey, 1978; Ferrini-Mundy, 1986; Wehling and Charters, 1969). These instruments are usually in the form of questionnaires or rating scales, where teachers identify those statements which apply to their own classrooms. They result in scores which place teachers' beliefs in some specific, pre-established category. Such questionnaires, as Munby (1984) pointed out, have two debilitating drawbacks. First, test scores cannot capture the uniqueness of a teacher's belief. The scores of an individual teacher have meaning only in comparison with all other test scores, and we cannot interpret individual scores without reference to the group. The second drawback relates to the nature of the test items. Teachers are usually asked to generate a response to hypothetical beliefs they would not necessarily have considered themselves. Test items are designed by a researcher and support his or her idea of what is important. Teacher responses elicited by these instruments do not necessarily correspond to the teacher's own thoughts and beliefs.

Some studies on teacher's conceptions of learning and teaching have used open-ended questionnaires as their sole source of data (VanRossum, Deijkers & Hanner, 1985). The participants are usually asked to give written answers on questionnaires. Researcher involvement in research using this type of instrument is greater than in surveys using scales. This is because the researcher must carefully design questions that will generate adequate and rich information. In this sense, open-ended questionnaires are better than objective instruments for identifying teachers' beliefs.

The disadvantage of both objective and open-ended questionnaires is the impossibility of going back to the teachers for clarification. However, this lack of depth into teacher cognition is compensated for by the increase in the number and variety of answers, since questionnaires as well as surveys can be administered to large samples. Another disadvantage of these instruments is that in framing the survey or questionnaire, researchers decide what is relevant and teachers have little opportunity to reveal what is important for themselves. As a consequence, research results using these methods may stray quite far from teachers' real conceptions. Finally, objective and open-ended instruments reflect the assumption that researchers and teachers share the same language and perspective. If this is not the case, researchers' questions may be misunderstood by teachers, resulting in vague or incorrect data.

Verbal Reports: Process Tracing and Stimulated Recall

The purpose of "thinking aloud" and stimulated recall methodologies is to know what teachers are or were thinking while performing a task, solving a problem, or teaching a lesson. Process tracing (thinking aloud) is used when the activity is such that teachers are able to verbalize the content of their thoughts without much interference with the flow of a task (i.e., planning) (Ericsson & Simon, 1980; Shavelson & Stern, 1981). Other activities, such as teaching or talking to students, do not allow teachers to introspect and communicate directly with the researchers. In these cases, stimulated recall is considered a better methodology than "thinking aloud" to capture teacher's thoughts. Stimulated recall consists of audio or video taping the teacher's activity followed by a session where the teacher is assisted by the researcher to recall the covert mental processes that accompanied specially selected passages shown in the video tape. In both methodologies the interactions between the researcher and the teacher are audio-taped and transcribed and they constitute the main data source for the researcher's analysis of teachers' thinking.

Bloom (1953), the first author who reported this technique, defines very clearly the rationale of its use: "The basic idea underlying the method of stimulated recall is that a subject may be enabled to relive all original situations with great vividness and accuracy if he is presented with a large number of cues or stimuli which occurred during the original citation (Bloom, 1953, p161)."

The stimulated recall methodology has been used by researchers within several professional and scientific areas such as medical education, psychotherapy and therapeutic counselor education, methodological studies, and studies of teaching and learning (Elstein, Shulman, Sprafka, 1978; Conners, 1978; Yinger & Clark, 1982). Although these researchers considered their results valid and reliable, questions have been raised concerning this method.

Critics of verbal reports have seriously questioned several assumptions underlying their use. One such assumption is that teachers act on the basis of well-articulated thoughts. This position has been criticized by Nisbett and Wilson (1977) and by Calderhead (1986). Nisbett and Wilson argued that professionals, artists and teachers act without full awareness of the exact processes which lead them to action. Psychological phenomena like creativity or subliminal perception support this criticism. People know more than they can tell (Polanyi, 1966; Calderhead, 1986). Critics have also pointed to the richness and complexity of teachers' thoughts and to the difficulty of putting these experiences into words, particularly in the form of reasons for actions.

A second, arguable assumption is that teachers are able and willing to report their thoughts (Shavleson & Stern, 1981; Clark & Peterson, 1986; Conners, 1978). Nisbett and Wilson (1977) strongly criticize this belief. They dealt with the reliability of teachers' verbal reports of their actual thinking at specific times in the past. Teachers retrospectively generate causal theories about specific classroom events instead of consulting their short term memory. All human beings have a strong tendency to explain and infer in an attempt to make sense out of their experience, rather than reporting the concrete details of their actual practice.

It seems wise to assume, with Marland (1977) and Conners (1978), that there is no single technique for establishing the validity of a subject's reported thoughts. However, there are many indirect ways to increase the accuracy of these reports

1. conduct the stimulated recall interview as close as possible to the actual occurrence of the event (Conners, 1978; Ericcson & Simon, 1980; Nisbett & Wilson, 1977);

2. check the teacher's degree of confidence, and the frequency of "no recall" answers (Conners, 1978);

3. provide a non-threatening and non-evaluative atmosphere (Conners, 1978);

4. ask the teacher to predict future events that were actually taped, before watching them (Conners, 1978);

5. collect verbal reports concurrently with other records of behavior, to check their consistency (Ericcson & Simon, 1980); and

6. elicit verbal reports with care and interpret them with full understanding of the circumstances under which they were obtained (Ericcson & Simon, 1980).

A last, doubtful assumption of the verbal reporting method is that teachers and researchers share similar perspectives, has been thoroughly criticized by Munby (1982). He identified two research phases where this assumption creates problems. The first occurs when the researcher selects the questions and cues to give to the teacher. The meaning and importance given to these cues and questions can differ for researcher and teacher. The second occurs in the analysis and interpretation of verbal reports. In analyzing the data, the researcher has in mind a coding system to classify and later make sense of what the teacher has said. The researcher should, however, define his categories tentatively, since there is no easy way to assure that they correspond to those of the teacher.

Repertory Grid Technique

The Repertory Grid Technique is an adaptable technique originally developed by Kelly (1955) as a method of discovering the personal constructs that influence on individual's behavior. The first step is to present (or ask the teacher to supply) activities, people, or situations called "elements." These elements are written on cards, so that the teacher can easily read them. Next, the researcher asks the teacher to group the cards, and give his personal thoughts about each particular grouping. Each reason or thought articulated by the teacher is called a "construct". The purpose of this second step is to simulate teachers' rationales associated with specific classroom situations. The third step is the construction of a grid whose axes represent the elements and the constructs. The teacher then rates the association between the elements and the constructs on a three point scale, so that each element is weighted against each construct. This third step provides a quantitative indicator of the relationship between classroom situations (elements) and teacher rationales (constructs). The fourth step is a factor or cluster analysis of the ratings included in the grid, in order to find important relationships among the constructs. This analysis gives a psychological status to the groupings of constructs identified through cluster or factor analysis. These groupings express the underlying framework which guides the teacher's thought and actions.

The research studies reviewed have introduced variations in the repertory grid technique (Munby 1982, 1984; Eisenhart et al., 1985). In spite of these differences, they all shared the assumption that teachers have particular and personal knowledge which cannot be verbally articulated.

In more recent studies, Munby (1986) indicated that teachers give wider, deeper and more organized meanings to their teaching than those captured through the repertory grid technique. Although this technique represents one of the first attempts at capturing non-verbal knowledge based on propositional statements of the teacher's own practice, language remains a mediator.

Case Studies and Ethnographies

Case studies and ethnographies are rich descriptions of special events, people, or social settings, which take into account the relationship between the personal meanings of participants and the context in which they are situated. Traditionally, ethnographies were studies of social systems within wider contexts such as that of a culture. In contrast, case studies focused on special events, people or social situations within much narrower contexts. This distinction, however, has recently been blurred, as some ethnographers began narrowing their focus (LeCompte & Goetz, 1982).

An underlying assumption of these methodologies is that teachers' meanings cannot be studied independently from the context in which they are used and generated. Different data collection strategies are used to construct case studies and ethnographies of teachers: intensive interviewing (Spradley, 1979); participant observation (Spradley, 1980); and analysis of personal journals and other written materials (Yinger & Clark, 1981; 1985), among others. Case studies and ethnographies represent the first methods reviewed here which attempt to identify teachers' implicit theories, beliefs, and knowledge as they relate to their cultural contexts.

Discussion

All the methodologies reviewed so far work under the assumption of an existing reality independent of the researcher. These methodologies seek to guide the researcher in capturing an external reality - called teachers' implicit theories, beliefs and knowledge - as accurately as possible. LeCompte & Goetz (1982) have extensively discussed the criteria for judging the validity and reliability of qualitative studies, and compared them to experimental ones. One of their conclusions is that "attaining absolute validity and reliability is an impossible goal for any research model... For decades, reputable ethnographers have used a variety of strategies to reduce threats to reliability and validity. This has been a major source for the defining characteristic of present-day ethnography - its multimodality (LeCompte & Goetz, 1982, p. 55)."

Fully capturing teachers' implicit theories, beliefs and knowledge as they really are seems then an impossible task. Goetz and LeCompte's suggestion of a multimodal research methodology provides the best grounds for undertaking research on teachers' implicit theories, beliefs, and knowledge.

STUDIES ON REPRESENTING THE TEACHER'S MENTAL WORLD

Beliefs: The Inner Nature of the Teacher's Mental World

There is no apparent agreement among researchers on the definition of 'belief' or the proper methodologies for its study. However, almost all the studies here reviewed consider beliefs part of the content of the teacher's cognition. For instance, Shavelson et al. (1977) consider beliefs as teachers' own theories of learning; Munby (1982) distinguishes principles from beliefs, but equates the latter with repertoires of understanding and implicit theories; Conners (1978) also distinguishes principles from beliefs, but considers beliefs as resulting from the mutual acceptance of the truth or actuality of something; Nisbett and Ross (1980) introduce beliefs, constructs, perceivers' schema and understandings as separate conceptual entities; Ferrini-Mundy (1986) conceives attitudes, beliefs and concepts separately. In spite of their apparent disagreement, all these studies share views about the nature of beliefs.

Conners (1978) categorized and described the beliefs, principles, rules and other mental variables which influence teachers' behavior during student/teacher interaction. He chose nine elementary school teachers, one each from first, third, and sixth grades at three schools. The methodology used was stimulated recall, and the author analyzed teachers' verbal reports at the micro and macro levels. The categorization systems were different at the different levels of analysis. Results were given as frequency counts of the appearance of different categories in teachers' verbal reports. The author began his analysis with a pre-imposed categorization system. This system tried to be exhaustive and mutually exclusive, as objective as possible, and systematic. The categories selected were: instructional moves; perceptions; interpretations; expectations; mediator-pupil; self awareness; beliefs; objectives; lesson content; information-pupil; information-other; feelings. As a consequence of the researcher's desire that the category system be exhaustive and mutually exclusive, the categories tended to be very compartmentalized and lacking in theoretical meaning.

For instance, Conners defined a belief as "a mental assent or acceptance of anything as a fact of truth on the ground of testimony or authority. It is a statement or state of affairs on the basis of which one is willing to act (p.

150)." But elsewhere in defining his categorization system, he defined beliefs as: "statements by the teachers about children and the behavior of children. These statements allude to how children learn, remember, are motivated and why they behave in certain ways in the classroom (p. 101)." The author split "beliefs statements" into the following categories: 1) general pedagogical beliefs; b) developmental beliefs; c) general beliefs concerning learning; d) beliefs concerning specific learning principles; e) beliefs concerning memory; f) beliefs concerning general psychological principles. He mentioned, however, that these were not the only beliefs teachers have, since his categorization was developed after watching only two lessons per teacher.

This micro-analysis was complemented by a more general macro-analysis that did not aim at categorizing each single verbal report. Instead, the macro-analysis was carried out by reading each transcript, segment by segment, to ferret out general meanings. Macro analysis of the transcripts did not reveal much about teacher beliefs, according to the author. It was, however, useful in revealing a number of pervasive principles that influenced the teachers classroom behavior.

Connors called one group "overreaching principles." The teachers showed that they did not have to express all their emotions overtly (principle of suppressing emotions). They also expressed a desire to behave openly, sincerely and honestly with their students (principle of authenticity). Finally, they felt the need to be fully aware of their own and their students' behavior (principle of self-monitoring). The other, pervasive group of principles uncovered by Connors related to the pedagogical aspects of teaching. Teachers who participated in the study claimed that the information gained should be related to past and future learning experiences of students (principle of cognitive linking). At the same time, they felt that new information should apply to other subject areas. They also thought that lessons needed a summary and review at their end (principle of closure). It was important for them to fully involve students in class activities (principle of general involvement) and to give fair, consistent treatment to each student (principle of equality of treatment).

Eisenhart et al. (1985) focused on the ways teachers define teaching to create complex "belief systems." The study derived its general perspective from anthropology. Belief was defined as an attitude consistently applied to a set of activities, and a belief system was defined as a set of interrelated attitudes. These belief systems were thought to be fairly consistent across individuals sharing similar circumstances, and to serve to orient and direct the preferences of those holding them.

Within this framework, the researchers designed a study to search for the interrelationships among the multiple ideas that student teachers hold about their jobs, and to see how these ideas coalesce into a widely shared system. The methodology chosen was a variation of the Repertory Grid Technique. Construction of the grid was based on activities and beliefs carefully selected from the literature. The sources consulted emphasized the complexity and interrelationship rather than the discreteness of teachers' beliefs. The purpose in developing such a belief matrix was to determine whether beliefs about teaching held by student teachers in the researchers' own institutions were consistent with those represented in the qualitative literature on teacher beliefs. The researchers and 52 student teachers completed the grid. The researchers, however, completed the matrix following criteria found in the literature review on teachers' beliefs. This represents an interesting variation in relation to other studies that used the Repertory Grid Technique as the main source of data collection.

The study uncovered beliefs that seemed to be shared by the majority of the teachers. These broke down into three clusters:

1. Beliefs related to curriculum delivery and student development (positive feelings):

• Teachers are responsible for creating a good learning environment.

• The classroom is the private domain of the teacher.

• Activities where students have visible success are the most rewarding.

• It is more important to promote student development than the transmission of particular subject matter.

2. Beliefs related to discipline and work with other teachers (mixed feelings, some responsibility):

• Sharing and cooperating with other teachers is important for support and encouragement, but not for the advice it provides.

• Teaching success is beyond the teacher's control.

• Students' success in learning is determined by outside school support.

• Teaching requires much work and has less recognition than other similar jobs.

• As a teacher, one is expected to give a lot and receive little in return.

3. Beliefs related to developing new curricula, obtaining public support and influencing student behavior outside of class (negative feelings):

• Teachers are not comfortable in the development of new curriculum materials or standardized tests.

• Non-classroom business interferes with teaching.

Cluster analysis of the grids showed that both student teachers and researchers viewed in-class instructional activities as the most rewarding and positive. Student teachers and researchers, however, did not agree on which activities were negative. For example, student teachers were consistently more negative about in and outside class activities over which they felt they had little or no control: using a required test; following time schedules; testing students' competencies.

The conclusions of the study were written in the form of recommendations for undertaking educational innovation. They suggested that teachers are likely to accept innovations which allow them to obtain more of the rewards they already value, and which diminish the impact of perceived obstacles.

Munby (1982, 1984) studied the beliefs or repertoires of understanding driving teachers' planning and class work. He saw beliefs as deep structures which cannot be easily articulated. Munby was acutely aware of the problems that arise when the researcher imposes his own meaning of beliefs to interpret teachers' behavior. The resultant teachers' beliefs are usually either too simple and obvious, or incorrect.

Munby's method was an adaptation of the repertory grid technique, which attempted to solve the deficiencies mentioned above. Two characteristics distinguish his adaptation of the Repertory Grid Technique: 1) The teacher, not the researcher, selects the activities which are most representative of her own practice. This ensures that the elements are related to teacher's own experience. 2) Once the grid is completed and factor analyzed, it is discussed with the teacher in an interview. The purpose of this is to obtain more information about emerging beliefs, and to give the teacher more opportunities to reflect on his or her own constructs and hidden beliefs. Thus the Repertory Grid Techniques stimulates the teacher's articulation of deeper levels of understanding.

The three studies reviewed here all deal with one teacher (Munby, 1982; 1984; 1986). They seek to obtain the particular knowledge of a single teacher, and to understand the uniqueness of his professional practice.

A clear evolution in the researcher's concept of teachers' beliefs can be seen throughout the studies. The first study identifies five principles (beliefs or understandings):

1. caring for the students genuinely is as important as the curriculum if not more so;

2. the conduct of teaching and learning is purposeful and mannerly;

3. learning requires considerable activity;

4. teaching and learning involve developing open and candid relationships; and

5. seventh graders are insufficiently mature to make fully valid judgments.

In the second study, Munby (1984) developed a more precise definition of beliefs. What were indistinctly defined as principles, beliefs or repertoires of understanding in the first study, are consistently called principles in the second. A belief is defined as a more encompassing and more significant concept than a principle. Beliefs drive the teacher's professional actions.

Munby used a modified version of the repertory grid technique to indentify one science teacher's principles which were labeled by the teacher in the following way (Munby, 1984, p. 36):

1. Student success at curriculum content and subsequent confidence

2. Making students think

3. "Daily life" information is important

4. Application and transfer by making factual information more real

5. Successful use of resource material

6. Group work and social learning

A more general belief seemed to explain the science teacher's actions and the above principles. He valued "helping the student cope with information" and showed "concern for students' confidence and increasing ability to handle information independently" (Munby, 1984, p. 36). The third study (Munby, 1986) represented another step towards understanding how teachers think. The author realized that teacher thinking was represented in part in teachers' language. Use of the repertory grid technique in the earlier studies had yielded discrete statements of beliefs and principles. These statements were interpreted as the teacher's attempt to put into words something which was normally unconscious.

Munby felt a more direct analysis of teachers' language could uncover new aspects of their thinking. Since metaphoric language is used in everyday life to communicate tacit knowledge, the study of teachers' metaphors presented an attractive heuristic. The study explored the utility and theoretical significance of metaphors, defined as teachers' constructions of their world. Using stimulated recall interviews and the repertory grid technique, the crucial metaphors of 5 junior high school teachers were analyzed, based on the work of Lakoff and Johnson (1980). After a long and cumbersome analysis, the metaphor "lesson as a writing object" was drawn from teacher's language. This figure was so salient in the teachers' language that it represents a significant feature of how they construct their world of teaching.

Discussion

The studies reviewed illustrate three different definitions of belief. For Conners, beliefs are certain types of teacher statements which can be fitted into a category predefined by the researcher. Eisenhart's definition of beliefs implies that they cannot be grasped through verbal reports. For her beliefs are associated with feelings. Munby conceives beliefs as more encompassing entities, that can be inferred from teachers speech. These research studies all searched for teachers' deep meanings through verbal reports. None, however, dealt with teachers' verbal classroom interactions, analysis was based on conversations and interviews with the teachers outside of the class.

Both Conners and Eisenhart assume that teachers' beliefs are easily generalizable. This assumption lies, for instance, behind Conners' efforts to fit the frequency of teachers' answers into pre-imposed categories. These researchers are more interested in the similarities than the differences in teachers' beliefs. Munby, in contrast, aims to find what is strictly personal in each teacher, what makes each teacher different from another. The review uncovered three questions.

1. Can researchers study what is not directly articulated by teachers?

2. Can researchers study teachers' beliefs without having a stable concept of belief and a well developed methodology to study the unique characteristics of each teacher?

3. Can beliefs be studied in isolation from past experience and social forces?

Perspectives: The Effect of the Social World on Teachers' Mental Worlds

The studies of teacher beliefs reviewed above approached teacher thinking in isolation. They did not attempt to identify the influence of teachers' past experiences or of social forces in shaping teacher behavior. Other studies on the socialization of teachers suffer from the same deficiency. These studies view the teacher as either completely conditioned by institutional forces (where the study centers on an institution) or molded by the past (where the study centers on biographical data).

Studies focusing narrowly on either behavior, beliefs, biography, or social forces have not been able to capture the interplay between belief and action. One reason is that dissimilar actions may be guided by the same principles or beliefs, and conversely similar actions may be guided by differing beliefs. To overcome these deficiencies some researchers have investigated teacher thinking using a symbolic interactionist approach.

Janesick (1979) defines symbolic interactionism as a process of interpretating the elements individuals encounter in their environment. In this framework, an individual is active, an actor, rather than a passive social unit merely reacting to external forces. Making sense is understood as a self-indication process. The individual immersed in a social setting points to himself, and interprets the appearances of all the surrounding social factors, noting the social demands that are made on him. By continuously self-indicating himself, the teacher develops perspectives on the social world. A perspective is integrated in a combination of beliefs and actions continuously modified by social interactions. Perspectives are conceived as dynamic, allowing individuals to adapt themselves to a changing social environment. They are also conceived as ordered, enabling individuals to see the world as predictable and stable.

Goodman (1986) adopts this framework and extends it to teaching by introducing the notion of teaching perspective. "Teaching perspectives take into account how situations within classrooms are experienced; how these situations are interpreted given the teacher's previous experiences, beliefs and assumptions and how these interpretations are manifested in behaviors (Goodman, 1986, p. 1)."

Janesick (1979) conducted a case study describing the classroom perspective of one teacher. His field work, which included participant observation and interviews with the teacher and key informants, lasted for 7 months. The study characterized the teacher's perspective by its "concern for maintaining and restoring the group." This perspective was broken down into the following five elements:

1. concern for maintaining a sense of groupness;
2. respect and cooperation as major goals;
3. planning and organizing the day;
4. the teacher as a leader; and
5. displaying a style of teaching.

Janesick identified the following context variables influencing this perspective:

1. interaction with the principal;
2. interaction with the reading center;
3. the teacher himself; and
4. interactions with the classroom teaching team.

Goodman (1986) took a developmental approach to the study of student teachers' professional perspectives. His research had two purposes: to explore the professional perspectives of student teachers; and to examine the psycho-dynamics underlying the development of these perspectives. The method used was ethnographic. Participating student teachers were observed and interviewed in seminars, while student teaching, and in other academic settings over a period of six months.

Goodman found two prevalent teaching perspectives among student teachers at the training institution: "teaching as a problem of control;" and "teaching as a facilitation of children's growth." However, he described these perspectives differently than Janesick. The categories chosen to define each perspective represent a higher level sociological concept called images. The perspective "teaching as a problem of control" included three images: cooperation; authority; and autonomy. The perspective "teaching as the facilitation of children's growth" included two images: individualization; and self concept. Perspectives are conceived as integrated in unified systems of thought and action called practical philosophies of teaching. In Goodman's study the perspectives "teaching as a problem of control" and "teaching as a facilitation of children's growth" integrated well with the practical philosophy of teaching prevalent in the institution.

The second part of Goodman's study identified student teachers' psychological difficulties in adapting their personal perspectives to those prevalent at the institution. Goodman called the first stage in this development building an intuitive screen. Student teachers brought their own perspectives to the institution, which were influenced by their early childhoods, school experiences, and their culture. This educational view acted as an intuitive screen for new ideas. The less structured these initial perspectives, the more open the students.

A second stage was characterized by conflict between the past and the present. During this phase, students acted intuitively towards new ideas. Those that contradicted their initial intuitive feelings were rejected; attractive ideas were put into practice. The lack of previous exposure and opportunity for experimentation kept the student teachers from using many new ideas.

The final stage was characterized by a thoughtful consideration of new ideas. Students engaged in a process of internal dialogue to develop a practical philosophy of teaching. Goodman sees this as a continuing process which would probably continue beyond the student teachers' graduations.

Discussion

The concept of perspective introduces the social environment into the study of teachers' understanding. Although the research studies reviewed here share similar concepts of perspective, they use them somewhat differently. Janesick studied the perspective of one teacher within a school environment, whereas Goodman traced the development of student teachers' perspectives resulting from conflict with the existing perspective held at the university. Goodman's work was more theoretical, describing perspectives in terms of well defined sociological concepts. Although these concepts were general, they explained the process of conflict in a particular institution. As Glaser (1978) argues, the essence of theoretical research in the social sciences is identifying basic social processes. These concepts, however, cannot be imposed on the data but must they emerge from them. Valuable research results can only come through a long and well-grounded process of interpretation.

Both studies identified the constituents of teachers' perspectives and their modification through interaction within schools and universities. They prove that the concepts making up teachers' mental worlds are not fixed entities, but are modified over time. However, much of how perspectives influence teachers' actions remains unclear.

Practical and Personal Knowledge: Teachers' Construction of Their Mental World

The following studies deal with the teacher's personal knowledge, developed and used in the daily practice of teaching. The literature refers to such knowledge as: practical theories (Elliot, 1976), personal philosophies

(Connelly & Clandinin, 1986), practical knowledge (Elbaz, 1981), functional knowledge (Hubermann, 1985), and intuitive knowledge (Lampert, 1986). All these studies share the belief that teachers actively construct their own knowledge, and try to do justice to this fact. Teacher knowledge is seen as directly tied to a particular teaching context. These researchers postulate a new, more dynamic relationship between teachers' actions and thoughts.

Elbaz (1981) studied the practical knowledge of a single English teacher over a period of one year. For Elbaz, practical knowledge encompasses personal knowledge of practice as well as knowledge mediated by practice. The questions the author sought to answer included: How is knowledge held? How is it used? What is its content?. The case study methodology was especially apropriate for attaining a better understanding of practical knowledge, from a teacher's point of view. Data collection was based on 5 interviews of 1 or 2 hours each, and two periods of classroom observation.

Elbaz distinguished four areas wich defined practical knowledge:

1. content (subject matter, curriculum, instruction, self and milieu of schooling);

2. orientation (situational, social, experimental, theoretical);

3. structure (rules of practice, practical principles, images); and

4. cognitive Style (the manner in which persons experienced everyday reality).

Elbaz found that teachers' practical knowledge is oriented to a particular context, rather than being a compendium of practical advice from other fields. Practical knowledge originates in teachers' specific problems, and develops through deliberation. This knowledge also has a social orientation, which explains why some teacher actions go against the norms and expectations of the immediate environment. The personal orientation of such knowledge is defined by the purposes and personal meanings of teachers' actions.

The author identified some practical rules guiding the methodical implementation of teachers' purposes. Practical principles were defined as statements enunciating the rationale of a process of deliberation. Elbaz (1981) also described the imagery in teachers' metaphorical statements about the content areas of practical knowledge. The analysis of such images pointed out the core cognitive style of the teacher. This work was one of the first to develop a theoretical representation of a teacher's mental world, which accounted for the practical nature of teachers' knowledge.

Connelly and Clandinin (1986) introduced a new method to reconstruct teachers' personal philosophies, called narrative method. Their working question was not much different from that of other researchers' reviewed in this chapter: "What is the meaning of specific classroom actions for teachers and students?" To answer this, the researchers conducted case studies of two 7th grade science teachers. They captured the teachers' ongoing classroom thinking (reflection-in-action) through intensive classroom observation, while they probed the meaning of specific teaching acts (reflection-on-action) through teacher interviews. The narrative method is essentially dialectal. The teacher and researcher work together to conceptualize the teaching philosophy espoused by the teacher. The process is best described as a reconstruction of the teacher's personal philosophy, by reordering classrooms events into a narrative form.

The researchers' first step was to begin building an understanding of teachers' actions. Data collection consisted of taking field notes, conducting formal, open-ended interviews focusing on practices noticed during field work, and writing narrative accounts based on these field notes and interviews. Next, the researchers discussed these narrative accounts with the teachers, and modified the narratives based on the teachers' reflection-on-action. Through the repetition of these two steps, teacher and researcher constructed a personal philosophy deeply grounded in the teacher's experience, in its full historical dimensions.

The narratives developed around central themes selected by the teachers, such as "copying science notes" or forget the fancy technical terms." They included quotations from interviews, classroom interactions, and researcher comments. From these, the researcher identified the crucial elements in the teacher's personal philosophy. For example, the researcher defined one teacher's conception of the role of schooling in society as follows:

> "Schooling, in a sense, contradicts the student's environment, for example, by inculcating the values of cooperative effort when the students need individualism to cope with their natural environment. The children in the area are excluded from middle class jobs and therefore lack the opportunity to 'graduate their way up in the system' (Connelly & Clandinin, 1986, p. 1)."

The personal philosophy of another teacher was summarized as follows:

> "He places his own experience, his biography, at the center of his teaching and that by using continual references to his own origins, development, successes (and a failure in high school), he weaves a zig-zag pattern of connection between students, community, school, language, science subject matter and personal experience. From the point of view of science teaching, science is both of little importance in itself and everything (ibid., p. 15)."

Science was here an expression of the teacher's personal philosophy, and a language to prepare students for the transition from school to the work force.

Lampert (1986) participated in project "Teacher-as-researcher," done at the Division for Study and Research in Education at M.I.T. For a period of two years, cognitive psychologists and elementary teachers worked together to accomplish the following goals: make teachers aware of their intuitive knowledge about the world, and its difference from formal knowledge; explore whether an appreciation of this own intuitive knowledge could help teachers help children to connect their intuitions and their formal knowledge.

Teachers and researchers met once a week, to develop awareness of their own ultimate knowledge through group discussion. As the teachers were trained as teacher-researchers, they developed a dichotomous style of looking at classroom practice. The distinction between intuitive and formal knowledge was illustrated by means of practical dilemmas. These allowed teachers to understand students' problems in terms of a confrontation between their intuitive ideas and the formal ideas of the curriculum. This conflict, discovered as an explanation of students' learning problems, developed into a conflict between the teachers' own understandings and institutional expectations. Teachers started analyzing their work, and found contradictory responsibilities. They felt unable to meet both the students' needs for understanding, and institutional and social expectations. Consequently, teachers felt frustrated playing the roles of both teacher and "teacher-researcher." Although upon reflection the teachers saw daunting conflicts, they were able to manage these conflicts in practice. Researchers observed a clear difference between teachers' thinking about teaching and teachers teaching. Teachers showed special, practical techniques of managing unresolvable tensions, despite their feelings of helplesness articulated in group discussions. Lampert explained this in terms of teachers lacking an appropriate language of practice. But researchers in the MIT project introduced concepts and language which did not come from the teachers' language of practice. Unless researchers pay closer attention to the practical language of teachers, little can be learned about how they to teach. A final work reviewed here is the Ford Teaching Project in England. Elliot (1976) directed a program of action research to help teachers implementing inquiry/discovery approaches in classrooms. Researchers started the project assuming that changes in classroom practice occur only if teachers become conscious of the guiding principles of innovations. A lateral outcome of inducing teacher awareness was the teachers' construction of their own practical theories. Although Elliot's project was not specifically designed to identify teachers' practical theories, it provided an alternative way to study them.

The first phase of the project was designed to induce awareness in teachers. Teachers were led to reflect on their own practice. This was done through discussion of video-tapes, transcripts and tape-slides of other teachers at work. Discussions quickly showed the need to eliminate confusion and misunderstandings by creating a common language among teachers. Since discussions centered around problems related to innovation, all the terms used by the teachers related to the discovery/inquiry approach to teaching. Words most often used were 'formal-informal,' 'structured-unstructured,' 'framework,' 'teacher directed,' 'self-directed,' 'guided,' 'open-ended,' 'dependent-independent,' and 'subject centered-child centered.'

Teachers discussed these terms with the aim of reaching agreement on their meanings. Although final agreement was not possible, researchers isolated three dimensions of meaning:

1. formal-informal or dependent-independent (the degree of intellectual dependence of teachers and students);

2. structured-unstructured or subject-centered/ child-centered (helping students achieve preconceived knowledge outcomes); and

3. direct-guided/open-ended (the implementation methods used by the teacher).

Further discussion made clear that these dimensions were related to create what could be called practical theories. Teachers connected these concepts in different ways, to form their own practical theories on the discover/inquiry approach to teaching. The following associations were elicited from the participants:

- Open-Ended
- Unstructured --------
- Guided
Informal --------
- Open-Ended
- Structured ----------
- Guided

Formal ----------- Structured ----------- Directed

Teachers' values determined the meanings of these various associations: "theories of teachers are not value-free and they imply practical judgments about what ought to be done (Elliot, 1976, p. 22)." The researchers conclude the first phase of this study with the observation that if theory development is to have any practical significance, it must be rooted in conceptualizations arising out of teachers' practical deliberations. These conceptualizations constitute practical theories, which are value-laden and contextually bounded.

Discussion

Although all four studies reviewed in this section deal with teachers' personal and practical knowledge, Elbaz's study differs considerably from the other three. The categories she uses to describe teachers' mental worlds are research generated and imposed on the teachers' own language. In contrast, the studies of Connelly & Clandinin (1986), Lampert (1986), and Elliot (1976) develop joint representations of teachers' mental worlds, constructed by both teachers and researchers. Elbaz's study appears to have the underlying assumption that teachers' practical knowledge is an external reality, which can be better captured by the researcher's more precise, appropriate concepts. The representation of teachers' mental worlds is solely the responsibility of the researcher.

The remaining studies assume that teachers' personal and practical knowledge is a socially constructed reality. Their approaches better represent teachers' mental worlds, by utilizing teacher-researcher discourse. This discourse was constituted through a dialogue of personal narratives (Connelly & Clandinin, 1986), through group discussion of the implementation of an educational project (Elliot, 1976) or through discussion of childrens' understanding (Lampert, 1986). Under these approaches, the representation of teachers' mental worlds is the responsibility of both teachers and researchers.

CONCLUSIONS

The first part of this review summarized the main research methodologies used to study teachers' implicit theories, beliefs and knowledge. It concluded with the suggestion that multimodal research methodology is the best way to capture teacher thinking.

Recent methodological criticisms (Smith, 1985; 1988), however, and developments in radical constructivism (von Glasersfeld, 1984; 1987) suggest another way to approach knowledge construction within educational research. This new approach would not assume that reality is out there, waiting to be discovered, but rather that it is constructed through purposive human interaction (in this case, interactions between researchers and teachers). This makes the researcher/teacher relationship of foremost importance.

From this point of view, the results of research on teachers' implicit theories, beliefs and knowledge represent researchers' mental constructions of teachers' mental constructions of educational situations. Research methodologies that enhance communication between teachers and researchers will provide an optimum context for the construction of both researcher's and teacher's mental representations, and consequently increase the validity of research results.

The second part of this review summarized selected studies of teachers' thinking. These studies were presented in thematic rather than chronological order. The first group dealt with the identification of teachers' beliefs about teaching. They attempted to capture the innermost nature of teachers' mental worlds. Although researchers conceived teachers' beliefs as difficult to articulate and encompassing varied areas of experience, they still attempted the almost impossible task of capturing the evasive nature of these mental entities. This line of research ran into several problems including: a lack of agreement on conceptual definitions among researchers; difficulty in finding methodologies able to capture the inner nature of the beliefs behind the teachers' words; and a meager theoretical understanding of the relationship between teachers' beliefs and actions.

A second group of studies investigated teachers' perspectives. These studies used more dynamic constructs to represent teachers' mental worlds. The concept of perspective was postulated to account for the influence of social interaction on teacher thought. This construct represented a conceptual advancement over the concept of belief, by introducing action into the theoretical framework. With the use of perspective, the representation of teachers' mental world expands to include social action.

Studies of teachers' beliefs and of teachers' perspectives both assumed that these representations of teachers' mental worlds exist in teachers' minds. The conceived role of the researcher is that of identifying these mental entities. Further research should include other conceptual entities to represent teachers' mental worlds, such as personal biography, and emotional and personality variables; and explore the dynamic aspects of the construction of teachers' mental worlds, using longitudinal designs or cognitive developmental frameworks.

The third group of studies reviewed dealt with teachers' personal and practical knowledge. These studies assumed that representations of teachers' mental worlds must be created by the teachers themselves, if they are to have any value. Thus, research results emanate from teachers and researchers jointly creating meaning through interaction. While teachers know their own classroom practices, researchers develop knowledge about teachers. In this framework educational research is conceived as a double inquiry. Teacher inquiry is first order action research, researcher inquiry is second order action research (Elliot, 1988). Suggestions for future research using this approach include: developing a deeper understanding of teachers' processes of inquiry, and identifying the optimal contexts for its occurence; exploring the interactive dynamics of mutual agreement between researchers and teachers; and identifying the changes in classroom teaching that occur as a consequence of first order and second order action research. These research suggestions are more methodological than substantive, illustrating the importance given to self inquiry and communication as guides to educational research.

CHAPTER 3

ACTION, THOUGHT, AND INTERACTION ACROSS SOME LOGICAL, PHILOSOPHICAL, PSYCHOLOGICAL AND SOCIAL PSYCHOLOGICAL APPROACHES

INTRODUCTION

The study of teachers' thought processes has been acknowledged by the community of educational researchers as an already well established area of research, notably in the third Handbook of Research on Teaching (Wittrock, 1986). This field can be divided into three areas: planning (pre and post-active), interactive thinking (during teaching), and implicit theories, beliefs, and knowledge. The first two areas deal with the description of teachers' thought processes, whereas the last one deals with the representation of teachers' conceptual entities. Teacher thinking research assumes that teachers' thought processes, implicit theories, beliefs, and knowledge influence the action of teaching (Clark & Peterson, 1986). However, the conceptualization of this relationship is still under scrutiny. Recent research has started to explore the relationship between teachers' thought processes and teaching performance in terms of students' outcomes (Carpenter, Fennema, Peterson, & Carey, 1987; Peterson, 1988). These studies used the correlational approach to the identification of a relationship between teachers' thought processes and the effects of teachers' actions. However, they did not provide a conceptualization of the relationship between thought and action. Attempts at providing a conceptualization of the relationship between teachers' thought processes and action are to be found in recent investigations and theoretical studies within the fields of implicit theories, beliefs and knowledge, and interactive thinking.

A comparison of research on teachers' interactive thinking and research on their implicit theories, beliefs, and knowledge, reveals common trends. In Chapter 1, I reviewed the development of research on teachers' implicit theories and beliefs and showed that researchers have begun to introduce action into their representations of the teacher's mental world. Researchers are switching from a static and propostional towards a dynamic and context bound representation of teachers' mental entities. This switch reveals a genuine concern to link teachers' representations of the external world with the conditions and actions involved in the formation of these representations. The assumption that thought can be studied and represented separately from action and environment has begun to be questioned.

A parallel development can be detected within the area of interactive thinking. Yinger (1986, 1987a) has reviewed the most influential conceptions of interactive thinking in teaching. Researchers have used various metaphors to conceptualize the types of thinking that might be going on in teaching: teacher as decision-maker (Peterson & Clark, 1978; Shulman & Elstein, 1975), teacher as manager (discussed in Yinger, 1986), (c) teacher as choreographer (Leinhardt, 1987), (d) teacher as improviser (Yinger, 1987a), and (e) teacher as professional (Schon, 1983, 1987; Yinger, 1986). These metaphors support different conceptions of the relationship between thought and action during teaching.

The teacher as decision-maker metaphor implies that teachers follow a preestablished plan for action. Quick and on-the-spot decisions are made when problems arise. Researchers found that teachers engage in analytical decision making every two minutes while teaching.

The metaphor of the teacher as manager implies that teachers design paths of action, appropriately organize knowledge and technical skills in order to accomplish their goals, and make rational decisions when problems arise. Both these and the earlier metaphor highlight the more rational and analytical aspects of teaching. They also assume that action needs to be planned and justified every time it is performed.

The metaphor of teacher as choreographer introduces the concept of routines, as segments of behavior with specific aims and means attached to them. Routines can be connected to form more encompassing entities called scripts. The teacher as choreographer metaphor implies that the teacher is following plans of actions embebdded within scripts. In contrast with the metaphor of teacher as manager, the teacher's action has not been consciously designed. Instead, it has been drawn from his mind in response to external cues from the environment. Routines and scripts might account for the lack of conscious planning found in expert teachers.

The metaphor of teacher as improviser introduces new and provocative relationships between teachers' thought and action. "The distinctive feature of improvisational action is that it is composed during and in response to action. A performance is composed of patterns providing pathways for action. A pathway is not something to be followed but to be traversed and explored. A course of action is not followed but constructed (Yinger, 1987a, p. 72)."

This notion of improvisation recognizes the non-deterministic and constructive features of a teacher's action. Teaching, on this view, is constructed in-situ based on a sort of pattern combination which provides a general framework. These patterns of performance and interaction are constituted by an integration of thought and action. The specificity of the environment provides a general distinctive form for the patterns. The improvisation metaphor acknowledges the interactive nature of teaching. Each pattern expresses the relationship between a context, a problem, and a solution.

The teaching as improvisation metaphor reveals similarities between language construction and teaching. Patterns are organized into wider patterns, like words into sentences. They constitute what Yinger calls "the language of practice (Yinger, 1987b)." Much needs to be done to provide a clear idea of the structure of these patterns and the ways they are constructed at the external and mental levels. Yinger (1987a) is very careful in asserting that improvisation cannot explain all teachers do. However, the improvisation metaphor accounts for the unpredictable, immediate, fluctuating, and interactive aspects of teaching.

The metaphor of teacher as professional would provide a more eclectic image of the relationship between thought and action in teaching. Teaching is a complex action which involves many different kinds of psychological and social processes, including problem solving, decision making, planning, theorizing, and improvising.

In sum, research on teacher thinking seems to converge towards a common ground. This is the recognition that action and thought should be conceptualized together and be related to the specificity of the environment. Researchers are exploring new notions which would account for the unity between action, thought and interaction in teaching. The static, propositional, isolated and deterministic views of teachers' knowledge and action are being replaced by more dynamic, holistic, integrative and constructive views.

The concern for the conceptualization of the relationship between thought and action is certainly not new. It is not an oversimplification to state that it has been, and remains, the essential problem of the social sciences, psychology and philosophy. These disciplines deal with different, albeit complementary, aspects of the relationship between thought, action and interaction within very different theoretical frameworks. Some consist of truly complex systems of interrelated concepts (i.e. Piaget's theory of intellectual development), others are more specialized (i.e. symbolic interactionism, practical reasoning). A review of the most influential theories of action from different fields in the social sciences would provide the essential elements to be included in a conceptualization of the relationship between action and thought in teaching.

PURPOSE

The present paper reviews theories of action from the fields of logic and philosophy (Practical Reasoning & John Dewey's Philosophy of Inquiry), psychology (Soviet Theory of Activity & Genevan Constructivism), and social and organizational psychology (Symbolic Interactionism, & Action Science/Reflection). The first purpose of this review is to summarize the most relevant constributions of these theories to the following three themes: their description of action, their understanding of the relationship between action and thought, and their account of the role of interaction in action. The second purpose of this review is to synthesize the contributions of these theories of action across the three themes mentioned above. This review has been written from the perspective of an eclectic research practitioner (Schwab, 1978) whose aim is to understand the most important aspects involved in the act of teaching. Table 3-1 provides a summary of the main concepts drawn from each approach.

LOGICAL AND PHILOSOPHICAL APPROACHES TO ACTION

The logical and philosophical approaches reviewed here have not been validated through an empirical follow up. However, they have inspired some research studies on problem solving and inquiry. Both Gauthier's practical reasoning (1963) and Dewey's theory of inquiry (1933, 1938) were grounded upon concern for what constitutes good action. Gauthier's work represents action as a rational approach for overcoming uncertainties. The best actions are based on practical reasoning or decision making about competing goals or alternative courses of action. On the other hand, Dewey's theory of action introduces the notion of the dynamic construction of both actions and problems. Uncertainty is not resolved through the exercise of rationality, but through the exercise of inquiry. The best action is constructed through a process of refinement and clarification of both actions and facts. In the following, both theories' description of action, of the relationship

Table 3-1

Action, Thought, and Social Interaction Within Several Approaches to Action

Approaches	Action	Mental Unit	Action & Thought	Social Interaction
Practical Reasoning	Practical problem solving	-	-	Discourse
Dewey's Theory of Inquiry	Inquiry	Knowledge	-	-
Soviet Theory of Activity	Activity	Activity	Internalization	Mediation
Genevan Constructivism	Self-regulation mechanisms	Action schemata Theory in action Operation	Abstraction mechanisms	-
Symbolic Interactionism	Act	Perspective	Interpretation	Social interaction
Action Science	Reflection in/on action	Frame	Framing	Aprenticeship

between action and thought, and of the role of interaction in action are discussed.

Practical Reasoning

Description of Action: Practical Problem Solving

Work done in the field of logic on practical reasoning has important implications for the understanding of the elements involved into the process of acting.

Logic has been mostly concerned with a formal way of defending the truth of statements about the world, and especially with the process of reasoning from premises to conclusions. Toulmin, in his influential book The Uses of Argument, suggested a new approach to logic, focusing on the soundness rather than the truth of the claims human beings make. Reasoning would then be concerned with the solidity and firmness of the information provided to defend a particular case. "Logic (we may say) is generalized jurisprudence" (Toulmin, 1964, p. 7).

Practical reasoning is part of a process of dealing with practical problems. A practical problem is a problem about what to do, emerging out of a concrete situation. The solution to a practical problem is the performance of an action in a specified situation. The process of acting out of a practical problematic situation has the following phases: (a) Feeling uncomfortable; (b) Practical reasoning; (c) Decision making; and (d) Acting (Gauthier, 1963).

Feeling Uncomfortable

The subject feels uncomfortable because of the uncertainty of the situation he or she is in. A practical question emerges in terms of what to do.

Practical Reasoning

Following a practical question comes its answer. The answers to practical questions are practical judgements. Attached to these actions are value statements. Practical judgements are hypothetical actions which deserve consideration for the value they are believed to have. Practical reasoning consists in showing that an action fits a specific context. The purpose of practical reasoning is to generate practical judgements.

Aristotle called this phase of acting deliberation. "We deliberate about things in which our agency operates but does not always produce the same results... "It follows that we do not deliberate about ends but about means. Nor yet do we deliberate about particular facts (Aristotle, 1962, pp. 137, 139)."

Gauthier differs from Aristotle, claiming that men also reasons about goals. Action is guided by different and sometimes conflicting goals. Practical reasoning involves not only consideration of means but also consideration of ends.

Decision Making

An answer to a practical problem (that is, a practical judgement), does not imply a resolution to act. After the generation of different practical judgements, the subject makes a resolution to act by deciding among different alternatives. Decision making generates resolutions to act.

Acting

Once a resolution has been made, the subject engages in action within the concrete situation. Attempting an action can generate procedural problems about how to implement it. Although procedural problems are acknowledged by Gauthier, they are not the object of his inquiry since they do not require practical reasoning. This contrasts with Aristotle, who asserts that deliberation deals with ways to use the means. "In practicing an art, the question is at one moment what tools to use, and at another how to use them; and similarly in other spheres, we have to consider sometimes what means to employ, and sometimes how exactly any given means are to be employed (Aristotle, 1962, p. 139)."

Gauthier has correctly pointed out some characteristics of the process of acting out of practical problematic situations. But despite his identification of these four different phases, I believe successful solutions to practical problems might occur without practical reasoning or decision making. Practical judgements, resolutions, and solutions might be stated and performed without any previous consideration. Moreover, even if practical reasoning and decision making took place, subsequent actions might have nothing to do with them. This poses the question of "practical inference." Is there one clear, predictable way to infer answers to practical questions, or solutions in practical decision-making? What is the role played by logic? Gauthier argues that action is essentially an uncertain enterprise:

> "One can never demonstrate a practical conclusion unless one can predict, with full certainty, all of the consequences of all the actions open to the agent, and specify the agent's entire basis of action, his wants present and future, and the relative desirability of their objects. The sphere of the practical is the sphere of the uncertain (Gauthier, 1963, p. 49)."

Action and Thought

These studies of practical reasoning do not deal with problems of thought and knowledge. They are mostly concerned with ways to justify action within discourse; that is, within verbal interaction.

Interaction: Practical Reasoning in Discourse

The role of interaction in resolving practical problems becomes fundamental at the moment of practical reasoning. Discourse is the traditional setting for practical reasoning. Within discourse, people attempt to support, prove, explain or make probable particular action statements. These arguments try to convince, persuade, secure approval and so on. Practical reasoning has the underlying purpose of producing agreement about the best course of action within an interactive environment. However, the problem still remains of what constitutes a good action.

Both Gauthier and Toulmin suggest the model of jurisprudence to determine the adequacy of an action. Through talking (discourse), actions are supported, assessed, or justified. In doing so, the agent makes practical arguments. Practical arguments contain statements supporting, proving, explaining, or making probable what is said in other statements (Thomas, 1986). There is no clear and straight way to action. The most desirable action, given some particular ends, will be that which has the strongest and most solidly defensible practical arguments.

> "In general, a practical argument is satisfactory if the arguer takes reasonable care to determine the sufficiency of the basis, recognizing that to presume to know the agent's future history, whether the agent be himself or another, is absurd. If reflection does not suggest the presence or probable future presence of wants as sufficiently compelling to over-ride those considered, if the situation in which the action must be performed is carefully assessed, if the consequences of the more promising actions are examined, then it is probable that the action proposed in the consequent judgement will be the most desirable one for the agent to perform (Gauthier, 1963, p. 49)."

The need for practical reasoning emerges in an interactive context. Practical reasoning occurs when people try to agree about what constitutes a good action. Practical reasoning provides standards to determine the worth of an action before its performance. Actions can also be evaluated based on the changes they were intended to bring about. "To act is intentionally to bring about or to prevent change in the world...A change is a transformation of states. A change takes place when a state of affairs ceases to be or comes to be (Von Wright, 1967, p. 121)."

The empirical validation of actions is not contemplated within practical problem solving. Although Gauthier has pointed out the uncertainty involved in action, he has not studied the role played by empirical validation. Practical problem solving provides a detailed account of the rational processes that occur before an action is performed. Dewey's theory of inquiry will provide some insight into the dynamic nature of experimenting in action within the process of inquiry.

Philosophy of Inquiry: John Dewey

Dewey's contribution to the understanding of inquiry was motivated by the need to find a new approach to logic which was not based on formal and mathematical rules. Instead, he stressed the need to support the truth of statements about the world within the process of inquiry generating them. Since each discipline produces statements about the world through a process of inquiry, logic should be the study of patterns of inquiry across disciplines. A theory of logic should be a theory of inquiry (Dewey, 1938). Dewey's approach to logic used a different metaphor than Toulmin (1964). Whereas Toulmin used the metaphor of jurisprudence, Dewey used the experimental metaphor of inquiry. Toulmin recognized the role of social interaction and discourse with the production of statements about the world; Dewey supported empiricism as a way to validate knowledge. Although Dewey justified his work on logical and philosophical grounds, the present review focuses on his insights into inquiry.

Description of Action: Patterns of Inquiry

Dewey (1933, 1938) distinguished the process of inquiry from that of reflective activity. The phases he suggested as constituents of inquiry, however, were very similar to those of reflective activity. Given this similarity, inquiry and reflective activity are here blended and presented as a unified system.

Pre-reflective Activity

The indeterminate situation. The pre-reflective phase is constituted by a perplexed feeling in the inquirer; a doubtful, confused state out of which the problem might arise. Dewey attributed the cause of disturbing feelings to the situation rather than to the subject: "It is the situation that has these traits. We are doubtful because the situation is inherently doubtful (Dewey, 1938, p. 105)." These indeterminate situations invoke inquiry through the questioning.

Suggestion: Go ahead. Human beings naturally act their way out of perplexing situations. They respond to troubling states with an idea for action. It is an impulsive reaction which is in agreement with Mead's first stage of the act: Impulse.

Reflective Activity

The reflective activity is constituted by five different phases which do not present themselves in any one order. Dewey called them functions of thought as well.

Intellectualization. What was first an emotional state of perplexity or confusion gets intellectualized. The indetermined situation is transformed, through intellectualization, into a problem. This is done by stopping the natural flow of action and noting the conditions causing the trouble. The actor focuses his thinking and identifies some aspects of the situation as relevant. By focusing on selected aspects of the situation, the problem gets formulated.

Guiding idea or hypothesis. The guiding idea or hypothesis constitutes the transformation of the first impulse or suggestion into a controlled idea under the circumstance of the problem. Hypotheses are first vague and undefined and only later become more precise. The hypothesis guides the collection of new information, which in turn redefines the hypothesis. Hypotheses are possible actions which might have desired consequences.

Reasoning. Reasoning connects ideas and their consequences. In doing so, new elements are discovered. "The development of an idea through reasoning helps supply intervening or intermediate terms which link together to a consistent whole elements that at first seemingly conflict with each other, some leading the mind to one inference and others to an opposed one" (Dewey, 1933, p. 112).

Different cognitive activities contribute to reasoning: symbolization (putting the idea into words), focusing (selecting some aspects of phenomena); clarification (rejecting irrelevant details), meaning creation (relating the idea to other experiences, through discourse), understanding (foreseeing the mechanism for reaching the desired solution). In contrast to more formal, logical approaches to reasoning, Dewey conceptualized reasoning as a dynamic process. Through reasoning, ideas are not only supported, but also developed into forms very different from their original.

Testing hypotheses by action. Testing a hypothesis by action gives the subject experimental corroboration for a conjectural idea. Putting ideas into operation provides the subject with a higher degree of certainty. Reasoning also provides certainty about actions, but of a different kind. While reasoning attaches meaning and social justification to actions, testing proves their empirical adequacy.

Post-reflective Activity

The post-reflective activity is characterized by feelings of satisfaction, mastery, or enjoyment. The trouble has been resolved and a new equilibrium attained. However, Dewey sees inquiry as a continuous activity with no final end. Since inquiry involves changing the conditions of the environment, it creates new situations which occasion new problems.

Action and Thought: A Serial Process

Dewey's approach to human inquiry recognizes the ambivalent nature of action. Actions not only attempt to reach goals or bring about specific changes within the environment. Actions also serve the purpose of collecting information about the environment, in the form of facts. Inquiry seems to involve the search for the best actions as well as for the best facts. Human beings construct both actions and representations of phenomena through the process of inquiry. Ideas or hypotheses guide actions, which in turn modify the environment, leading towards new observations. Dewey describes the relationship between ideas and observations as a serial process (Dewey, 1938). Ideas guide actions which instigate new observations and therefore new facts. Facts lead towards more ideas. Some observed facts point to an idea that stands for a possible solution. This idea leads to more observations which, together with the original observations constitute a new whole. This suggests new sets of observations, and so on.

The ambivalent nature of action points toward a general hypothesis of how action contributes to the development of knowledge about the world. Testing the adequacy of an action provides elements that help constitute our representation of the world. Each action changes both the environment and our the perception of it. Action and knowledge are in constant evolution.

Dewey himself did not develop a model for the mental representation of the world which fully included the role of actions. Although he recognized the important role played by actions within the construction of reality, he did not introduce action as one element within the representation. Action was conceived as a means towards the construction of the representation of the world.

Interaction

Although Dewey recognized the role of interaction within human inquiry, he did not dwell on it. In common with the logical approach to practical reasoning discussed earlier, Dewey's approach to human inquiry included social interactions, particularly at the stage of defining the consequences of actions. However, it is not clear how he saw these social interactions influencing the processes of group and individual inquiry.

Summary

Practical problem solving provides a picture of action as a rational process of making practical judgements and decisions about the best goals and courses of action. Practical reasoning and decision making take place under the assumption that goals and actions are well defined and available to the subject. Although this picture of action is reasonable, it certainly does not fully represent the conditions under which actions are undertaken. In fact, actions can be undertaken without a clear definition of their goals or course.

Dewey pictures action as a process of constant refinement and increasing precision. Actions, goals and knowledge about the external world are clarified through inquiry. Reasoning is not only a process of providing sound judgements for action, but a process of mentally exploring the consequences of possible actions. In Dewey's theory, the notion of action expands. Action not only pursues goals, but provides information about the external world. Action is a means for changing as well as learning about the world. It is precisely this dual character of action that allows us to judge its adequacy.

The relationship between action and thought was not well explored within either of these approaches. This is not surprising, given their philosophical bias. Dewey's theory of inquiry dealt with the problem of knowledge construction through inquiry. However, his writings show a strong belief in the existence of an external reality constituted by facts. Inquiry is the process of discovering these facts. In this sense, action is a means of getting facts, and hence knowledge. Consequently action is not embedded within the representation of the world, and knowledge appears to be a static collection of discovered facts about the world.

The psychological approaches presented below provide a stronger emphasis on the conceptualization of mental units and their relationship to action. This is, after all, the basic purpose of psychological theory.

PSYCHOLOGICAL APPROACHES TO ACTION

Two psychological approaches to action are reviewed, the Soviet Theory of Activity, and Genevan Constructivist psychology. These psychological approaches expand and enrich our understanding of action in two areas: (a) their consideration of mental units; and (b) their recognition of the changing aspects of action and of mental units, and of their mutual relationship within the life of an individual. In contrast to the logical and philosophical approaches to action, these psychological approaches place the actual mental world of human beings solidly within their theoretical frameworks. Moreover, change is at the core of their descriptions of action. As Vygotsky puts it, "It is only in movement that a body shows what it is (Vygotsky, 1978, p. 65)." Actions, mental units, and their relationship are described with an understanding of the directionality of their development.

This review focuses on the following partial aspects of these psychological approaches: the description of action; the relationship between action and thought; and the role of interaction in action.

Soviet Theory of Activity

Structure of Action: Activity

The description of the structure of action is based on a functional analysis of its constituents. This functional analysis has been extensively developed within the Soviet Union (Vygotsky, 1978; Leontev, 1972/1981). This school views activity as the necessary starting point or basic unit of any study of human conduct. "The real function of this unit (activity) is to orient the subject in the world of objects. In other words, activity is not a reaction or aggregate of reactions but a system with its own structure, its own internal transformations, and its own development (Leontev, 1972/1981, p. 46)."

The structure of activity is determined by the different functions it seeks to fulfill. The broadest function of an action is determined by the subjects motives and objectives. At the same time, activities are a composite of actions which together allow the person to fulfill her motives. An action's function is determined by the subject's goals; goals are the conscious ends of actions. Actions are accomplished through operations. The function of an operation is determined by the conditions under which it is carried out. Operations are usually activated automatically. Therefore, activity is conceived as a complex system guided by different functions, all of them related to the intentions and cognition of the subject.

ACTION	FUNCTION
Activity	Motive or object
Action	Goal
Operation	External conditions

The theory of activity explains the apparent lack of motivation in some activities. Leontev pointed out that an activity without an apparent motive is not necessarily unmotivated. Rather, the motive has been subjectively or objectively concealed (Leontev, 1972/1981).

The distinction between motives and goals has been questioned by the Rubinshtein group (Brushlinskii, 1987). They argue that motives and goals can be used by people to guide both activities and actions. In analyzing the nature of motives and goals, the group saw that goals could be quite general and motives very concrete. Their criticism did not seek to eliminate the unit of activity, but to flesh out the simplicity of the concept with diversity and detail. The theory of activity developed by Vygotsky and Leontev introduced the important insight that behavior is an empty concept if it is not linked to intentionality. When a human being acts, he or she seeks to fulfill different functions, with varying degrees of awareness.

Interaction: Mediation

Interaction is included in the theory of activity through the concept of mediation. Activity is mediated by the use of tools or instruments. These tools, which can be objects, actions, or processes, are first encountered or provided by the environment. Tools are then socially derived. Through social interaction, activity develops.

The concept of mediation was thought essential for understanding the relationship between cognition and culture. However, not all mediated interactions were considered successful in fostering development. Only those at the zone of proximal development could be integrated by the individual into his own intellectual repertoire (Vygotsky, 1978). The concept of the zone of proximal development introduced limitations in the types of actions which might eventually become part of each indivdual's cognitive system.

The notion of mediated activity provided the guiding framework for experimental work by the soviet school. Researchers recognized that they interacted with their subjects by providing them the tools necessary for the development of activity.

Action and Thought: Internalization

The bridge between external action and internal thought is understood through the concept of internalization. Within the life of an individual, activity is at first purely external, and only later acquires an internal mental component. Internalization is then the transformation of external activity to mental activity.

Leontev faced the problem of conceptualizing mental activity. He was confronted with three options: (a) the structure of mental activity had nothing to do with the structure of external activity. In that case the work of psychology was impossible; (b) the structure of mental activity was the same as that of external activity. In that case the work of psychology was meaningless; and (c) mental and external activity shared a similar structure. External activity underwent specific transformations (generalizations, verbalizations, abbreviations, extensions) during the transition to mental activity.

Leontev chose this third option. "To me the discovery of this common structure represents one of the most important discoveries in modern psychology. Internal activity, which has arisen out of external, practical activity, is not separated from it and does not rise above it; rather it retains its fundamental and two-way connection with it (Leontev, 1972/1981, p. 58)."

The essential cognitive unit for the study of human cognition was activity. This mental unit was composed not only of actions, but also of motives and goals. The origin of activity lay in social mediation processes which transferred culture-specific cognitive tools.

The Soviet Theory of Activity represents one attempt to study the social mechanisms that guide human action and thought. In contrast, the Genevan Constructivist psychology emphasizes the relation between the subject and his environment, without specific consideration of social interaction.

Genevan Constructivist Psychology

Piaget's work at the beginning of the Genevan constructivist movement dealt primarily with the development of cognitive structures, as they emerged through the subject's interaction with the environment. Later Piaget's interest shifted towards the study of the transformative mechanisms linking action and thought. His studies of the relationship between action and thought are deep and insightful contributions to this crucial issue.

> "The combined lights of history, prehistory and ethnography do not suffice to solve the important problem of the relationship between action and thought, and their findings must be complemented with psychogenetic analysis of data...to reconcile the affiliation of "knowing" to "doing" with their qualitative differences, we must lay hold of the underlying transformative mechanisms, and this is precisely what psychogenetic studies can help us to do, whereas history or anthropology can only throw light on the succession of, or differences in, level (Piaget, 1974/1978, p. V)."

Description of Action: Self-regulatory Mechanisms

Actions lie at the origin of thought. Genevan constructivist psychologists chose to study the development of action and thought within an experimental setting of goal-directed actions or problematic environments. Researchers provided the general goal as well as the task environment to subjects under investigation. Subjects engaged in action in order to reach a goal or solve a problem. Goal-oriented actions were conceived as cyclical processes which could remain unfinished. The following are idealized phases subjects pass through in undertaking goal-directed actions within a problem environment. They are a blend drawn from the work of Genevan psychologists Piaget (1974/76), Cellérier (1983), and Karmiloff-Smith & Inhelder (1975).

Acting

Subjects first act in order to reach a goal or solve a practical problem. The perception of the results of the action determines its success. If the action is successful, the problem is solved. If the action leads to failure, self-regulating mechanisms come into play.

Self-regulating Mechanisms

If the action is unsuccessful, the subject engages in a sequence of new corrective goal-directed actions. Such sequences are called self-regulatory mechanisms. They correct actions, in order to reach desired goals or states. There are three different types of self-regulatory mechanisms:

1. Autonomous or Automatic regulation mechanisms are unconscious adjustments of actions, usually related to motor activities. Different actions are tried without a clear awareness of their specific nature. Automatic regulatory mechanisms finish when the subject finds the actions that help her reach the desired goal.

2. Subjects using active regulatory mechanisms focus on undesired results and the means to attain desired results, rather than just the desired goal. This shift of attention towards the action itself and the result accomplished by it represents a new level of cognizance. It also represents the beginning of differentiation between the subject (action) and the object (observation). Subjects appear to engage in exploration as if they were developing a catalogue of actions which produce different results upon various objects.

At a further stage, subjects evoke or construct assimilatory schemes, models, theories, analogies, or metaphors. Cellérier describes these cognitive entities as: "preconstructed telic sensori-motor entities that not only specify an interpretation (a 'description') of 'reality' but also contain finalized pragmatic prescriptions for modifying it in ways that are desirable within this interpretation (Cellérier, 1983, p. 151)."

These cognitive entities act as "theories in action (Karmiloff-Smith & Inhelder, 1975)." They are usually very robust and resistant to change. They guide action, and determine which observations are to count as valid. Counter-examples are seldom considered. If counter-examples are experienced often, however, a new and parallel theory explaining these and related aspects may be developed. The creation of a new theory in action implies the cognizance of new properties of objects.

Finally, one formal way to improve on this cyclical regulatory mechanism involves unifying theories or models. Such unification links theories in one system. The subject sees structural similarities underlying various theories. He constructs a cognitive invariance through comparison of different models. Linking several theories in action in one unified system allows the subject to predict results and therefore solve problems.

3. Finally using Conscious regulation mechanisms, the subject formulates hypotheses and tests them via imaginary confirmatory evidence. This mental process occurs at the conscious level. Consciousness eliminates the need to test hypotheses actively. Problems can be solved or goals attained when the subject has mentally ruled out all apparent relevant actions.

Acting Successfully

As stated earlier, the first thing subjects do when faced with a practical problem or a goal oriented task, is to act. If their action succeeds, the practical problem is solved. However, the three kinds of self-regulatory mechanisms identified suggest that practical success might vary qualitatively.

1. Success might be reached automatically, impulsively and unconsciously. The subject uses schema which were attached to specific goals in the past. Action and goal are a unit, triggered by felt needs. Success is attained without cognizance or conceptualization.

2. Success might be reached as the consequence of an inference made from a theory, metaphor or analogy already assimilated. Success is then based on knowledge about causal relationships between actions and the objects under manipulation. Success is reached consciously but without understanding.

3. Success might be reached based on understanding. This success is qualitatively different from those mentioned above. It comes out of a complete conceptualization of all possible actions and their consequences for the object under consideration.

> "Success means having enough understanding of a situation to attain the requisite ends in action, and understanding is successful mastery in thought of the same situation to the point of being able to solve the problem of the how and why of the connections observed and applied in action (Piaget, 1974/1978, p. 218)."

> "The subject must, in order to understand the process, be able to construct in thought indefinite series involving recurrence, transitivity or regular alterations, etc... and hence to treat the series he has actually observed as just one sector of this unlimited range of possibilities (Piaget, 1974/1978, p. 222)."

The operational power that results from understanding gives the subject the possibility of transcending action and the world of the real, and entering into the world of possibilities.

Action and Thought

Thought lags behind action, as Piaget's later work persistently shows (Piaget 1974/1976; 1974/1978). Action and thought are related, but different; they develop in tandem. Although action and thought develop parallel within the life of an individual, their courses are structurally different. Action develops by forming goal-directed groups of actions called schemata, which are applied to objects. These action schemata are used to reach goals or solve practical problems (assimilation). Action schemata are also changed through self-regulatory mechanisms, when goals cannot be reached or problems solved (accommodation). These regulatory mechanisms force the subject to develop some degree of consciousness about the means he uses to attain goals, and about the properties of the objects. The action schemata, at first an unconscious and unified action-goal unit, separates into two elements. One element relates to the object and its properties, the other relates to the subject and his actions. The origin of thought and knowledge lies here, at the disjunction of subjective consciousness. Knowledge about the physical world is a consequence of the coordination, through an understanding of causal relationships, of means to ends so as to affect that world. On the other hand, cognitive structures develop through consciousness of these actions. Actions are separated from their original goals, abstracted into operations, and these are coordinated to other operations (Inhelder & Piaget, 1955/1958). Cognitive structures are constructed through different abstraction mechanisms; these were introduced by Piaget (1977) and skillfully discussed by von Glasersfeld (1989).

At the beginning of development, thought lags behind action. Once the subject learns to conceptualize, action lags behind thought. Now thought guides action and even preceeds it into the realm of the possible. Thought is developed along two fronts: a front of cognitive systems, and a front of knowledge about the physical world. The former originates the abstraction of actions detached from the concrete characteristics associated with them; the latter in the coordination of actions with the properties of objects, and the discovery of casual relationships. While the mind is coordinated and abstracted into cognitive systems, reality is constructed as causal relationships with the physical world.

Interaction

The work of the Genevan school focused only indirectly on the role of social interaction in intellectual development (Inhelder & Piaget, 1958). As Brown (1987) pointed out, the importance of the Genevan school lies in their clarification of the role of self-regulatory mechanisms in cognitive change and growth.

Summary

The picture of action provided by the Soviet Theory of Activity and by Genevan Constructivism bear some similarities. First, both approaches explain the transformation of action into thought. Both recognize that action lies at the origin of thought. The Theory of

Activity solved this problem with the concept of internalization. Genevan Constructivism built an extremely sophisticated theory to explain the transformation of action into cognitive systems and representations of the physical world.

Second, both approaches hypothesize a mental unit for cognitive functioning with active structural features. The Theory of Activity posits activity as the basic mental unit. Genevan Constructivism creates action schemata which are transformed into operations in later phases of cognitive development. Both mental units are constituted by a unified system of goal-directed actions. These units undergo transformations and integrations leading to ever greater abstraction's this process makes intelligent behavior possible.

Perhaps the distinctive contribution of the Theory of Activity has been to clarify the role of social interaction and culture in cognitive growth and change. Genevan Constructivism has provided a detailed account of how cognitive organization influences individual action. The results of this search were the distinction of three different levels of action associated to three different levels of cognitive organization. The Genevan school distinguished three levels of action or self-regulatory mechanisms (autonomous, active, and conscious) and related them to three levels of cognitive organization (automatically retrieved schemata, theories in action generated in-situ, mental consideration of all possible hypotheses). These distinctions correspond to three qualitatively different types of success in action: Automatic success in action; success in action through hypothesis testing; and success in thought.

Explaining the role of social interaction in the construction of action has been the main strength of social psychological approaches. The most relevant contributions of two such approaches are presented below: Symbolic Interactionism and Action Science.

SOCIAL PSYCHOLOGICAL APPROACHES TO ACTION

Although Symbolic Interactionism and Action Science have been joined under the same label, they were first developed to answer very different problems. Moreover, the social science communities inspired by these two approaches do not overlap in terms of problems, institutions or methods of study. In spite of this, the present review groups them together, since both approaches conceptualize action and thought within social contexts. The social dimensions of individual action have been neglected by the logical/philosophical and psychological approaches, with the exception of the soviet Theory of Activity. Given the social nature of most human actions, it is of foremost importance to introduce this dimension within a theory of action.

The present review, however, will focus on the following aspects of Symbolic Interactionism and Action Science: the description of action, the relationship between action and thought, and the role of interaction in action.

Symbolic Interactionism

Description of Action: The Act

Mead developed a conception of action within the framework of pragmatic philosophy (Mead, 1938). Action as well as thought are seen as instrumental, since both aim at the consummation of a subject's impulses or interests. Although Mead's conception of the act was philosophical in nature, he strongly influenced the development of the symbolic interactionism movement in psychology.

Mead identified four stages of the act, which apply to both individuals and social groups: (a) impulse; (b) perception; (c) manipulation; and (d) consummation.

Impulse

Man acts as a consequence of a state of disequilibrium, discomfort or disruption. He naturally acts without any clear goal in mind. The term impulse comes from the idea that human beings are active organisms reacting to problems, organisms with an impulse to act. This first phase represents the origin of the act as experienced by the subject.

Perception

In this phase subjects define their situations. The goals subjects are developing selectively guide their perception. Mead defines perception as a subject's observation of what needs to be done. Based on what she sees, she determines her goal. Between what she sees and the determination of the goal there is a process of "covert action." For Mead, "covert action" occurs at the mental level and involves a kind of action applied to the self. He describes covert action as a slow, deliberate rehearsal of an "overt act."

Manipulation

In the manipulation phase of the act, a subject puts into practice the action which she rehearsed as "covert action" in the previous phase. Subjects contact relevant aspects of the environment with the aim of reaching their goals. In this third phase, subjects perform what Mead calls an "overt action."

Consummation

This phase ends the act, as the goal is achieved and equilibrium restored. A new cycle starts, in which subjects would pass through the same phases.

Some actions, called habitual actions, might not go through a period of deliberation, perception, or covert action. They are functional and performed automatically. Mead conceived acting as a cyclical process, in which definitions of situations, the means and ends are continuously redefined.

Action and Thought: Interpretation and Perspectives

Symbolic interactionism resolves the relationship between action (overt action) and thought (covert action) using the interrelated concepts of interpretation and perspective.

Interpretation is the mental process of a subject interacting with himself. This is conceived as an internalization of overt social interaction. Blumer (1969) sees interpretation as a communicative, personal mental action with two steps: (a) actors indicate to themselves objects or events that are meaningful. This indication is an internalized social process; and (b) based on the situation in which they find themselves, actors select, check, regroup, or transform the meanings which will guide their actions.

Perspective is a representation of the social world generated through interpretations. All the relevant meanings and actions brought by the actors to a specific situation constitute their perspective. Human beings bring perspectives to action and modify perspectives as a consequence of on-site interpretations. Perspectives are dynamic, continuously changing representations of each subject's meanings and actions as they apply to particular situations.

Symbolic interactionism sees action and thought as two interdependent systems. External or social action is internalized as mental action, which in turn allows the process of interpretation. At the same time, interpretation allows the individual to develop new meanings, which will guide new social actions.

Social Interaction

Symbolic interactionism puts human interaction at the core of its theory. Internally social interactions influence the construction of mental perspectives. Externally, actions are constructed socially, through interaction. Symbolic interactionism emphasizes that social interactions are not just the context for the release of human conduct and thought. Instead, social interactions constitute the means through which human conduct and thought constructed. "Symbolic interactionism recognizes social interaction to be of vital importance in its own right. This importance lies in the fact that social interaction is a process that forms human conduct instead of being merely a means or a setting for the expression or release of human conduct (Blumer 1969, p. 8)."

Social interactions play an important role in constructing and transforming perspectives. First of all, social interactions become the building blocks of individual perspectives. Perspectives are formed by the meanings that actors attribute to action, within a specific context. In addition, social interactions are internalized as self-interactions, helping to transform perspectives. While interacting within themselves, actors interpret external social actions. As a consequence of these in-situ interpretations, perspectives change to include newly developed meanings.

Social interactions also contribute to the construction of social action. Social action is conceived as a linking of individual actions. Some of these links are so settled and routinized that they constitute a pattern of recurrent action (Blumer, 1969). These patterns are performed without any in-situ process of interpretation. In contrast, some other links of action occur as a consequence of each actor's interpretation of the action of others. The result of such symbolic social interaction is a unique and locally constructed course of social action.

One consequence of social interaction is the construction of common perspectives. Group members need to take into account new information brought by other members. This forces actors to put their perspectives aside and consider the perspectives of other members. As a result, group members construct more homogeneous perspectives out of shared definitions of social situations. Joint action is made possible by the creation of joint meaning through social interaction.

Symbolic Interactionism provides a rather complete picture of social action and its transformation in individual thought. Its most important insight is that individual action occurs within a social context, as the result of an in-situ interpretation of other peoples meanings and actions. Instead of explaining action primarily in terms of the nature of mental unit or action schemes, symbolic interactionism intercedes local interpretation between perspectives and action. As a result of interpretation, both perspectives and actions are transformed. Perspective is conceptualized as a very flexible and open mental entity whose purpose is to orient the individual actor to action and change.

Action Science

The purpose of action science is to create communities of inquiry within communities of social practice (Argyris et al., 1985, p. 34). This approach to organizational development is based on a new epistemology of practice which resolves the present deficiencies in the practical professions. Organizational developers at MIT and Harvard (Argyris, Schon, and Torbert among others) advocate an epistemology of practice which acknowledges the expertise involved in the practical professions. Although their purpose is to understand how can knowledge about action be developed, their approach provides relevant insights for the conceptualization of action within the practical professions.

Description of Action: Epistemology of Practice or Reflection in Action.

The model for an epistemology of practice is constituted as a series of idealized phases of a cyclical process of inquiry into practice. Argyris et al. (1985) called this process an epistemology of practice, whereas Schon (1983, 1987) called it reflection in action, and argued that it should not be considered an epistemology of practice. According to Schon, the process by which practitioners construct knowledge remains unknown, being mostly implicit. In any case, the two models are similar. This is not surprising, given that these authors worked together at one time (Argyris & Schon, 1974). The following account draws on the work of both.

Action

Practitioners begin with routinized actions. These actions reveal a "knowing in action" which is spontaneous, tacit and functional.

Puzzlement

Practitioners confront a complex, puzzling set of circumstances. Perhaps something unexpected gets the practitioners' attention, and they feel uncomfortable and uncertain about how to proceed. These practical situations are unique events which involve conflicts among goals, values, and understandings.

Reflection in Action

Practitioners engage in reflection. In so doing they draw on tacit knowledge to reframe the situation. New understandings are brought to the situation, which suggest new directions for thinking and acting. Schon (1983, 1987) understands reflection in action as a conversation between the situation and the individual. Implementation of action is not involved at this phase. Practitioners engage in mental testing of possible courses of actions, in order to explore their consequences. Schon provides the following phases for the process of reflection in action: (a) reframing the situation; (b) experimenting with the situation (Conversation); and (c) detecting consequences.

Reframing the situation. The problem is reframed, that is, approached in a different way. New directions for thinking and acting are suggested by the new frame of reference.

Experimenting with the Situation (Conversation). Practitioners conduct experiments within the situation. Schon's approach (1983) assumed that these experiments took place intellectually. In contrast, Argyris et al. (1985) emphasized that such experiments could also take place in action. In both cases, one experiments to find out the implications and consequences of one's frame of reference. Experimentation generates information about the situation, and about the suitability of intellectual framing and practical action. There are three kinds of experimentation in practice: hypothesis testing (actions as hypotheses); exploratory experiments (actions as probes); and move-testing experiments (actions as moves).

1. Hypothesis testing generates a plausible hypothesis of action by comparing several competing hypotheses. Once the most plausible hypothesis is selected, it is implemented to confirm its suitability. Action as hypothesis is action which aims at confirming or disconfirming expected results.

2. Exploratory experiments originate out of a desire to explore an action and its consequences. Practitioners are not guided by rigid expectations or specific predictions when they engage in such probing actions. Exploratory experiments familiarize practitioners with actions. Exploring action succeeds when it discovers something new or striking. The question that guides exploratory experiments is "What if I do this?"

3. Move-testing experiments attempt to attain specific results. Such actions are taken with clear ends in mind. The success or failure of the actions are evaluated in terms of their results. If the actual consequences are not the intended ones, the actions are judged unsuccessful.

Re-starting. If experimentation gives unsuccessful results, a new spiral of appreciation, action and reappreciation begins. Through these reflective spirals, the practitioner develops a new frame for the situation. What was fuzzy or puzzling at the beginning, becomes clear and understood. "The unique and uncertain situation comes to be understood through the attempts to change it, and changed through the attempts to understand it (Schon, 1983, p. 132)." Reflection in action clarifies situations, makes explicit frames of reference, and constructs better actions.

Action and Thought: Framing

The reflection in action model uses the concepts of "conversation" and "framing" to explain the relationship between action and thought in professional practice. The mental units that practitioners bring to problems of action are called frames. These constitute ways of seeing specific situations in the light of the past. Frames contain both concepts to consider and actions to perform.

Framing a situation does not always bring certainty. Sometimes practitioners need to engage in conversation, to ensure that the framing is appropriate to the situation. Conversation involves experimenting at the mental as well as the active level. As a consequence of reflective conversations, practitioners frame the problems that arise in their practices and shape situations to fit their frames of reference. This is a two way construction of professional reality. "Underlying this view of the practitioner's reflection in action is a constructivist view of the reality with which the practitioner deals- a view that leads us to see the practitioner as constructing situations of his practice (Schon, 1987, p. 36)."

Interactions: Apprenticeship Relationship

Interactions play an important role the education of novice professionals. Appropriate frames for practice must be constructed with the help of experienced professionals. The interaction between experienced and novice practitioners as they "reflect in action" provides the appropriate context for the beginner to organize her experiences. Through this apprenticeship interaction the novice practitioner learns to see her experiences through the lens of professional frames. This relationship not only provides the novice with actions to solve specific problems, but also with more general frames which will allow her to respond to a variety of practical situations.

Summary

The pictures of action here drawn from Symbolic Interactionism and Action Science bear important similarities. Both approaches hypothesize the existence of a mental unit which accounts for past action and guides future action (perspective or frames). These frames are thought to be flexible, readily available, personal and linked to specific contexts. These mental units contain objects, actions, transformations resulting from actions, and the meanings of other participants. Thus a perspective or frame is dynamic in nature.

Both approaches consider interaction essentially conversational or improvisational. Neither Symbolic

Interactionism nor Action Science view action and thought as guided by mental units or external constraints. Instead, they see action and thought constructed through a conversation among people, objects, and the self. For instance, Symbolic Interactionism defines interpretation as an internalized conversation with the self. Schon understands reflection in action as a conversation between individuals and practical situations. Experimenting-in-action and experimenting-in-design are also conversations, with the external situation or with the object of design. The results of such conversations are unique actions, interpretations, or designs constructed through an improvisational process.

Finally, both approaches provide mechanisms for the development of shared views among people. Whereas Symbolic Interactionism treats the construction of homogeneous perspectives through group interaction, Action Science highlights the transference of frames of reference from the experienced professionals to the novice through the apprenticeship relationship.

These two approaches study action in somewhat different contexts. Schon's conception of a reflective practitioner situates professional action within the context of inquiry. Thus he identifies different types of actions with different functions in a process of inquiry: action as probe, action as move, and action as hypothesis. Symbolic interactionism does not place the study of action within the context of inquiry. Although Mead recognized that social action emerges out of a puzzling situation, he was primarily interested in explaining the formation of social action.

SUMMARY AND CONCLUSIONS

The theories of action reviewed here approach the conceptualization of action from different view points. Their complementary approaches will be summarized with an emphasis on their descriptions of action, the relationship between action and thought, and the role of interaction. The summary is organized according to three levels of the description of action: the structural functionalist; the micro-genetical; and the onthogenetical levels. Some of the approaches reviewed only dealt with one level of description, whereas others integrated two of these descriptive levels. The most comprehensive of the approaches reviewed, Genevan Constructivism, includes all levels of description, whereas Dewey's Theory of Inquiry includes only one.

First Level. Structural Functionalist Description of Actions: Action as a Multidimensional System.

The structural functionalist level of description is constituted by a static representation of actions using discrete units. These units account for a subject's overt behavior while interacting with specific tasks or problems, and the intentions associated with it.

The Soviet Theory of Activity describes actions as systems with their own structure, not as isolated behavioral entities. Actions are guided by intentions (motives, goals, conditions) which are hierarchical in nature. For instance, motives are general, whereas goals refer to the specific ends of action. Mirroring intentions, actions also have a hierarchical structure. Any action is both part of a system of more general actions, and composed of other, inclusive actions. Despite this apparently unlimited hierarchy of actions and intentions, clear boundaries can be found that delimit systems of actions from one another. It is possible to conceived actions as unified systems of individual goal-directed actions. Thus the flow of human activity can be described as a succession of complex hierarchical systems of goal-directed actions serving different functions.

Actions can be associated with mental units which have an homologous structure. The Soviet Theory of Activity, Genevan Constructivism, Symbolic Interactionism, and Action Science hypothesized mental units for action. However, the structures hypothesized for these mental units differed. These differences can be attributed to differences among the specific tasks involved in action. For instance, the Soviet Theory of Activity and Genevan Constructivism dealt with actions related to the physical world. In contrast, Symbolic Interactionism and Action Science dealt with actions related to the social world. Thus, social interaction is incorporated in the mental unit of action in those cases in which action deals with the social world (perspectives and frames).

Second Level. Micro-genetical Description of Actions: The Construction of Action within Specific Contexts.

The micro-genetical description of action includes sequences of actions subjects undertake while interacting in specific situations. In other words, this description treats the evolution of the relationship between subjects and their environment. It accounts for the construction of actions within specific contexts.

The approaches reviewed in this paper provide three general contexts for action: (a) the deliberative context (Practical Reasoning), (b) the inquiry context (Dewey's Theory of Inquiry, Genevan Constructivism, and Action Science), and (c) the social action context (Symbolic Interactionism). This separation, made for purposes of analytic clarity, does not imply that these contexts are not simultaneously present in particular actions.

The micro-genesis of action has been described as a process of gaining certainty in action, when it is not clear how the subject should act. When the flow of spontaneous action is blocked, human beings engage in conscious activity about the best course of action. This process is conceived as cyclical rather than linear. It is precisely at this point that the three contexts of action mentioned above differ.

Action within a deliberative context is determined through deliberation about practical judgements. Certainty about action develops by means of a rational process which involves supporting and justifying possible courses of action. Instead, action within an inquiry context is determined through attempts at changing the environment. Certainty about action develops as the result of a progressive adjustment of the subject's actions in order to reach the desired effects. However, an action cannot be considered successful unless the subject constructs a representation by which to interpret its effects. Therefore, both action and the conceptual representation of the environment are simultaneously constructed. Action within a context of inquiry becomes an instrument for changing, knowing and exploring the environment.

Action within a social context is determined through an interpretation of other social participants' actions. Certainty about action is gained as a consequence of the homogenization of people's perspectives. While people interact within a social setting, they progressively develop a similar description of situations and therefore similar perspectives. This convergence of perspectives within social settings also involves convergence as to the best courses of social action. Action is constructed through interaction with people and interpretation of one's own actions. This process of "fitting in" each other's actions leads towards convergence of perspectives, and ultimately certainty about particular actions.

The micro-genetical descriptions of actions provide the construction mechanisms for the units of actions mentioned above. Three contexts for the micro-genetical description of actions have been discussed. These contexts involve three different ways of gaining certainty about the constructed action.

The relationship between thought and action at the micro-genetical level is dynamic. Thought and action are constantly affecting one another. People bring the mental units of action (perspectives, schemata, frames) to the specific situation. These guide the subject's action which in turn is transformed by the consequences of action. However, Practical Reasoning assumes a different relationship between thought and action. In order to make practical judgements and decisions, subjects need to have the representation of different courses of action, and clear goals and ends.

Social interaction plays an important role within the micro-genetic level of action. On the one hand, social interaction provides the source of the structural elements of action, such as goals, means, frames etc. Thus, social interaction is the channel through which individual action is constructed. On the other hand, social interaction provides the context for deliberation. Making practical judgements and resolutions depends on the persuasiveness of the case presented. Finally, social interaction provides the context for the construction of social action. Each individual action fits those of others in such a way that an overall social action is constructed.

Third Level. The Ontogenetical Description of Action

The ontogenetical description of action includes the changes that individual actions undergo through a long period of time. Both the structural characteristics of action and the micro-genesis of action change over the life span of an individual. Genevan Constructivism has provided the most solidly supported interpretation of the development of action and thought at the individual level. It points to three different relationships between action and thought. Action is performed as a consequence of an automatically activated action schemata. Later on, action is guided by locally developed theories of the external situation. Finally, action results from a conscious process of eliminating all other competing actions. Although action might be successful at all three levels, the cognitive nature of success is qualitatively very different. Onthogenetical descriptions of actions should include both descriptions of the differences between levels of action and thought over time, and descriptions of the mechanisms of change between these qualitatively different levels.

This review of theories of action has provided elements for a more dynamic consideration of action, thought and social interaction. It suggests that the action of teaching should be approached within an integrative frame, in order to capture the dynamic relationship between action, thought and social interaction in teaching. Thus, the metaphors of teacher as decision-maker, teacher as a choreographer, and teacher as improviser represent different, albeit complementary, aspects of teaching.

The question remains of how to conceptualize the action of teaching. Should teaching be understood through the teacher as professional metaphor, including a group of complementary but uncoordinated partial metaphors?. Or, should teaching be understood through a coordinated theory of action which accounts for all the different and apparently uncoordinated aspects of teaching?

CHAPTER 4

"HOMEWORK FOR CONCEPTUAL CHANGE": THE INTELLECTUAL JOURNEY OF A GROUP OF HIGH SCHOOL SCIENCE TEACHERS DOING ACTION RESEARCH[1]

> "Lo mejor del mejor saber es que descubre nuevas y fascinatntes parcelas de la ignorancia. El resto de lo que con certeza conocemos es rutina, pasmo enganoso, aquietamiento, devocion dogmatica. La ignorancia, en cambio, es zozobra, acicate, pregunta, imploracion y exploracion. Como bien suela decirese, la ignorancia es atrevida; en cambio, la certeza es timorata. Vivimos de nuestro ignorante atrevimiento"
> (Fernando Savater, Ficciones utiles, El Contenido de la Felicidad, 1986)
> (What is best about the knowledge is that it discovers new and facinating areas of ignorance. The rest, what we know with certainty, is routine, deceptive awe, calming down, dogmatic devetion. Instead, ignorance is worry, spur, questionning, imploring and exploration. It is well said, that ignorance is daring, while certainty is timid. We live from our ignorant boldness.)

[1]This paper is co-authored by Carlos Castel and Paco Garcia. An earlier version of this paper was presented at Jornadas de Investigacion en la Escuela, Lleida, Spain, May 1988.

INTRODUCTION

Researcher's Note

This chapter is the product of action research undertaken by one experienced high school science teacher, one novice high school science teacher, and one outsider/collaborator. It describes the group construction of actions and meanings which emerged through this particular pedagogical inquiry. My role as the outsider/collaborator was to facilitate the teachers' pedagogical inquiry, ensure the continuity of the experience, and collect data for further analysis.

The chapter was co-authored by all three participants. The group began writing this report immediately following the action research project. It took us several meetings of sharing, negotiating, and rewriting, to agree on the meaning of the experience.

As a participant my main concern was to help the teachers solve their particular problems. In this role, I shared my understanding of the problem and the journey they had undertaken. Thus, some of the ideas and changes described in this report originated in my participant interventions.

As a researcher, I was concerned with how this particular case could contribute to our understanding of the act of teaching in general. In this sense, the following action research report represents original data which could be used to undertake a detached reflection on the development of teachers' knowledge within group inquiry. This second level analysis is not performed in the present dissertation; I hope to undertake such research in future.

Background of the Action Research Problem

This paper contains the narration of the intellectual journey we, a group of two high school science teachers and one external collaborator, went on while doing action research within our own classrooms. This approach to educational research appeared more interesting and more valuable to us than the traditional educational research. Action research, as we understood it, allowed us to confront our practical problems, to interpret the gathered information through discussion/reflection, and to consider the validity of the results in terms of their usefulness and applicability (Elliot, Sutton, Harding, 1978; Carr & Kemmis, 1982; Grundy, 1982). This way of undertaking inquiry was in clear opposition to the traditional educational research which had not proven very useful in our daily teaching.

The problem of our inquiry originated from our concern about students' responses to homework. We, the teachers who participated in this study, had adopted a fairly long time ago the paradigm of the directed discovery and conceptual change for the learning of physics and chemistry. However, we were not totally satisfied with the results of the students' learning. In the last two years we were persuaded that some element was missing that might multiply the effectiveness of our approach. That key element, it seemed to us, was homework. The study started with the following question: "How can we make students work at home with divergent and complex physics problems?" or "How can we use homework to increase the effectiveness of the directed discovery and conceptual change approach to the learning of science?"

The following narration presents our description of the phases we went through in developing the theme of "homework for conceptual change". This narration includes what we did, thought and learned. In other words, it traces back our intellectual biography as a group. We would like to highlight the moments of trouble and sense making we went through in order to reach some coherent and harmonious solution for action. We would also like to share the complexity of coming to learn about our classrooms. This, we believe, is the strength of our study and the safest way to support the validity of our inquiry and results.

METHODOLOGY OF THE STUDY

The Role of Teachers and the External Collaborator

We entered the study very much aware of the multiple roles we would need to play as teachers. Among the different roles that a teacher could possibly assume, we were especially interested in those of experimenter and researcher as described by Osborne (1985). Both roles were needed if we were to participate in an action research study. As experimenters we were interested in evaluating the effectiveness of our changes implemented in the classroom. The presence of an external collaborator could provide some detached evaluations through classroom observation and subsequent group discussion. As researchers, we were interested in creating a community of inquiry about the problems emerging from daily practice. A group of teachers could create the ideal context for such an inquiry. Moreover, the presence of an external collaborator could also constitute a cohesive element to ensure the continuity of the inquiry process.

The relationship established between us, the teachers and the external collaborator, was bidirectional, in such a way that both could be mutually enriched. The teachers brought forth the initial formulation of the problem, the richness of information collected through their daily contact with the students and the possibility of contrasting ideas through immediate action. The external collaborator, submerged in the environment of the teachers, was able to offer her findings on the analysis of the problem proposed and new information gathered by the direct observation.

Organization of the Experience

The action research got started because of the external collaborator's interest. None of the teachers had participated in an action research project before. This fact, however, did not prevent us from getting involved in the project which seemed useful and interesting.

All of us decided upon the general constraints of the experience during the first few meetings. The external collaborator suggested that we engage in two kinds of activities: the observation of each other's classroom and group meetings. As for the former activity, each teacher was observed twice a week by both the external collaborator and the other teacher. Although each observation had a specific focus, it was not systematic. Only the external collaborator took field notes from her observations which served as materials for discussion when needed. Although we were initially afraid that the presence of the two outside members could disturb the students' spontaneity in the classroom, we found that they rapidly got used to their periodic presence without altering their behavior. As for the group meetings, we decided to meet once a week for an average time of one hour and a half. These meetings were held at the same school where both teachers were working. Each meeting was usually organized around the following three parts: (a) an evaluation of the action tried out in our classrooms during the previous week, (b) a reflection on the state of the problem and other possible solutions for action, and (c) the planning of a new strategy for action to be experimented within the classroom.

The problem out of which the action research started was "How can we make students work at home with divergent and complex physics problems?" or "How can we use homework to increase the effectiveness of the directed discovery and conceptual change approach to the learning of science?". We did not have any predetermined idea of what it would take for us to solve this problem. In every meeting, new ideas for action and new understandings of the problems emerged. Each subsequent action was a direct consequence of our discussions in each meeting. In spite of the unpredictability of the process of inquiry, our understanding of the problem and the clarity of our actions steadily increased along the action research.

PROCESS OF RESOLVING THE PROBLEM OF HOMEWORK

In this section, we explain the path we followed to solve the problem of homework for conceptual change. Each of the following three sections corresponds in time to the natural quarters of the academic year. They also represent the three phases of the total process that followed. The process is explained not only in terms of what we did, but also in terms of what we learned and understood. Thus, the actions we undertook, the results of our inquiry, and the reflections which resulted in the making of important decisions are presented together.

First Quarter: Initial Attempts

The students' work in our classrooms was organized around a program guide handed out at the beginning of the academic year. This program guide included a series of exercises, problems, necessary explanations and activities that allowed students to reconstruct the key scientific concepts by themselves. The purpose of the exercises was that of students' practicing and reinforcing a learned algorithm within a familiar context. The purpose of the problems was the use of a learned principle within a new context. Finally, the purpose of the activities was that of expanding and enlarging a learned principle within a totally new context. Initially, we assigned for homework only the typical problems and exercises already seen in previous classes. In order to diversify the type of task we assigned them some open and complex problems and activities whose resolution could not be discovered automatically from what had been studied in the classroom. This change originated on the need of engaging students in high level thinking at home.

The follow-up and evaluation of homework took about ten minutes of each class. During that time the teacher went over the homework of six to eight students and graded them with the following marks: a "+" (if it was obvious that enough time had been spent regardless of whether the correct result was reached or not; an "o" (in the case that only the minimum had been done); or a "-" (in the cases in which no work had been done, or in which excuses are given, etc.).

The results of that first attempt, as the first quarter went on, were fairly deceptive: the number of students who did the homework when they were faced with open complex problems and activities never exceeded 10%. The cause of this failure was evident: homework was more difficult and required a greater dedication of time from the students.

Second Quarter: A Double Front

According to Slavin (1980), what occurs in the classroom is the result of the combination of three elements: a) the structure of the question posed to the students, b) the structure of recognition or evaluation of the work realized, and c) the structure of authority.

This scheme proved useful to organize our next actions towards the solution of the "homework for conceptual change" problem. It occurred to us, that we could apply Slavin's conceptualization scheme to homework. As a consequence of such analysis, we concluded that there were two fronts on which we could act simultaneously: on one side, the presentation and structure of the questions proposed for homework (problems or activities) had to be directed conveniently and, on the other, a greater consideration should be given to homework within the students' final evaluation. We directed our efforts towards the following two fronts: (a) the structure of problems and activities presented for homework; and (b) the homework checking strategy.

The Structure of Homework Task

Strategy Followed

The science department in our school has advocated for some years the conceptual change approach for the teaching and learning of physics and chemistry (Hashweh, 1986; Hewson, 1981; Posner et al, 1982). The way we started to adopt this approach was that of transforming the typical physics and chemistry problems and exercises into real open and complex problems. In doing, so we wanted students to engage in a similar process that scientists undergo when they solve new problems (Gil y Martínez-Torregrosa, 1983).

The new transformed structure for problems and activities was constituted by both the statement of the problem and a series of guidelines. The purpose of the guidelines was that of guiding students' thought toward the resolution of the problem in accordance with the scientific method. The guidelines could be omitted once the students were used to thinking in this way. The statements included in the guidelines were the following:

1. Qualitative analysis of the situation and emission of hypothesis. The students are asked to explain what they believe were the physical magnitudes that intervene in the problem. They were also asked to describe their qualitative role in the problem.

2. Elaboration of strategies for the resolution of the problem. The students were encouraged to articulate how

they would manipulate the intervening magnitudes in order to solve the problem.

3. Resolution of the problem. The students were asked to actually solve the problem through analytical and quantitative procedures.

4. Analysis of the results. The students were asked to check the results in order to see whether they were compatible with the original expectations.

We provide some examples of the transformations whose guidelines have been introduced above. These examples constitute three rather typical cases of thought in 10th grade physics classes: the case of the elevator, the case of friction, and the case of the planet. These examples will be consistently used throughout the paper for illustration purposes.

Example 1: The case of the elevator.

Statement of a typical exercise.--"A 300 Kg. elevator climbs by the effect of the cable tension with an acceleration of 0.5 m/s^2; calculate the tension of the cable".

Statement of the transformed problem.--"How much is the tension of the elevator's cable? (a) Analysis and emission of hypothesis; (b) elaboration of strategies, (c) resolution, and (d) analysis of results".

Example 2: The case of friction.

Statement of a typical exercise.--"A body of 100g is slung at a specific speed over a horizontal surface, in such a way that it stops after going 1.5m in 2 sec; calculate the value of the force of the friction that has stopped it".

Statement of the transformed problem.-- "How would you determine the friction of a body slung over a horizontal surface? (a) Analysis and emission of hypothesis; (b) elaboration of strategies, (c) resolution, and (d) analysis of results".

Example 3: The case of the planet

New transformed activity. -- "A planet spins around the sun (a) sketch and justify the forces that you believe are acting on the planet, (b) your hypothesis--is it in contradiction to some basic points of those seen in the classroom? Explain it; (c) conclusions".

The new transformed problems and activities seemed very promising as homework for two reasons. The first is that the guidelines constituted an excellent help for students to approach the resolution of the complex homework problem by themselves. The second reason was that these guidelines would prevent those lazy students from getting by with a simple answer or a short calculation.

Although the new transformed problems and activities had different purposes, they both introduced the students to new and initially unknown situations. The problems encouraged students to "go backwards" to what they had learned in the classroom and explore how it could be relevant for the new situation. The transformed activities forced students to articulate their learned knowledge and relate it to other things. Activities encouraged the students to "carry forward" the progressive construction of their knowledge. Both "going backwards" and "carrying forward" were two essential, albeit different parts of the learning process. We were very eager to see whether students could work by themselves at home on these two important kinds of learning experiences. Our underlying purpose was to make the students as autonomous as possible in relation to open and complex problems and activities which were essential for the learning of science.

Evaluation of the Strategy

In order to evaluate students' responses to this second attempt at the homework assignment, we collected and analyzed all the students' answers to the three cases presented above: the case of the elevator, the case of friction, and the case of the planet. We analyzed the students' responses using the following categories: (a) NH-EXC designated those students that did not do the homework or gave excuses; (b) MEM indicated that the students did homework, but their answers were based on weak ideas extracted from memory rather than from reflection on previous ideas; (c) MEM-ADAP designated those students who used their memory to successfully adapt learned information to the new situation ("intelligent but lazy students" were usually here); and (d) REV-ADAP indicated that students systematically reviewed and adapted the ideas they had collected along the academic year (the most disciplined students were usually here).

Table 4-1 presents the results of the analysis of the students' answers to the three homework cases. These percentages have been calculated with the sole aim of detecting general tendencies within the particular context of our classrooms. Notice that the MEM-ADAP and MEM-REV categories have been merged into one. The new merged category would represent those students who solved the problem correctly. The percentage of students who sufficiently reflected upon the problem (MEM-ADAP & MEM-REV) and solved it varied depending on the type of case. Thus, the case of the elevator was solved by approximately 65 percent of the students, whereas the case of the planet was solved by 20 percent of them. The percentage of students who correctly solved the case of friction oscillated between 65 and 20 percent. The students who did not spend any time doing the homework (NH-EXC) represented the 20 percent of the total number of students. This percentage renmained constant in all three case problems. Finally, the percentage of students under the category MEM was 15 percent for the elevator case, 60 percent for the planet case, and a percentage in between the two for the friction case. In addition to this small statistical description, students under the category of MEM never went further than the first guideline included in the problem. In contrast, students falling in the categories of MEM-ADAP

Table 4-1

Percent of Students' Answers to the Cases of Homework for Conceptual Change

	Homework Cases (N=70)		
Answers	Elevator	Friction	Planet
NH-EXC	20	20	20
MEM	15	15<x<60	60
MEM-ADAP & REV-ADAP	65	65>x>20	20

and REV-ADAP were able to go through all the guidelines given in the problem. Contrary to what we had expected, though, these students were not able to defend their posture in response to the teachers' questions.

The results of our analysis were discouraging in some aspects and encouraging in others. On one hand, no matter how we changed the structure of the problem, there was a stable group of students that persistently rejected doing the homework. On the other hand, the percentage of students who successfully solved the homework problems increased in relation to the 10 percent obtained in the last quarter.

The Checking of Students' Homework

The strategy we used to check our students' homework changed in relation to the previous quarter. Instead of spending ten minutes of each class checking homework, we went on to spend 20 to 25 minutes. During this time, the teacher moved from side to side and ostensibly checked for homework from at least ten students. The mark collected from such checking strategy accounted for 20 percent of the final grade. The aim of these strategies was to teach the students the importance of doing homework. Later on in the quarter we realized that these strategies were much more effective if something additional was done. Instead of just checking some specific students' homework every day, we collected and marked everybody's homework once a week.

Third Quarter: Interpretation

During the third quarter, we devoted our efforts to the reflection and criticism of the work done in previous quarters. This reflection was centered around the two fronts mentioned above: the structure of homework assignments, and the strategy of checking the students' homework. As for the first front we came to understand the students' responses to homework as one part of a more global problem solving process. As for the second front, we were persuaded by the a priori effectiveness of group work in motivating students to do homework. What follows is a description of the process we followed to come to the conclusions just mentioned.

Solving Problems: A Process of Double Resolution

The experience of the second quarter showed us that, in spite of the recommended guidelines included in the homework problems and activities, the students did not solve them automatically. It became clear to us that we were missing an important factor. This factor should account for the unstable and sometimes low percentage of students who solved the homework problems correctly.

The reading of Hashweh's work on conceptual change (Hashweh, 1986) made us realize that different factors were contributing to the conceptual change of our students. The factors that we had been most concerned with were those external to the students. However, Hashweh identified the psychological factors as being equally important in determining conceptual change. We certainly could have tried to find an explanation for the homework's apparent failure using psychological factors. The explanation would have been concluded when we had identified those strong naive conceptions which prevented the students from changing toward more advanced conceptions. For instance, in the case of friction, the naive conception which prevented the students from doing the problem correctly was the "force of movement". However, we were more inclined to find the explanations of homework failure among our actions as teachers. In other words we wanted to identify those actions, as teachers, which did not contribute to students' increasing autonomy in facing and solving homework problems.

To identify the external factors we chose to study closely three of our best lessons which could be considered a "model". Since the external collaborator was observing most of our lessons, we used her field notes as the basic material for reflection. We felt that two conditions had to be met for a lesson to be considered a "model": (a) a subjective condition; and (b) an objective condition. The first, subjective condition was that both the teachers and the "external collaborator" needed to have the impression that the lesson had gone well. The second, objective condition was that students who initially held a naive view about the problem changed it towards the scientific one.

Those same students made arguments designed to persuade other students who were still holding the naive view.

This going over the field notes of three "model" lessons made us realize that the work students do as homework has clear limitations. Although students might have addressed all the steps suggested in the guidelines, their answers were still superficial and without explicit connection to the essential points of the problem. This fact induced us to believe that the students' process of learning could be composed of different albeit connected phases.

The first phase is what the students do at home for the first time. Their work represents nothing more than the beginning of an incomplete process of solving the problems and activities. The second phase of the process would consist of revealing the incompatibility of the students' first ideas and results with those drawn in previous classroom work. Unfortunately, there seems to be very few students who spontaneously reflect upon the coherence of their own ideas. It is precisely because of this that the second phase of the resolution requires the intervention of the teacher. The third phase, which only for reasons of clarity is considered a different phase, consists of showing the way to the correct solution. The means used to carry the second and third phases on has been the contrast and confrontation between two opposite positions about the problem under study. This cognitive strategy has shown to be effective in other studies such as those of Gick and Holyoak (1983) cited in Hashweh (1986). The fourth and final phase of the students' process of solving a problem is the "de facto" solution to the problem. The students are able to solve the problem thanks to the reflection and contrast which occurred within the two previous phases. At this point, the students develop a holistic view of the problem and therefore they are able to write down the complete process of solving the problem.

In summary, the process of solving a problem or activity requires two resolution cycles in whose point of inflection is found the teachers' intervention. It was certainly very encouraging to notice some similarities between the structure of our selected three "model" lessons and Posner's model for conceptual change (Posner et al, 1982). This coincidence has been a source of strength and encouragement for our further inquiry.

Motivating Students to do Homework: The Role of Group Work

The strategies we followed for checking students' homework were motivated by our interests in knowing about the effectiveness of the transformations done over homework problems and activities. The results drawn from the implementation of these strategies during the first and second quarter showed that 20 percent of the students did not spend any time doing homework. This percentage was sufficiently high so as to block a lesson which was built on the assumption that all students had done the homework. In addition to this, we were overtly concerned about the fact that this percentage could increase if the students' motivation to do homework was solely based on grades. If this was so, we could easily find ourselves at the same situation as that of the first quarter.

The reading of Slavin's work on group work (Slavin, 1984) encouraged us to reactivate the use of group work in our classrooms for motivational purposes. The conceptual change approach advocated by our department lead us to use group work for the purpose of discussion and confrontation of the students' views. However, we were not completely satisfied with the results. Although group work was ideally an interesting strategy, the reality was far removed from this ideal. Among other problems encountered in group work we were especially concerned about the passivity of some members. Slavin's work suggested new ways of stimulating and improving the work of all the team members in the group discussions. The central idea consisted of assigning the same grade for all group members. This grade was obtained as the mean of all the contributing students' grades. Slavin's strategy for the evaluation of students' learning appeared to be more efficient than the strategy of assigning a different grade to each student according to his/her work. The metaphor underlying Slavin's proposal would be that of a sports team in which all the members contribute to the success of the team. We hypothesized that good students would help and push the slower students within the group. The structure created in such way seemed promising to us given its cooperative nature.

If Slavin's cooperative learning proposal was effective in getting students to actively participate in the classroom discussions, we hypothesized that it might also be equally effective within the context of homework discussion and evaluation. Actually we envisioned Slavin's idea of cooperative learning as having more advantages when applied to homework discussion and evaluation than to the regular class discussions. Homework might give slow students the possibility of working on the problems at their own pace before being subjected to the collaborative rhythm of group work in the classroom.

Since the idea of group work applied to homework revision and evaluation seemed plausible, we started to work towards the design of a departmental project for the next academic year. We started to consider the following strategies: (a) assigning students to heterogeneous groups (composed of high, middle, and low achievement level); (b) changing group composition after each unit as a way to protect students who have not been able to adjust to the assigned group; (c) checking each students' homework at least once every two weeks; and (d) assigning a global grade for the group once every two weeks.

A MODEL OF THE CLASSROOM FOR CONCEPTUAL CHANGE

The inquiry we undertook at the beginning of the academic year brought us toward two apparently different fronts. On one hand we dealt with the change of the structure of homework problems and activities. On the other hand we started to change our homework checking strategies. As for the structure of problems and activities, we moved from using traditional homework exercises toward rewriting problems and activities better suited for inducing conceptual change. As for the homework checking strategies, we started with simple qualitative strategies and we ended up rehabilitating group work. It is worth noticing that when we were dealing with one of these two fronts, the other was completely ignored. The reverse was also true. In other words, we never made conscious connections between these two fronts of inquiry.

However, there was still a fundamental question to be confronted. This question was that of knowing whether the joined consideration of both fronts would lead us toward some useful classroom orientation. Fortunately, when we attempted to implement the changes of both fronts within each lesson, we saw an emerging underlying structure for the general organization of the lesson. We think that this structure would well constitute a model of the classroom for conceptual change. Our model conceived a lesson as being formed by three parts with different albeit complementary functions: (a) preparation or presentation; (b) the knot; and (c) outcome and accommodation.

We would like to draw on the analogy between a novel and a classroom in order to point out some similarities. The first is that a classic novel is composed of three parts, as our model of the classroom for conceptual change does. The second similarity is that a novel represents just one small, though significant, interval of the total life of the characters. In the same way, a lesson comprises but a fraction of the total process of the students' learning. The learning of our students does not only occur within the classroom. In fact, we believe that most of it occurs outside the classroom.

Next we will introduce the three parts of a lesson comprised within our Model of the Classroom for Conceptual Change. The three homework cases presented in previous paragraphs will be used again for illustration purposes. The use of the same examples will help to make our points stronger.

Preparation or Presentation (normally between 10 and 30 minutes)

Two preconditions prior to the beginning of the lesson need to be met. The first is that the students are assigned to small groups. The second is that the students bring to the classroom their own thoughts and responses to the homework assignment.

The teacher starts the class inviting the students to share their thoughts and responses to the homework assignment with the other members of the group. This sharing of ideas acts as a social presentation of each student within the group. Since each student's ideas and proposals are influenced by their previous experiences and level of understanding, it is reasonable to expect that their thoughts will be very different. In spite of this diversity, students are encouraged to agree upon one unified view of the homework problem. This implies that other students' alternatives are silenced. The prevalence of one view over another within a small group usually depends on the reputation of its defendant, or on the strength of the arguments put forward. The agreed view emerging from each small group also differs from that of other groups. However, the diversity is not as great as it first appears. It is our experience that only two or three basic view types emerge from 10th grade students' group work.

It might be the case that the diversity of students' views does not occur as expected, and only one major view arises from the students' group discussions. The teacher is in the position of inducing diversity by using the following two strategies: (a) presenting an alternative view on the blackboard; and (b) indirectly "spill" the idea on some selected students from different groups with the hope that they will expand on it.

While students are sharing and discussing their thoughts on the homework problems, the teacher walks around the class. The purpose of it is that of evaluating the students' homework. The teacher might want to talk to specific students about their own work to appraise the degree of their understanding and the amount of effort devoted to homework. This homework checking strategy also serves the purpose of exploring the students' main views and errors. As a result of this exploration the teacher constructs a "situational map" of the location of the students' views. This map is of foremost importance to prepare the second part of the lesson, since it gives the teacher an idea of which students held which views. Thus, while checking on homework, the teacher gets the necessary information to be used in the second part of the lesson.

For illustration purposes, we present the different types of students' responses to the three homework cases introduced in previous paragraphs: (a) the case of the elevator; (b) the case of friction; and (c) the case of the planet.

<u>Example 1.</u> The case of the elevator

All the students agreed that the tension of the elevator cable will depend on one static and one cinematic magnitude. However, students are divided as to which static and cinematic magnitudes play a role. The two most frequently stated static magnitudes are mass or weight, whereas the two most frequently stated cinematic magnitudes are speed and acceleration.

Example 2. The case of friction

Students' views are divided into two groups. One group represents the view according to the principle of inertia. In this case, students draw the normal force, the weight, and the horizontal component of friction within the sketch of the problem. The second group represents the view in contradiction with the principle of inertia. In this case, the students draw the same forces as the students within the first group, but they add a fourth one which is in the direction of the body's movement. This stands in clear opposition with the principle of inertia.

Example 3. The case of the planet

Three different views appear after the first attempts at solving this problem. One representative sketch for each of the three students' views are presented in Figure 4-1.

The first view is usually dismissed in the small group discussion. The last two views prevail through the group discussion and are brought to the whole class.

Knot (between 20 and 40 minutes)

The second part of the lesson is called knot. The teacher calls some students to the blackboard. These students have been selected for their characteristic views about the homework problem. For the knot part of the lesson

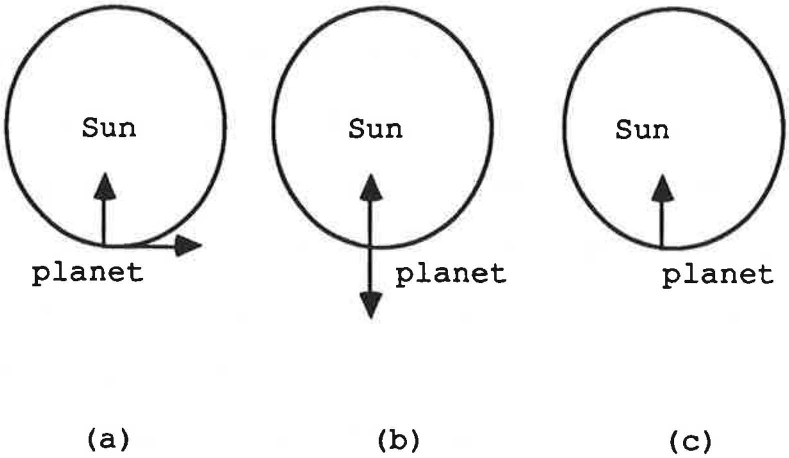


Figure 4-1. Students' Sketches for the Homework Case of the Planet.

to be developed, it is necessary that students draw or present their different views. If the students draw sketches on the board, they are asked to explain them to the whole class. The teacher has previously made sure that all students' views are represented in the students he or she selected. After each student's verbal explanation of his position, the teacher articulates their mutual incompatibility. Students in the classroom usually react to the teacher statements with comments which support one or the other view. These interventions are the beginning of highly intense discussions within the students' groups.

In order to guide this emergent discussion toward a more fruitful path, the teacher needs to intervene with a strong guiding question. This question will help students to focus their dialectical confrontation on those features that might eventually lead to the solution. To find the best questions applicable to the knot part of a lesson has been the most difficult task we have encountered as teachers for conceptual change. This questions usually emerges after some failed attempts and lots of reflection time with our colleagues.

Once the teacher has asked the question, the students are directed to work in small groups again. At this point, it is advisable that the teacher stops having the leading role, and transfers it to the small groups.

After students have spent some time reflecting on the question, two things can occur. The first is that the correct answer imposes itself. In this case, students agree upon which view represents the best answer to the problem. This happens more frequently than the teacher would expect.

The second outcome of the students' reflection in small groups is that they maintain the same two or three different views. When this happens, students usually invent stronger and often creative arguments supporting their own views. If the majority of the students cannot be persuaded as to the correct answer, then the way out of the mire consists of the teacher presenting what science considers to be the correct answer. Only at that moment are the students sufficiently receptive to the teacher's explanations. In the event that the teacher has opted for this way, it must be made clear that the idea presented is only one of the many possibilities. The correct scientific solution has been traditionally more in agreement with the body of knowledge and methods that science has previously constructed than all the others.

Next we present the same three homework cases introduced earlier with some comments about the more common students' views. The information adduced below is drawn from our personal experience with students working on these three cases.

Example 1. The case of the elevator.

This is not a very polemic case. After the first attempt of sharing their opinions, students usually align themselves with the correct view, in this case, acceleration.

Example 2. The case of friction

Students' views get quickly split in two basic positions. One position is defended by those students who think that the force of movement does not exist. The other position is defended by those students who think that the said force was accumulated at the moment of the flinging of the body. At this point the teacher has several strategies to follow. The first thing he or she can do is to apply the Newtonian equation to the second situation defended by the students. In applying the Newtonian equation, students see that an additional unknown appears. The question is then posed by the teacher as how can one experimentally determine such unknown force. At this point some students might shift toward the accepted scientific view. Those who still maintain the existence of the force of movement suggest the following experiment to measure it. They suggest to measure the acceleration of a ball rolling along a smooth, almost frictionless surface. Obviously, they quickly realize that under such conditions the acceleration of the body would be zero. The teacher makes the connection between this logical conclusion and the principle of inertia, magnifying the advantages of holding the correct view.

Example 3. The case of the planet

The position represented by sketch (a) is ruled out at the beginning of the discussion. This is so because the case of the planet is usually presented to students at the end the unit on dynamics. The students that support the position represented in the sketch (c) argue that there cannot be any other force than that of the sun, given that it is the only known object around the planet. The students defending the position represented in the sketch (b) appeal to their daily experience in driving cars. They provide their feeling of being pulled away when taking curves as the argument supporting their sketch. The main task of the teacher is that of providing some new line of thought which will help them to overcome the misleading effects of direct experience.

One successful way to do this is by acknowledging the students' discovery of a new principle of inertia different from Newton's. The new principle of inertia would state that two forces of equal value but opposite sense produce a circular trajectory. Following this, the teacher encourages these students to think of an example where two equal but opposite forces apply. This transition from the planet situation to a normal environment produces some conflict. Students realize that the trajectory should be linear rather than circular. Those students who are enlightened by this insight usually come up with ingenious experiments. An example often suggested by students is that of attempting to make an iron ball pass between the same poles of two magnets.

Having arrived at this point, the teacher introduces the historical solution of Hooke (Khun, 1978) to this problem. This shows how a circular orbit can be generated by applying a force normal to a linear trajectory. The history of science provides an elegant example of how the principle of inertia can be used to explain the circular orbits of planets.

The Outcome and Accommodation (about 10 minutes)

The final part of the lesson is the outcome of the knot and the accommodation of the new view. The task done within the previous part is insufficient to make a student accommodate the scientific view. This is especially true for those students who were sustaining alternative positions. The knot part of the lesson has served the purpose of pointing out the scientific view, and provide some persuasive arguments in favor of it. The purpose of the outcome and accommodation part is to provide students with opportunities to solve the homework cases again. The teacher suggests that the students solve the homework cases in the light of what they learned in the class. At the same time he or she assigns new homework problems which are closely related to the topic. These assignments should deal with the application and extension of the main idea developed in the classroom.

It does not seem to us discardable that the small groups existing in the classroom can meet outside of class and work on their homework.

CONCLUSIONS

The outcome of this long process of inquiry lead us to a new formulation of a classroom model. What started with the question "How can we make students work at home with open complex problems?", developed into a model of the classroom for conceptual change. This model was the result of integrating students' homework and group work within the flow of the classroom. We are determined to begin a project for next year in which homework and group work will be emphasized. We would like to encourage teachers from other disciplines to join the project. We would also use the same approach followed within the present study. We have realized that the whole experience has been an excellent catalyst the articulation of our implicit beliefs and underlying classroom models. What have we discovered, then?

CHAPTER 5

THE FUNCTIONAL, EMOTIONAL AND SYMBOLIC DIMENSIONS OF RESEARCHER'S INTERVENTIONS WITHIN ACTION RESEARCH

> "The manifestation of phenomena is not detached from the observer - it is caught up and entangled in his individuality"
>
> "There is a secret element of regularity in the object which corresponds to a secret element of regularity in the subject"
>
> (J. W. von Goethe, Maxims and Reflections #512 & #514, 1955/1988)

INTRODUCTION

Researcher and Teacher Subjectivities Within Different Educational Research Paradigms

Educational research aims at developing knowledge of the teaching and learning processes. Different research paradigms coexist within the educational community. Examples are: positivist (Gage, 1972), interpretive (Erickson, 1986; Goetz & LeCompte,1984; Lincoln & Guba, 1985) and action-research approaches (Carr & Kemmis, 1983; Elliot, Sutton & Harding, 1985; Stenhouse, 1980). These paradigms are based on differing assumptions concerning the roles of researchers and teachers in the production of educational knowledge. Researchers working under different paradigms establish different relationships with their participant teachers.

The positivist researcher is the producer of educational knowledge. The relationship with teachers is normative, detached and mediated through instruments. These instruments serve the dual purposes of collecting necessary data, and suppressing the subjectivity of both teachers and the researcher. The elimination of subjectivity is seen as essential to preserve the validity and generalizability of knowledge.

The interpretive researcher is also the producer of educational knowledge, but the relationship with teachers is more open, less structured and mediated through participant observation. The interpretive researcher deliberately seeks to identify teacher subjectivity; this is seen as an important part of educational inquiry. Despite the fact that the interpretive researcher's subjectivity is usually acknowledged, in the form of autobiographical accounts and theoretical positions taken within research reports, it is still considered a bias to be suppressed. This bias, it is felt, might prevent the researcher from capturing the true nature of the teacher's symbolic world.

In sharp distinction to the two previous approaches, teachers become researchers within the action-research paradigm. Teachers are themselves producers of educational knowledge which is personal, practical and highly usable.

Moreover, the traditional researcher becomes co-researcher and facilitator of the teachers' inquiry. The assumption which supports the role of researcher as facilitator, is that teachers live with professional constraints which prevent them from engaging in free inquiry about their own problems. On the one hand, teachers do not have the experience or education to undertake research by themselves. The facilitator must provide research strategies and stimulate teachers' openness and reflectiveness. On the other hand, political conditions force teachers to hold distorted values and beliefs about education. The facilitator provides the social and political theory to emancipate teachers from false values and beliefs.

Like the teachers, the facilitator is also an action-researcher inquiring into his or her facilitation task. Elliot (1988) called the facilitator's inquiry second-order action-research, and the teacher's inquiry first-order action-research. The relationship between the facilitator and the teacher is based on a reflective dialogue in which both focus on their own subjectivities, to produce valid educational knowledge.

Whatever paradigm the educational researcher employs, data collection necessitates some sort of relationship between the researcher and teachers. In the positivistic paradigm, this relationship is reduced to the administration of a research instrument. The negotiation of this relationship is based on the acceptance, by the teachers, of this instrument. The quality of data depends on the quality of the instrument and the relationship between the teacher and the instrument. In the interpretive paradigm, the relationship between the researcher and the teachers is mediated through data collection strategies such as interviews, informal conversations and participant observation. These are determined by the canons of the profession. This relationship necessitates more face to face encounters between the researcher and the teachers. Teacher subjectivity is incorporated in the purpose of research inquiry and researcher's subjectivity is conceived as a filter through which data are collected and interpreted. Finally, the action research paradigm assumes a very interactive relationship between the researcher and teachers, in which both subjectivities are constantly scrutinized. This paradigm fully recognizes the personal and relational nature of the research relationship.

The successive development of these various educational research paradigms shows a growing recognition of researcher's subjectivity within the research experience. This progression moves from a suppressed subjectivity within the positivistic paradigm, towards a scrutinized subjectivity within the action research paradigm.

The Interactive Nature of Data Collection in Educational Research

The need for a systematic study of the relationship between researchers and teachers has been pointed out.

Jarvie (1969) started a debate on the ethical integrity of field work in anthropology. One of the participants in this debate, the anthropologist Brandewie (1969), emphasized the need to introduce elements of the personalist philosophy into our understanding of field work. He recognized that the researcher brings to the observation beliefs, values and personal theories which shape data collection and analysis. He encouraged serious reflection on the impossibility of avoiding researcher subjectivity within the research process.

School ethnography also has strong advocates for consideration of field work as a personal and interactive process. Ball (1989), for instance, described data collection as a social contract between researchers and teachers. On this view, the quality of data collected depends on the researcher's ability to establish open relationships with teachers. Ball also suggested stylistic changes in reporting educational research, which would acknowledge its autobiographical nature. His conception of field work is truly relational, putting new personal demands on the researcher.

Some researchers in social psychology have stressed the need to pay more attention to the relational and personal aspects of behavioral science research. Devereux (1969) noticed that the researcher was always absent in positivistic studies on human behavior. To give an accurate account of a human situation both the subjects and the researcher should be included:

> "Not the study of the subject, but that of the observer gives us access to the essence of the observational situation. The data of the behavioral sciences are, thus, threefold: (a) the behavior of the subject; (b) the disturbances produced by the existence and observational activities of the observer; and (c) the behavior of the observer: His anxieties, his defensive maneuvers, his research strategies, his decisions...." (Devreux, 1967, p. XIX).

The research experience is not only a personal process for the researcher, but also for the participants (Reason & Marshall, 1988). These two processes develop together in mutual interaction. Thus, the research experience is a personal and a social process (Allender, 1986). Berg & Smith (1988) recognized the importance of this mutual relationship, between the researcher and his subjects, in affecting research findings. They suggested that the research relationship be scrutinized as deeply as other methodological issues in the research process. They did not, however, consider this relationship particularly easy or straight forward (Berg, 1988).

> "What makes research relationships in the social sciences complex is the fact that both the researcher and the social system being studied contribute to the creating of the research relationship. In turn, the relationship has both emotional and intellectual consequences for both parties (Berg & Smith, 1988, p. 22)."

The research relationship is then not only a personal process, but also an interactional one. The researcher and participants develop a mutual relationship, through which data are collected and interpreted. This relationship deserves deeper analysis than it has so far received, especially at its intellectual and emotional levels. If the research act is to be better understood, closer attention must be given to the intellectual and emotional dimensions of the research experience. This analysis will strengthen the understanding of what is involved within the process of creating educational knowledge.

A Framework for the Study of Researcher's Experience Within Action Research

The present study draws from three different approaches. The understanding of the interactional environment within the action research group has been informed by Erickson's conception of "discourse as improvisation of meaning and social organization (Erickson, 1982)." The researcher's experience has been described at two levels: (a) the functions of researcher's talk; and (b) the symbolic and emotional dimensions of researcher's talk within the action research group. Work on discourse analysis has provided a set of concepts and procedures to approach the description of the functional nature of researcher's talk. Symbolic interactionism has provided a general framework for the understanding the role played by interpretation in human interaction.

The Environment of Researcher's Experience

Within the present study, the relationship between teachers and researcher is conceived as a communicative event. Therefore, the researcher's experience is interactional in nature. This interaction occurs within a specific social context created by both the teacher and the researcher. Action that emerges within the research communicative event follows an internal and autonomous development. This action can be explained within the constraints of the micro-world created by the interactional partners (Erickson, 1982; Cicourel, 1981). The research experience is considered to have a life of its own which is sustained through the verbal communication of the participants.

Erickson (1982) has identified two structures which ensure communication within a lesson: the social participation structure and the task structure. Although he inferred these structures from school lessons, they can be applied in other contexts. These structures are conceived as governing the sequencing and articulation of interaction. The social participation structure is constituted by a patterned set of constraints on the allocation of the rights and obligations of participants. The task structure is constituted by a patterned set of constraints set by the logic and sequence of the task. However, the degree of ritualization of both the social participation and the task structures varies for different speech events. For instance, religious celebrations are highly ritualistic communicative events, whereas everyday conversations are mostly spontaneous. The social environment of an action research group is far from being governed by ritualistic forms of speech or other non-verbal interactions. In fact, the communication between teachers and researchers has a degree of spontaneity somewhere between ritual celebrations and everyday conversations. The nature of action research talk shows that the social participation and the task structures undergo constant mutual adjustments. Erickson provides a framework for understanding the interactional nature of the research experience, within action research. Action research, like school lessons, is a "partially bounded social occasion influenced by cultural norms and having within its own frame something of a life of its own (Erickson, 1982, p. 164)." This social occasion or communicative event is guided by social participation and task structures. The researcher's experience within an action research group of teachers is then constrained by the social participation structure, the task structure, and their mutual adjustments.

The Description of Researcher's Experience

Researcher's experience within action research is described on two levels: (a) description of the specific functions attributed to researcher's talk along the action research experience, and (b) description of the emotional and symbolic dimensions of researcher's talk as occurred along the action research experience.

The functions of speech have been studied by discourse analysts (van Dijk, 1983, 1984, 1985; Levinson, 1983; Sinclair & Coulthard, 1975; Coulthard, 1977; Labov & Fanshel, 1977). Discourse analysis grew out of the field of linguistics. It attempts to study speech at a level different than that of the sentence:

> "The aim of discourse analysis is to give a coherent account of how order, sequence, and form are signalled, maintained, and produced over the course of a discourse or written text. The overall project is to expand the application of linguistics concepts and to explore speech in chunks larger than utterance or sentences (Manning, 1987, p. 99)."

Discourse analysts are very much aware that the study of language through syntactic or semantic analysis does not satisfactorily explain the orderly nature of discourse. They consider the structure and meaning of sentences one among several components of speech. Austin (1962) and his student Searle (1969) first pointed to the pragmatic nature of language. That is, they were the first to assert that when people talk, they perform acts with specific functions. On this view, language is not only structured expression but also intentional action. Austin (1962) imagined 10,000 different functions of speech, and grouped them under five headings:

- verdictive: grade, estimate, diagnose...
- exercitive: appoint, order, advise, warn...
- commissive: promise, bet, guarantee, oppose...
- behatives: apologize, criticize, challenge...
- expositives: argue, affirm, postulate, concede...

Much work has been done since the seminal studies of Austin and Searle. Discourse analysts have investigated speech within specialized contexts: therapeutic discourse (Labov & Fenshel, 1977); classroom discourse (reviewed in Cazden, 1986 and Florio-Ruane, 1987); and supervisory conferences discourse (Zeichner & Liston, 1984). Each of these specialized discourse studies developed its own system for the categorization of speech functions and its own rules of speech production. To my knowledge, no study has been done on discourse between educational researchers and teachers. But given that the supervisory relationship shares similarities with the educational research relationship, discourse within the former setting might provide clues for the interpretation of discourse within the latter. Unfortunately, research on supervision is far from satisfactory. In the most recent review on supervision, Glickman and Bey point out that "what exists in the research of direct supervision is a scattering of isolated, one-time studies that have little coherence among themselves (Glickman & Bey, in press)." Moreover, most studies on verbal interaction within supervisory conferences were undertaken under a process-product research paradigm. These studies used standardized interactive instruments, for the purpose of establishing relationships among educational variables (Holloway, 1982; Blumberg, 1970; Weller, 1971). In spite of these problems, the functional categories included in these interactive instruments might provide insight into the functional nature of verbal interaction in an action research context.

Discourse analysis tries to identify the functions of speech and the rules governing speech production in specialized interactive environments. By assigning functions to parts of speech and rules of production to sequences of functions, discourse analysis describes the social participation structure of communicative events.

Discourse analysis has not dealt with the symbolic and emotional dimensions of speech. Although recent attempts at constructing an interdisciplinary communication theory advocate introduction of the cognitive and emotional effects of speech within that theory (van Dijk, 1985), these approaches use a psychology drawn from the information processing paradigm. Symbolic interactionism (Mead, 1934; Blumer, 1969) has proved more useful in understanding the symbolic and emotional dimensions of researcher interventions. Symbolic interactionism explains human interaction as part of a process of in situ interpretation. Action and thought are not determined by psychological or emotional constructs located within the individual, but are developed through highly contextual interaction with others. Therefore, the symbolic and emotional dimensions of researcher's participation cannot be conceived as fixed within an isolated researcher's mind. Instead these dimensions can be understood through contextual interpretations of teachers' actions through interaction.

PURPOSE OF THE STUDY

This chapter forms part of a larger study on secondary science teachers' pedagogical problem solving strategies. It focuses on the relationship between the researcher and two teachers, as these teachers collaborate to solve their own pedagogical problems, and shows the interactive nature of field work undertaken under an action research paradigm. This chapter tries:

1. To develop a typology of researcher's patterns of intervention within group pedagogical problem solving, answering the question, "What does the researcher do within an action research group?"
2. To describe the evolution of these patterns of interventions with reference to the emotional and symbolic dimensions of the researcher's experience, answering the question, "How does the researcher interpret and feel within an action research group?"

METHODOLOGY

Design of the Research Experience

The design of the research experience was inspired by the action-research models proposed by Taggart & Kemmis (1982), Elliot et al. (1978), and Ebbutt (1985). One experienced teacher, one novice teacher and one researcher participated in the study. Both teachers taught 10th grade physics at the same public high school in Barcelona, Spain.

The three participants met once a week for two hours between October, 1986 and July, 1987. The purpose of the meetings was to solve pedagogical problems posed by the participant teachers. Each teacher identified one problem, which was dealt with in alternate meetings. At the end of each meeting the teachers committed themselves to test, in their own classrooms, the conclusions which emerged from group reflection. Moreover the teachers observed each other's classrooms, as did the researcher. These observations were discussed in subsequent meetings. Once a week the researcher met with a supervisor, who provided support and advice on facilitating group dynamics. The supervisor had a professional background in individual and group psychodynamics. Supervisory meetings centered on the researcher's personal notes, written after each meeting with the teachers.

Description of Participant Teachers and Researcher

As noted above, one experienced teacher, one novice teacher and one researcher participated in the study. The researcher (myself) was introduced to the teachers by the superintendent of the Barcelona school system. Both teachers taught 10th grade physics at the same high school in Barcelona, Spain. The experienced teacher, a male in his thirties, had 7 years of teaching experience. He headed the physics and chemistry department, and held bachelors and masters degrees in physics. He had also completed some research work toward his PhD in physics, before deciding to leave the university. He had applied for a position in the public school system to secure a stable income. After two years of teaching physics, he began to develop curriculum units based on a conceptual change approach to the learning of physics and chemistry. At the time he joined the research group, this teacher had already developed all the curriculum units for the teaching and learning of 10th, 11th and, 12th grade physics under a conceptual change approach.

The novice teacher was also male in his thirties, but with no experience teaching high school physics and chemistry. He held bachelors and masters degrees in chemistry, and a PhD degree in organic chemistry. He had also decided to leave the university in order to have a stable income. These two teachers had a good relationship, based on trust and friendship. The novice had a profound respect for the teaching approach developed by the experienced teacher.

The experienced teacher identified, as his research problem, that of inducing his students to work on complex physics problems at home. He wanted to transform his classroom into a place where students brought their own ideas for debate. The novice teacher decided to work on the problem of managing conceptual conflict within the classroom. Conceptual conflict is a crucial learning strategy within the conceptual change approach. Students are encouraged to articulate their own ideas, conceptions and beliefs about phenomena. Once their views are known, a confrontation needs to take place in order to select the best among them.

Data Collection

Four sources of data collection were used: (a) researcher field notes based on classroom observations; (b) audiotapes and transcriptions of each meeting; (c) researcher's personal notes after each meeting with the teachers; and (d) researcher's personal notes after each meeting with her supervisor. Field notes from approximately 40 classroom periods were collected for each teacher. The teachers and the researcher met 15 times for an average of one hour and 45 minutes. These meetings were audiotaped and transcribed by the researcher; the total number of transcription lines was 10,870. There were 12 supervision meetings lasting an average of one hour.

Data Analysis and Interpretation

Data analysis occurred at three levels: (a) quantitative analysis of teachers and researcher participation; (b) functional analysis of researcher interventions; and (c) emotional and symbolic analysis of the development of researcher intervention patterns.

Quantitative Analysis

Quantitative analysis focused on participants' interventions within the conversation, based on quantitative indicators obtained directly from the transcripts of each meeting. The quantitative indicators provided a general though superficial portrait of each participant's interventions. These indicators included: (a) percent of transcription lines per participant; (b) percent of interventions per participant; and (c) number of transcription lines per intervention and participant.

Functional Analysis

Functional analysis focused on the researcher's intervention patterns. These were statements which had a specific function within the group conversation.

The functional analysis of participant's interventions within discourse has been extensively developed by discourse analysts (van Dijk, 1983, 1984, 1985; Levinson, 1983; Sinclair & Coulthard, 1975; Coulthard, 1977; Labov & Fanshel, 1977). The problem of finding the appropriate unit of speech to which a function can be associated was and remains difficult (van Dijk, 1985; Levinson, 1983). However, some researchers (Labov & Fenshel, 1977) de-emphasized this problem, asserting that nothing of theoretical importance depended on the size of this unit. In any case, each researcher needs to make a personal decision concerning the most appropriate unit of analysis.

Researchers agree upon the general characteristics of the functional categories of speech units (Sinclair, 1973). First, they should be finite in number; second, they should be comprehensive; third, there must be at least one impossible combination among them; and, finally, they should clearly relate to the data. However, the functions attributed to each speech unit are strongly dependent on the context in which speech takes place. Thus, each study needs to define its own units of analysis and functional categories, based on the specific contexts under observation.

Once the units of analysis have been chosen, and a category system of functions constructed, speech analysts look for patterned sequences of functions within discourse. These patterned sequences should account for the orderly nature of a discourse or conversation.

The unit of analysis for the present study of is the amount of speech included in one full turn. A turn is defined as the structural unit which contains what a participant says or does during a continued interactive intervention (van Dijk, 1983). This unit of analysis is called an intervention in the present study, and the different functions of researcher interventions are called intervention patterns. In making this selection, it is not implied that all analyses of researcher speech should use the turn unit of analysis. In this particular setting, the researcher participated with rather concise and monofunctional interventions. In settings where researchers had less frequent but longer interventions, smaller units of analysis might be more appropriate.

The category system was developed along lines proposed by Sinclair (1973): (a) the number of functional categories is kept small and manageable; (b) the functional categories are mutually exclusive; and (c) they are clearly related to the data and easily operationalized (the "impossible combination" requirement does not apply to the present study). This study does not try to capture the sequences of researcher's interventions within each meeting. Instead, patterns of sequences are sought across different conversations. This captures the regularity of researcher's interventions through the whole experience of group pedagogical problem solving.

Emotional and Symbolic Analysis

The third level of analysis, was an emotional and symbolic analysis of researcher's interventions from the researcher's point of view. It focused on researcher's personal world as it changed during interaction with the teachers, and described key events in the development of researcher's patterns of intervention.

The definition of an interactional event has been informed by the following conceptions: (a) the speech event (Gumperz & Hymes, 1964; Hymes, 1972), (b) conversational strategy (Craig and Tracy, 1983), and (c) units of communicative interaction (vanDijk, 1984, 1983). An interactional event is a sequence of interrelated interventions having the same theme. A sequence of interactional events make up a conversation or a meeting. Participants contribute to the interactional event with goal directed interventions guided by in-situ interpretations. The symbolic dimensions of human interaction were first pointed out by the symbolic interactionists (Mead, 1934; Blumer, 1969).

Interpretations sometimes cause conflict and generate emotional anxieties (Devereux, 1967; Berg, 1988). This is due to the varying nature of the goals and intentions of group members (Craig & Tracy, 1983). Hence, the description of researcher's intervention patterns must include both the symbolic dimensions of interaction and the emotional ones.

This analysis of the symbolic and emotional dimensions of researcher's intervention centers on key interactional events. These events were selected for their relevance in particular contexts. Data for this analysis consists of the researcher's personal notes on each meeting with the teachers, and her notes of her own supervisory meetings.

DESCRIPTION OF RESEARCHER INTERVENTIONS

Quantitative Description of Researcher and Teacher Interventions

The quantitative indicators used to analyze researcher and teacher interventions included: (a) percent of transcription lines per participant; (b) percent of interventions per participant; and (c) number of transcription lines per intervention and participant. The percentage of each participant's transcription lines per meeting is shown in Table 5-1 and Figure 5-1.

The experienced teacher talked the most in each meeting, averaging 55 percent of the total number of transcription lines. The beginning teacher averaged of 29 percent and the researcher 16 percent of the total transcription lines.

The number of interventions provides another indication of researcher and teacher participation within the conversation. The percentage of each participant's number of interventions per meeting is shown in Table 5-2 and Figure 5-2.

An average of 46 percent of the total number of interventions per meeting came from the experienced teacher. 35 percent of the total number of interventions per meeting originated from the beginning teacher, and only 19 percent came from the researcher.

Combining the number of transcriptions lines and the number of interventions produces a new indicator, called the density of intervention. It provides the average number of transcription lines per intervention and meeting. The density of interventions for each participant is presented in Table 5-3 and Figure 5-3.

Table 5-1

Researcher and Teacher Participation in Group Pedagogical Inquiry

(% Transcript lines per participant)

MEETING	TOTAL(n)	R(%)	ET(%)	BT(%)
Meeting # 1	694	23	59	18
Meeting # 2	671	27	49	24
Meeting # 3	651	16	60	24
Meeting # 4	781	7	72	21
Meeting # 5	788	15	60	25
Meeting # 6	974	12	54	34
Meeting # 7	644	32	42	26
Meeting # 8	568	10	56	34
Meeting # 9	704	29	39	32
Meeting # 10	944	17	48	35
Meeting # 11	428	16	60	24
Meeting # 12	756	11	60	29
Meeting # 13	809	3	52	45
Meeting # 14	872	12	65	23
Meeting # 15	528	6	57	37
TOTAL	10,812	16	55	29

R= Researcher; ET= Experienced Teacher; BT= Beginning Teacher

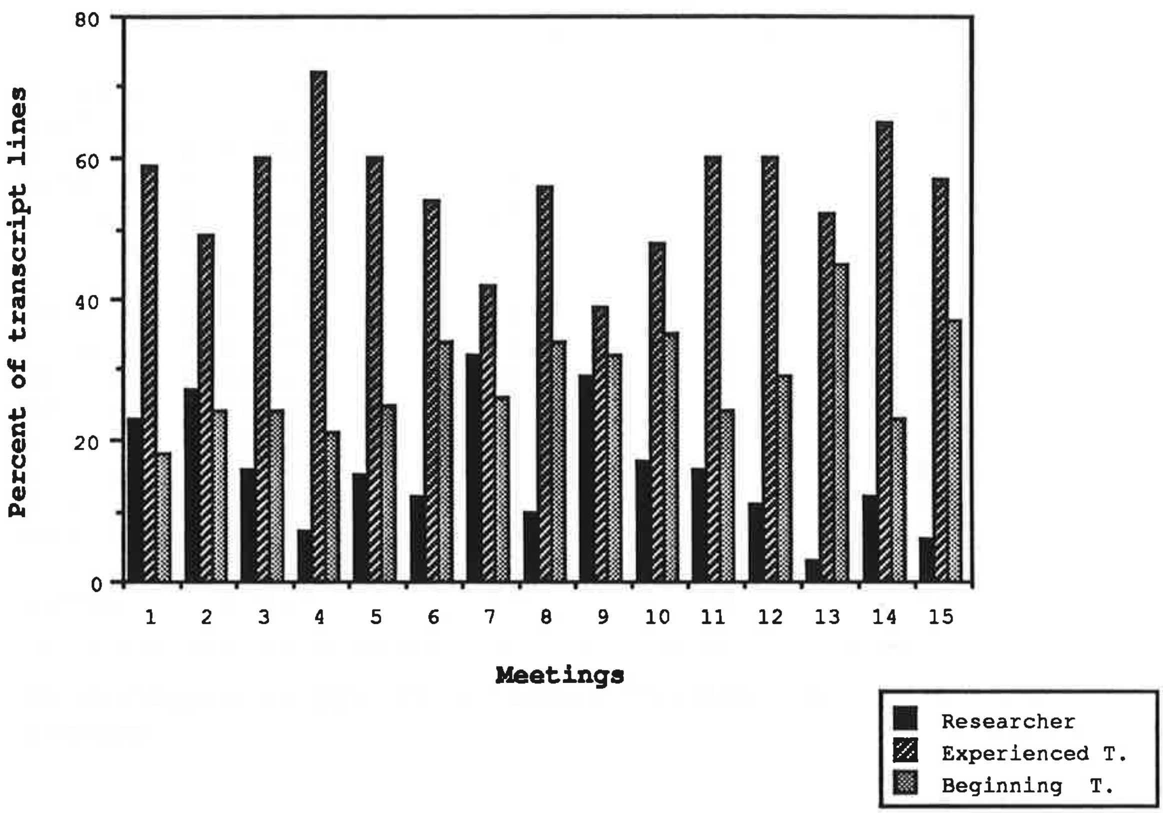


Figure 5-1. Researcher and Teacher Participation in Group Pedagogical Inquiry.

Table 5-2

Researcher and Teachers' Interventions in Group Pedagogical Inquiry

(% Interventions)

MEETINGTOTAL(n)	R(%)	ET(%)	BT(%)
Meeting # 1 123	31	49	20
Meeting # 2 145	22	45	33
Meeting # 3 182	19	50	31
Meeting # 4 153	13	54	33
Meeting # 5 217	23	48	29
Meeting # 6 250	24	44	32
Meeting # 7 173	28	41	31
Meeting # 8 135	19	42	39
Meeting # 9 235	25	36	39
Meeting # 10247	21	40	39
Meeting # 11138	19	44	37
Meeting # 12263	11	52	37
Meeting # 13272	7	47	46
Meeting # 14208	17	47	36
Meeting # 15176	8	48	44
TOTAL 2,917	19	46	35

R= Researcher; ET= Experienced Teacher; BT= Beginning Teacher

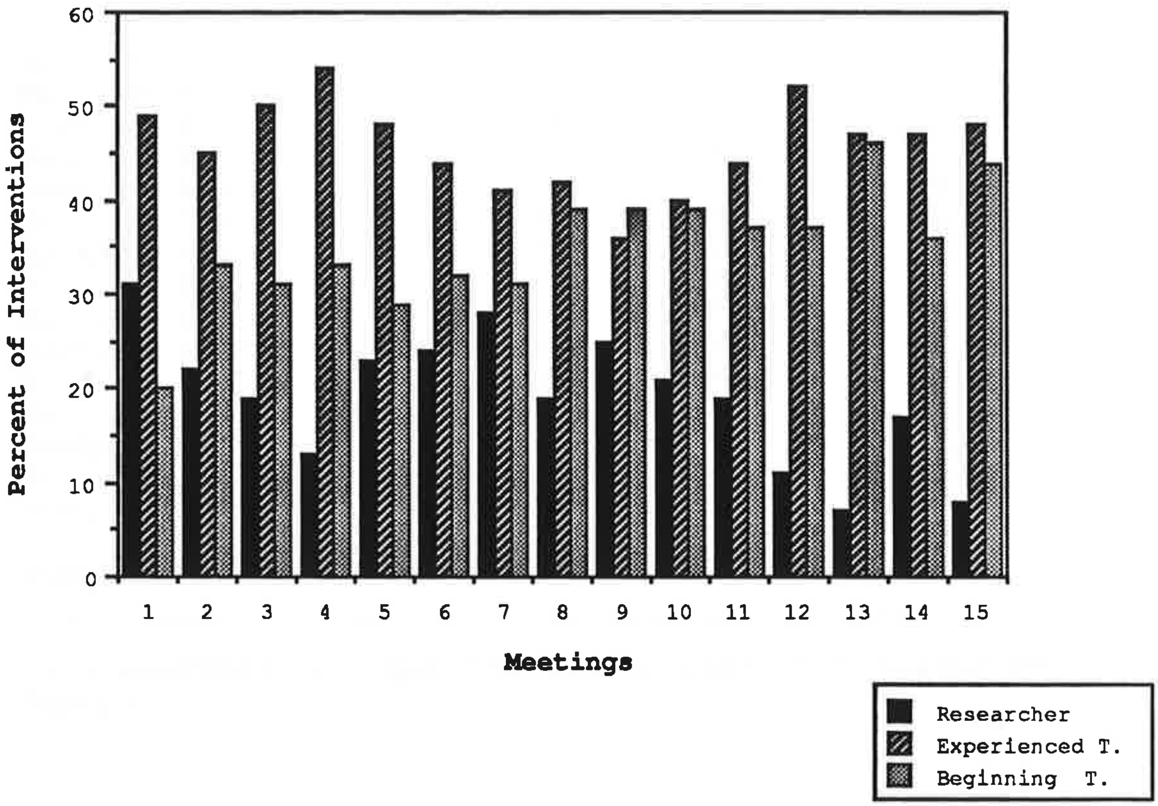


Figure 5-2. Researcher and Teachers' Interventions in Group Pedagogical Inquiry.

Table 5-3

Density of Researcher and Teachers' Interventions

(Average number of lines per intervention)

MEETING	R	ET	BT
Meeting # 1	4.2	6.8	5.0
Meeting # 2	5.6	5.0	3.3
Meeting # 3	3.0	4.2	2.8
Meeting # 4	2.5	6.8	3.2
Meeting # 5	2.4	4.5	3.2
Meeting # 6	1.9	4.8	4.0
Meeting # 7	4.2	3.8	3.2
Meeting # 8	2.2	5.6	3.7
Meeting # 9	3.4	3.2	2.5
Meeting # 10	2.9	4.7	3.4
Meeting # 11	2.5	4.2	2.0
Meeting # 12	2.8	3.3	2.3
Meeting # 13	1.2	3.3	2.9
Meeting # 14	3.0	5.8	2.6
Meeting # 15	2.0	3.5	2.5
TOTAL	2.9	4.7	3.1

R= Researcher; ET= Experienced Teacher; BT= Beginning Teacher

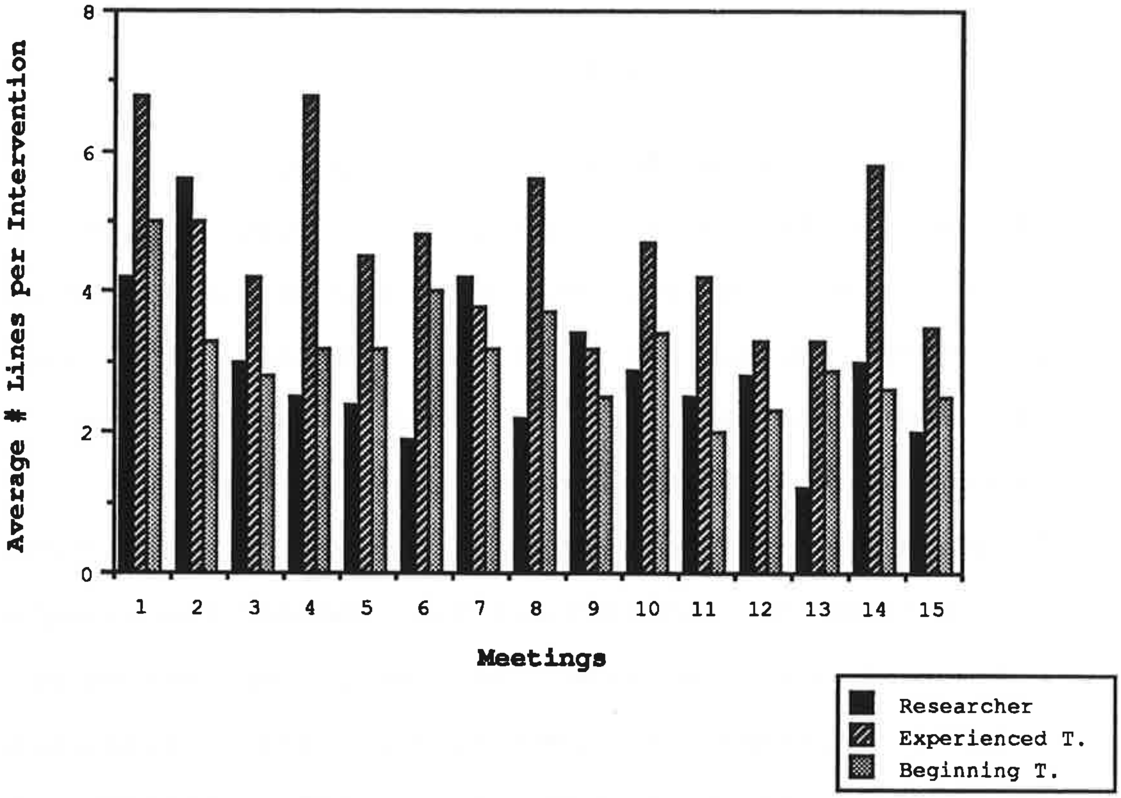


Figure 5-3. Density of Researcher and Teachers' Interventions

Here again, the densest interventions were those of the experienced teacher. His average number of transcription lines per intervention, across meetings, was 4.7. The density of the beginning teacher's interventions was 3.1 transcription lines per intervention across meetings, and the density of the researcher's interventions was 2.9.

Discussion

The average quantitative profile of the group pedagogical problem solving process was as follows: more than half of the transcription lines originated from the experienced teacher. His interventions were denser than those of the beginning teacher and the researcher. About one third of the transcription lines came from the beginning teacher. His interventions were shorter than those of the experienced teacher, and approximately as dense as those of the researcher. This quantitative profile bears some similarities with that reported in literature on the supervision conferences of student teachers. Chandler (1971) and O'Neal (1983) found that the discussion in these conferences was clearly dominated by the cooperating teacher.

Researcher's Intervention Patterns

The first level of analysis provides a quantitative, somewhat superficial description of researcher and teachers interventions. The second level of description, a functional analysis of the researcher's participation, creates a typology of researcher's intervention patterns, based on their function within the group's conversation. These patterns are exhaustive and mutually exclusive. Identification of these functional patterns of intervention allows systematic characterization of the different roles played by the researcher, within group pedagogical problem solving.

Four types of intervention patterns were identified: (a) procedural interventions; (c) provider interventions; and (d) reflection interventions. The frequency graph of these intervention patterns over time provides a general picture of the development of researcher's interventions. (Table 5-4)

What follows is a description of the various researcher intervention patterns, illustrated with examples from the transcripts.

Procedural Interventions

Procedural interventions helped to organize inquiry. Usually the researcher made these interventions, although the teachers did, too. The interactions from which these procedural interventions originated were usually short and not problematic. Researcher's procedural interventions had the following specific functions:

1) Opening the meeting:

> "R- What do you want to start with? Do we have enough time?" (M14)

Table 5-4

Evolution of Researcher's Intervention Patterns

Meeting	Procedural (%)	Facilitation (%)	Providing (%)	Reflection (%)
Meeting # 1	2	13	45	40
Meeting # 2	15	25	16	44
Meeting # 3	20	54	0	26
Meeting # 4	25	60	0	15
Meeting # 5	42	18	0	40
Meeting # 6	2	38	0	60
Meeting # 7	19	0	46	35
Meeting # 8	8	19	19	54
Meeting # 9	5	0	20	75
Meeting # 10	0	21	67	12
Meeting # 11	0	15	57	28
Meeting # 12	3	0	25	72
Meeting # 13	0	30	25	45
Meeting # 14	34	9	0	57
Meeting # 15	20	54	13	13

"R- Well, let's see... BT had new ideas... ET- Are we still dealing with this? R- This is so important!" (M4)

2) Closing the meeting:

"R- As long as we keep high spirit! Well, do you think we should discuss the same subject, tomorrow?" (M3)

"R- Then, next week we have decided to talk about the problem. I will observe both of you on Monday and Wednesday. In any case, we left everything kind of open, right?" (M7)

"R- Well, we can talk about... BT- I needed to go, but I will leave later. R- We have only two meetings left...any idea about how to organize them?" (M14)

3) Monitoring the process of inquiry:

"R- This is interesting for all of us. When things happen it is better to deal with them at once, otherwise we forget them" (M4)

"R- I think we do not have enough time. Should we switch to something else right now? ET- Do you think it is worth staying with the same or we should change? R- You still have the problem of group work. I am not sure what your schedule is" (M14)

"R- I think this is very interesting...I think this problem is not solved yet. Last meeting we were very much concerned with finding solutions, we were anxious about them. But nothing came up...because I think we were not facing the problem the right way. We did not reflect on possible explanations. If we understand why students did not do the homework we will be better able to find solutions, right?"(M3)

The procedural function of speech has been recognized by most discourse analysis studies. Labov & Fanshel (1972) identified similar functions within therapeutic discourse. They called these meta-linguistic functions, having the purpose of initiating, interrupting, or redirecting discourse. Holloway (1982) included a procedural function called "orienting" as one of the interventions within supervisory conferences. Bales (1950) developed one of the first analyses of small group interactions. He identified the speech function of orientation as a part of the group interaction. Two categories were thought to fulfill the orientation function: asking for orientation, and giving orientation. Conversational analysts have studied these procedural functions as part of the overall organization of conversations (Levinson, 1983). They conceive a conversation as a socially organized system of interactions. Opening and closing speech acts were identified as necessary parts of any conversation.

Facilitation Interventions

Researcher's facilitation interventions facilitated teacher discourse. These interventions occurred while teachers were either describing an experience or event, constructing an hypothesis of solution, or planning a solution to be tested in the classroom. Interactions in which facilitation interventions took place were dominated by the teachers. They had the central role while the researcher had a secondary, supporting one.

Four types of facilitation interventions were identified:

1) Rephrasing:

> "R- This would resolve, as you said, the problem of students saying 'I do not understand' right?" (M3)

> "R- If I understand correctly, you want to check only on the complex problems students do at home"(M5)

"R- That is, you use the word theory from the beginning, whereas you said to use it at the end of the unit" (M10)

2) Asking for expansion of contextual information:

"R- With whom were you talking when it happened? To John?" (M3)

"R- What kind of students were these?"(M3)

"R- What happened when you decided not to do it?"(M3)

"R- What did you do then?"(M1)

"R- Did it imply a lot of extra work for you?"(M4)

"R- What are the sections you said we needed to change?"(M10)

3) Predicting:

"R- And then, did you have to start the reconstruction of the argument?"(M1)

"R- Really?. This might have frightened all of them. Or not?"(M6)

4) Making value statements:

"R- You are all too nice to each other today!"(M5)

"R- Very interesting!" (M6)

"R- That's great! Don't you think so?"(M8)

"R- Yes...this would be great!"(M12)

Provider Interventions

Researcher's provider interventions gave information to the teachers, drawn from researcher's personal experience, readings, direct classroom observations, and intuition. The researcher's provider interventions were either requested by the teachers, or initiated by the researcher. In both cases, they generated interactions in which rejection or acceptance of ideas was negotiated through group conversation.

Provider interventions had three specific functions:

1) Adding classroom observations the teachers' descriptions:

> "R- I saw two different students' interpretations. You discussed with them which interpretation was the best. Students could distinguish the two phases of the elevator ascending movement" (M7)

> "R- I detected some students statements which I think are related to what you are saying. It's related to the frictionless movement. In each of your classroom two or three students were very interested in knowing more about it. They said: 'Let's do it!'" (M2)

2) Providing hypotheses of solution:

> "R- Why don't you select one student to be in charge of collecting scientific news? Or other similar things?"(M1)

> "R- Some researchers have been working on motivation techniques. I have an article on motivation techniques for the classroom. You might find some useful ideas" (M10)

> "R- There are different things we could do. One thing would be to exert pressure on them to have the homework done. What happens if students come back to the classroom without the work done? You cannot go further as a teacher. You need to do something"(M10)

3) Providing ideas to construct either a teaching strategy to be tested in action, an activity to be included in the curriculum units, or a classroom research strategy.

3.1 The construction of a teaching strategy to be tested in action:

> "R- If you do not have time to write a complete curriculum unit, why do not you try something less time consuming but equally useful?"(M9)

3.2 The construction of an activity to be included in the curriculum unit:

> "R- You might find useful what I did some time ago with the concept of heat. We asked our 12-14 years old students something as absurd as this" (M10)

3.3 The construction of a classroom research strategy:

> "R- I think the difficulty of the problem might lead to changes. However, we can also do something different, more qualitative. We could select three or four students and look closely at them" (M7)

Holloway (1982) identified two interactive categories of researcher interventions: (a) Giving factual information; and (b) Giving suggestions. Bales (1950) identified an area of interventions, of providing answers to group tasks. The statements gave either suggestions, opinions or orientation. Labov & Fanshel (1977) identified a group of speech acts called "representations." It included information giving and asserting.

Reflection Interventions

Researcher's reflection interventions encourage teacher deliberation on the ideas coming up in conversation. Both the researcher and the teachers used reflection interventions, which led to the most intense and emotional group interactions. Reflection interventions raised the conceptual level of the conversation from description to interpretation of actions.

Reflection interventions had four specific functions:

1) Requesting the comparison of events

1.1 Requesting comparison of two events separated in time.

"How much different is what happened yesterday from what happened some years ago?"(M13)

"What difference have you detected between students' response to the algorithmic problem and their response to this new and more open problem you have designed? How do you evaluate it?" (M6)

1.2 Requesting comparison between both teachers.

"Yes, I suppose this might depend on the curriculum guides. The guides you both have made, do they differ?" (M7)

"So, you think it is the activity. Do you think it is the activity as well, ET?" (M6)

2) Requesting reasons and interpretations

2.1 Requesting a teacher's point of view or interpretation.

"I do not understand the difference you make, that is, the problem of considering group work as a habit or as an instrument." (M1)

"I am thinking that you tested it in the past and for some reason it did not work. It would be interesting to know why it did not work." (M1)

"You had the feeling that students did not experience conflict. How do you interpret what happened?"(M2)

2.2 Requesting a teacher's reaction to new interpretations

" What does it mean to go with the flow? Do you convince students with arguments in order to force them to forget those ideas you are not interested in?"(M1)

"Couldn't we get some ideas from this event? I have the feeling that this is a very important issue. These students seem to be good drawers...there must be something which explains this. Some ideas?"(M3)

2.3 Challenging teachers' beliefs

"R- But...imagine you are participating in a debate between your approach and the traditional approach to the teaching and learning of science. ET- Oh! This is easy because I have many arguments. R- This is what BT is asking you." (M5)

"R- Do you think your teaching and learning approach is worth doing? BT- I think it is worth doing. R- Why? Could you convince me? BT- Why should students do all these activities? ET- This is a provocation!"(M14)

2.4 Requesting interpretations of the pedagogical problem solving process (meta interpretations)

"R- I would like to ask you something very important. ET- Is it interesting? R- I don't know, but it certainly interests me. Let's see, if someone is telling you that an activity works do you believe him? Or else, do you need to be convinced by him?"(M14)

"You have not changed the checking of homework that much, right? You already had a kind of habit with it. What have you changed? What has been your focus all this time? How do you explain your new perspective?" (M5)

3. Providing reasons and interpretations.

3.1 Providing alternative interpretations

"R- I would go deeper into it. These students might do something or not...however I see a problem of self-confidence in solving problems to which they do not already know the solution. Let's think of a student with low self-esteem in facing a difficult problem. He will never begin to deal with the problem if he feels he will never solve it." (M7)

3.4 Providing interpretations for a joint conversation.

"BT- Conceptual change is not something you. ET- you... you get up in the morning and oops! that's it! No more...you abandon immediately your old view... BT- It seems that everything is clear, but when you ask them to think differently... ET- It is a matter of a profound resistance... R- Or a matter of a conquest millimeter by millimeter; ET- True, it is a conquest millimeter by millimeter. Think of the poor Copernico. After organizing such a mess, he was more Ptolemaic than anybody else. Similarly with Galielo. He made serious mistakes with the principle of inertia. It is not a change at the individual level, but at the generational level. Any advancement is so, so slow!" (M6)

3.3 Providing reasons to convince a teacher.

"BT- What you say is that I could test the curriculum unit right now...to see how it works; R- You would feel so committed with your own curriculum unit! It's... ET- Yes... R- It would be like your son. It will not be easy, but you are going to learn so much! ET- It will be yours; R- Moreover your attitude will change completely. You will defend the curriculum unit because you will have reasons for it." (M9)

No functional category similar to the reflective has been found in the literature reviewed. Most discourse analysts separate the function of requesting from that of giving. Holloway (1982), for instance, emphasizes the distinction between giving and requesting interpretations, rather than joining them. Bales (1950) also distinguishes giving suggestions or opinions, from asking for suggestions or opinions. Labov and Fanshel (1977) posited two functions, one of providing information, evaluation and interpretation, and the other requesting them. However, he did introduce another speech function called "challenging" which included more personal speech actions like critiquing, attacking, praising and supporting. Although such interactions are not specifically reflective, they could be considered part of a reflection intervention as defined by the present study. The reflection interventions identified in this study both give and ask for statements, while sharing the function of encouraging reflection.

Discussion

The four functions of researcher interventions identified in this study point to the existence of four different researcher roles. Procedural interventions correspond to the role of organizing and monitoring. Facilitation interventions correspond to the role of supporting the teachers' talk. Provider interventions correspond to the role of giving information and knowledge. Finally, reflection interventions correspond to the researcher's role of encouraging the teachers' higher order thinking and argumentation. Some of these functions have been acknowledged by discourse analysts working in different contexts. This shows that speech functions have similarities and differences in specific contexts. Thus the use of a standardized system to study interactions is inappropriate. Each study, and each interaction group, needs to identify speech functions which were meaningful for its own participants.

The question of how the researcher's intervention patterns changed over time remains. Studies on supervisory conferences have mostly dealt with the interaction occurring at a specific conference. However, Kagan (1988), in a recent review on supervision, pointed out the need to investigate supervisory conferences over time, in order to capture the growth patterns of those involved.

Development of Researcher Intervention Patterns

The researcher's intervention patterns changed from one meeting to another. Their evolution is shown in Table 5-4 and Figure 5-4 and 5-5 which indicate the frequency of each researcher intervention pattern per meeting.

Procedural and facilitation intervention patterns show similar developmental tendencies (Figure 5-5). Their relative frequency increases from the first meeting on. The frequency of procedural intervention reached a maximum in meeting five, facilitation intervention reached a maximum in meeting four. The frequency of both types of intervention began to decrease after which they got consolidated. By meeting 13 the frequency of both procedural and facilitation interventions began to rise again.

The development of researcher's provider and reflection intervention patterns was different (Figure 5-4). The relative frequency of both intervention types decreased from the first meeting on. The reflection intervention reached its minimum in meeting four, after which it began to increase irregularly. During the last three meetings the frequency again faded, reaching a minimum in the last meeting. The provider intervention frequency, on the other hand, reached a minimum during the third meeting and remained constant until meeting six. After this it started to increase irregularly. By meeting ten, however, provider intervention frequency again decreased, to a minimum in meeting 14. While provider and reflection interventions

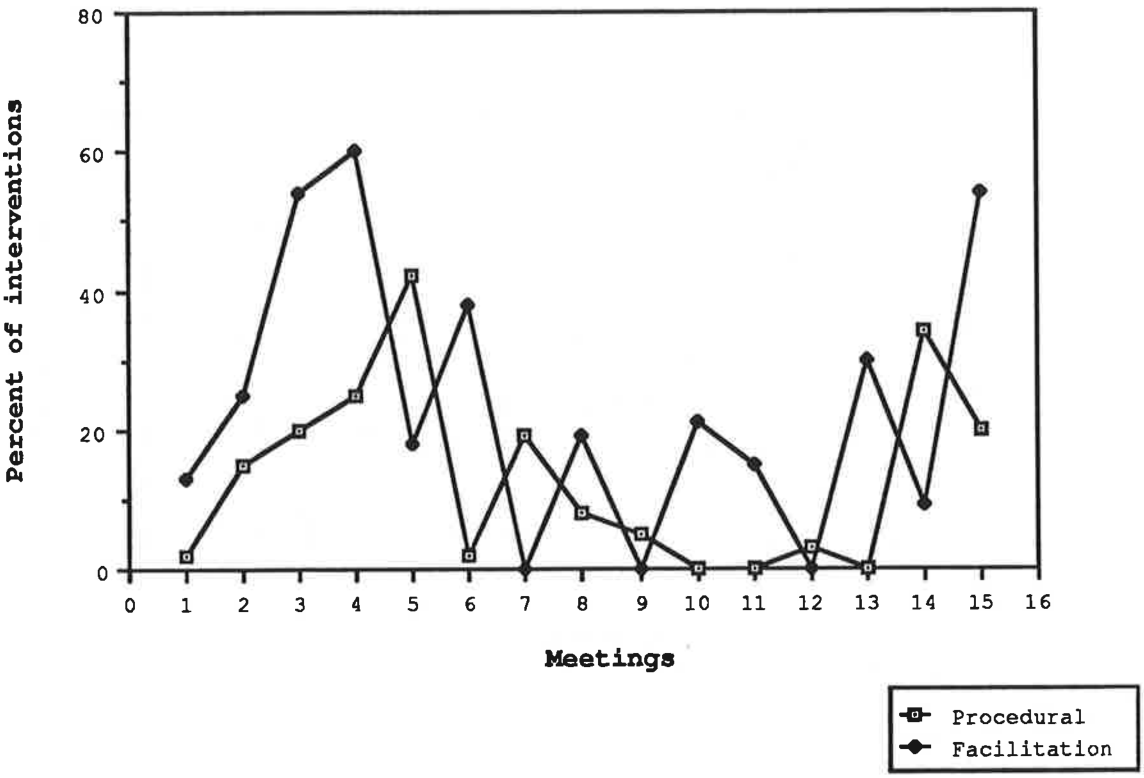


Figure 5-4. Evolution of Researcher's Procedural and Facilitation Interventions.

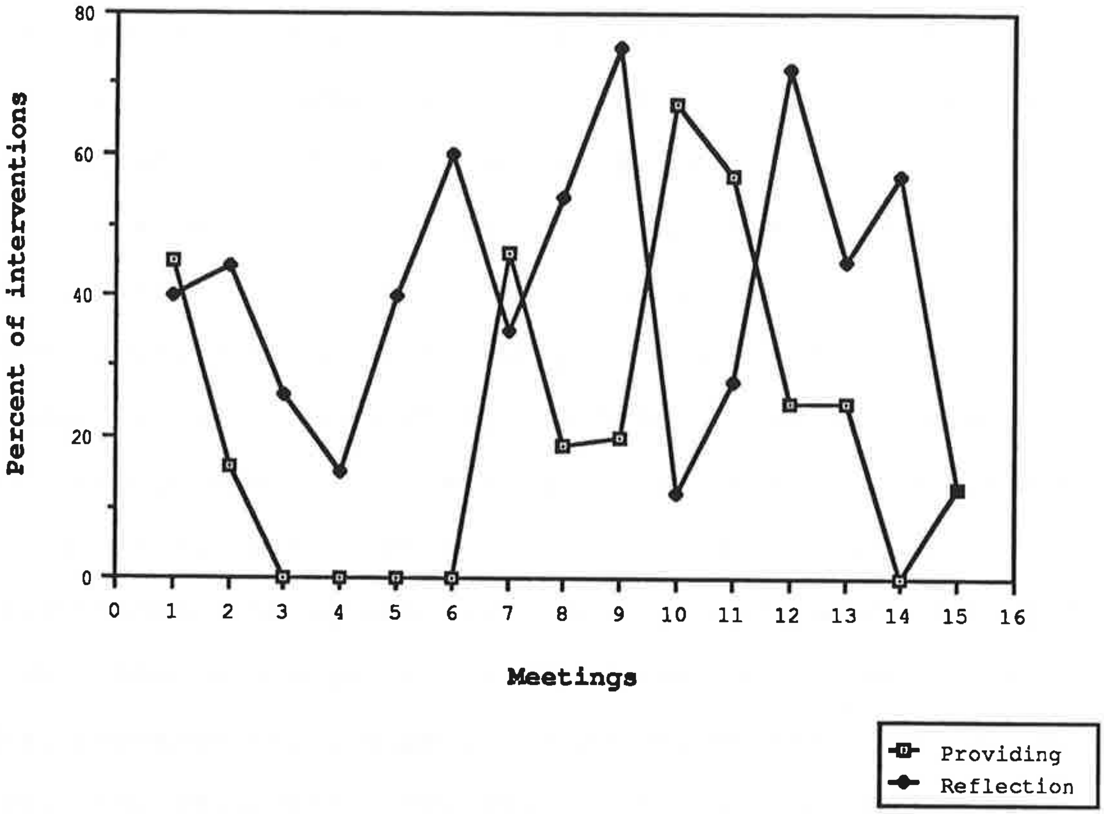


Figure 5-5. Evolution of Researcher's Providing and Reflection Interventions.

showed a similar decreasing tendency during the first four or five meetings, they evolved in opposite ways from then on. In meetings where the frequency of provider interventions was high, the frequency of reflection interventions was low. The opposite was also true.

One way to describe this development is to use the concept of group phases. Social psychologists have identified different phases to account for the emotional and intellectual changes in small group interactions (Bales & Strodtbeck, 1951; Bennis & Shepard, 1956; Bion, 1959; Schein, 1969). Researchers disagree on the number and sequence of phases; however, all seem to agree that there are at least three phases characterized by specific relationships among the group members and towards the group task. Recent studies on collaborative action research show that research teams experience phases in the group process (Smulyan, 1988; Oja & Smulyan, 1989). These phases are characterized by distinct research tasks and interpersonal concerns.

The development of the researcher's intervention patterns in the present study, seemed to indicate the existence of three different phases within the action research process. These phases were characterized by differences in teacher and researcher participation.

The first phase began with the first meeting and ended between meetings three and five. During this first phase researcher's procedural and facilitation interventions played an increasingly major role, while provider and reflection interventions became less frequent. A second phase began when researcher's interventions became more providing and reflective. Meetings were characterized by high frequency peaks in either provider or reflective intervention patterns. When the frequency of researcher's reflection interventions was high, the frequency of providing interventions was low, and vice versa. Between meetings ten and thirteen, the developmental tendencies reversed, indicating a third and last phase within the action research process. Table 5-5 provides quantitative indicators of teacher and researcher participation within each of the three phases. The three phases are not clearly delimited. Transition from one phase to another does not occur suddenly, but smoothly during several meetings. Despite this, selection of boundaries is necessary to provide quantitative indicators of teacher and researcher participation. Table 5-5 delimits Phase 1 as meetings 1 through 4, Phase 2 as meetings 5 through 10, and Phase 3 as meetings 11 through 15.

The first phase of the action research process was characterized by the densest interventions. The average density of interventions for all participants decreased in subsequent phases. The average frequency of beginning teacher interventions increased from the first phase to the third phase, while that of the researcher decreased. The experienced teacher's talk decreased from the first to the

Table 5-5

Phases of Group Pedagogical Inquiry
Supported by the Quantitative Indicators

Participation in Group Pedagogical Inquiry

Phases of Group Problem Solving	R(%)	ET(%)	BT(%)
First Phase (1-4)	18	60	22
Second Phase (5-10)	19	50	31
Third Phase (11-15)	10	59	31

Interventions in Group Pedagogical Inquiry

Phases of Group Problem Solving	R(%)	ET(%)	BT(%)
First Phase (1-4)	21	49	30
Second Phase (5-10)	23	42	35
Third Phase (11-15)	12	48	40

Density of Interventions

Phases of Group Problem Solving	R	ET	BT
First Phase (1-4)	3.8	5.7	3.6
Second Phase (5-10)	2.8	4.4	3.3
Third Phase (11-15)	2.3	4.0	2.5

R= Researcher; ET= Experienced Teacher; BT= Beginning Teacher

second phase, then increased from the second to the third phase.

Discussion

The relative frequencies of intervention patterns appear to indicate that group interaction changed qualitatively during the group action research process. The tendencies of researcher's intervention patterns and variation in the quantitative indicators support for a model of group action research as a sequence of three different phases.

The researcher's participation during each phase is characterized by specific, salient functions. For instance, during the first phase researcher intervention patterns were more procedural/facilitation than provider/reflection. In the second phase, researcher participation was more provider/reflective than procedural/facilitation. However, the provider and reflective functions of researcher talk showed opposite tendencies. When the meeting was characterized by frequent reflective interventions, facilitation interventions were relatively infrequent. The opposite was also the case. From this we can conclude that the participation of external collaborators within action research groups is multifunctional, depending on the development of the action research group.

Oja & Smulyan (1989) investigated the university researcher's roles across the group phases of a two year-long action research project. Their study identified five group phases rather than three, and fifteen possible researcher roles instead of the four suggested in the present study. Despite these differences, there are similarities. For instance, the most frequent researcher roles found by Oja and Smulyan during the first two group phases, were sets agenda/asks for agenda, leads the group, and questions/asks for information/probes. These roles are similar to the procedural and facilitation roles identified in the present study. The most frequent university researcher roles during the intermediate group phases of the former study were clarifies, summarizes, models research, and questions/asks for information/probes. Although these roles are not reflective, they suggest a more researcher involved in the action research process. The final group phase of Oja & Smulyan's study showed low frequency in almost all university researcher roles.

Researcher intervention patterns did not occur in isolation. In the current study they represented an average of 19 percent of the total interventions per meeting (Table 5-2 & Figure 5-2). In fact, researcher interventions were an important part of group interactions. Through these interactions the researcher was interpreting as well as feeling teachers' interventions. These interpretations and feelings influenced researcher's subsequent interventions. Only an understanding of the emotional and symbolic dimensions of researcher's interventions can provide a context for understanding changes in intervention patterns during the action research process.

THE EMOTIONAL AND SYMBOLIC DIMENSIONS OF RESEARCHER'S INTERVENTIONS

Description of the emotional and symbolic dimensions of researcher interventions will be divided into three parts, representing the three phases of the action research process as experienced by the researcher: (a) exploration, (b) consolidation, and (c) cohesion.

For each phase, each of the four types of interventions - procedural, facilitation, provider and reflection - are described. This division is supported by information drawn from quantitative, functional and symbolic/emotional analysis. Quantitative analysis described differences in levels of participation during each phase. Functional analysis showed researcher's intervention patterns changing to fulfill different functions at different times during the development of the action research group. Symbolic and emotional analysis will describe researcher's interpretations and feelings during the action research process. Data for this analysis come from the researcher's personal notes of her meetings with the teachers, and with her supervisor. Unlike previous sections, the following is written in the first person. Quantitative and functional analyses provided a detached view of researcher's participation, while symbolic and intellectual analysis gives voice to the researcher's experience.

First Phase of Researcher Experience: Exploration

I was part of a group of secondary science teachers working towards the solution of their own pedagogical problems. This process took some time to consolidate. The first, exploratory phase was the most difficult and emotionally draining period of the whole experience. Insecurity and uncertainty frustrated the interactions among group members. We each had our own expectations about the proper roles of researcher, facilitator and participant teacher. As a researcher, I knew that to collect good research data I had to allow teachers to feel open and free to talk. As a facilitator, I was the provider of time, space, and stimulation, allowing teachers to think, talk, and experiment in the classroom. As a participant teacher, I was convinced that the best solution to their problems would be found by the teachers themselves.

Researcher Provider Interventions: A Struggle

During the first and second meetings both teachers began asking me for solutions to their problems. The experienced teacher identified the problem of inducing his students to work complex physics problems at home, in order to change the nature of the classroom. The beginning teacher identified the problem of managing conceptual conflict within the classroom. The experienced teacher requested activities for students to do at home. For the conflict problem, he requested actions that could be done once the students had experienced conflict.

I did not expect such clear demands on my role as a facilitator. To avoid feeling trapped I used a strategy of explaining rather than solving. Another resistance strategy I used was interrupting the conversation and describing my observations of their students. This diverted the teachers' attention. I also interrupted their requests by asking the beginning teacher about his personal experience.

Since all these attempts proved unsuccessful, I had to give them up. However, group tension did not diminish with my decision to participate with provider interventions. In fact, almost all my solutions were rejected by the experienced teacher. My confusion and anger increased considerably. Not only was I being forced to participate against my will, but my authority as an expert was also being questioned. Moreover, I could not assure myself that the data collected would be sufficiently interesting and relevant. These problems resulted from the struggle between the expectations of the teachers and my own. Both the teachers and I tried to generate interactions based on each other's expectations. When this happened, the other party used different strategies to escape from the interaction. When I finally agreed to participate in the experienced teacher interactions new professional anxieties emerged. They were the consequence of having to interact against my values, beliefs, and professional expectations.

Researcher Reflection Interventions: Escaping Fixed Patterns of Interactions

I used reflection interventions to escape from the anxiety arising from having to provide hypotheses of solution. It seemed to me that I did not have a clear picture of the teachers' problems. The ideas I was providing were considered useless. Then, I asked the experienced teacher what exactly he was looking for. From this point on we began to interact at the hypothetical level, he picturing his ideal classroom and students. We started to play with images, models, and values in teaching. His awareness and conceptual understanding of his problem impressed me. I decided that I could indeed get relevant research data.

After this interaction, however, we relapsed into the same interaction patterns as before. One of the hypotheses of solution I suggested was group work. I was and remain a strong believer in group work. I not only encouraged it in my own high school classrooms, but made it the subject of research work. Both teachers rejected group work, for different reasons. I felt that group work deserved deeper scrutiny, than a few short and quick comments, and refused to give up.

An interaction began in which I encouraged the teachers' reflection on group work, in order to find out why they disliked it. The experienced teacher came to realize that he was using different standards for evaluating group work and whole classroom work. His resistance towards group work weakened; the fixed interaction patterns, with me in the role of the expert-provider of solutions, were beginning to change. From meeting 3 on, reflection was no longer necessary as a way to escape from rigid patterns of interaction.

Researcher's Procedural Interventions: Constructing the Experience

The professional anxieties I experienced during the first two meetings forced me to use other methods of data collection. I asked teachers to write reflective narratives of special events occurring in their own classrooms. This method, however, proved completely unsuccessful. Teachers were always forgetting their narratives, and I decided to stop using them after the fourth meeting.

My professional anxieties cleared up during the third meeting. I told them honestly and openly that we could not solve the problem because we did not know its solution. More time would be necessary for us to understand the problem and to be able to find the best solution. Contrary to my expectations, the teachers' reactions were very positive. The experienced teacher was very excited about the challenge of having to struggle with an important problem. For the beginning teacher and for myself, this was a relief. The interactions between the teachers and me changed radically. During the third and fourth meeting, the teachers initiated most interactions. They brought up lots of different issues and experiences. I participated with facilitation interventions.

By the fifth meeting, experiments in the classrooms were yielding interesting results. The experienced teacher realized that his students were doing more homework than he had thought. Should we consider that that particular problem solved? The beginning teacher was experiencing the difficulty of implementing strategies for conceptual conflict in a real classroom. He realized that only time and experience would solve his problem.

It was time to stop and redirect the action research. The teachers themselves had the option of either persisting with their problem or switching to another. The experienced teacher decided to go on with the original problem, believing it not yet solved. The beginning teacher chose to switch to another problem. Most of my interventions were procedural. I felt that the commitment of the teachers at this point would be crucial for developing a successful action research process.

Researcher Facilitation Interventions: The Equilibrium

The researcher's facilitation interventions were characterized by less emotional involvement than her reflective or provider interventions. During the third and fourth meetings the frequency of facilitation interventions increased considerably. This was so because the teacher took leading roles in an intense conversation. Their commitment towards the experience reassured me, and I was pleased with the development of the group.

Discussion

The fifth meeting represented a transition between the first, exploration phase and the next, consolidation phase of our group pedagogical problem solving. During the first and second meetings group members adjusted to each other's expectations. The negotiation taking place generated professional anxieties for the researcher. These anxieties were eliminated in the third meeting when the researcher clarified her role. During the third and fourth meetings group members had to adjust once again, to the process of solving pedagogical problems. The emotional environment was more relaxed, and also more task oriented. The fifth meeting began a second phase, in which the action research process began to consolidate.

Second Phase of Researcher Experience: Consolidation

Researcher interventions within the second phase were dominated by the successes and failures of the teachers' attempts to introduce changes in their classrooms. The emotional dimensions of the interactions related to these successes and failures. Between meetings six and ten the experienced teacher had two failures and one success, while the beginning teacher experienced one clear success. Most of my interventions were of the reflective and provider types. Procedural and facilitation interventions were relatively less frequent than in the first phase.

Researcher Provider Interventions: Helping in Failure

My provider interventions were most frequent in meetings seven and ten. These two meetings dealt with the experienced teacher's failure. At times, this teacher felt discouraged because no clear solutions were emerging. Although I had decided to avoid providing ideas and solutions as much as possible, I could not hold back in these cases of failure, with teachers requesting help after an intense period of searching and experimenting. During these highly emotional meetings reflection was less necessary than providing ideas and solutions. Table 5 and Figure 5 provide the relative frequency of reflection and provider interventions for meetings seven and ten.

At meeting seven, the experienced teacher was very upset because students were not doing homework. After a long conversation, we decided to undertake a small investigation. The investigation attempted to get a precise picture of who was doing homework and how. My provider interventions dealt with the need to undertake an investigation and the best strategies for data collection.

At meeting ten, the experienced teacher was deeply discouraged. He did not know which way to turn. Since I did not know either, I thought it was time to implement radical and unusual solutions. The experienced teacher rejected them as too strange. "I might be a good actor," he said, "but I do not know the script for this play." I gave him some papers to read on collaborative work and motivation (Slavin, 1980, 1984). The experienced teacher liked them; the beginning teacher thought them useless. These articles later catalyzed an innovative department project on group work in high school physics and chemistry.

Researcher Reflection Interventions

The second phase of group action research was certainly rich in opportunities for reflection. As with researcher provider interventions, researcher reflective interventions dealt with the failures and successes of experiments in the classroom. The emotional and symbolic dimensions of these reflective interventions were very different, depending on whether there was success or failure. I have identified four types of researcher reflective interventions: (a) celebration of the conceptual change approach after a successful experiment; (b) reaffirmation of values, beliefs, models and goals after failure; (c) breaking patterns of rigid explanations after failure; and (c) breaking rejection to further inquiry.

Celebration of Conceptual Change Approach After Success

The beginning teacher's success in managing his students' conceptual conflict initiated a reflective group interaction in meeting six. Through this interaction we celebrated not only the beginning teacher's success, but also that of the approach inspiring it. The values, beliefs and models underlying their approach to teaching physics and chemistry were strengthened. Since all of us believed in the worth of the conceptual change approach, reflection became a collective reaffirmation of the basic concepts supporting it. As a group we felt stronger. As a researcher, I was pleased to realize that I was collecting good research data. As a facilitator, I learned that it was possible to initiate novices into the conceptual change approach to the teaching of science.

Reaffirmation of Values, Beliefs, Models and Goals After Failure

Failure also generated reflective interactions concerning values, beliefs, models and goals. In meeting ten, the experienced teacher felt deeply discouraged in his attempts to make students do complex physics problems at home. He shared his hopes, wishes, and goals. While he pictured his ideal classroom, I participated with reflective interventions aimed at enriching his images. No matter the intensity of his feelings of failure, the experienced teacher never doubted the reasonableness of his goal. In contrast, the beginning teacher often wanted to give up. This helped me understand the importance of having strong images and beliefs about what is worth doing in education. The experienced teacher persisted in his search for the best solution thanks to the strength and conviction of his beliefs.

Reducing the Rigidity of Teachers' Explanations After Failure

The teachers' failures originated reflection interactions to explain their failure. These moments were usually emotionally intense and involving. The teachers' explanations of their failure were persistent, rigid and emotional. As a researcher, I saw other explanations which would contribute much more to solving their problems, provided that the teachers could open to them.

For instance, in meeting seven, the experienced teacher said that the cause of his students not doing homework was their habit of not working. The concept of habit, though very popular, did not make too much sense to me. The solutions it lead to were guided by aggressive images like "breaking the habit" or "stopping it." Moreover, students were conceived as victims of an alien factor called 'habit.'

My reflection interventions introduced explanations centered around students' personal world towards homework. For instance, I suggested that students might feel insecure about their ability to solve complex physics problems. We entered into a fixed pattern of reflective interactions, in which I proposed explanations which the teachers systematically rejected. Since this led nowhere, I decided to break this pattern by summarizing the factors we all thought influenced the situation. I secretly hoped that this would help teachers view my explanations from another perspective.

The strategy did not work. However, I did not want to give up. I began a new reflective interaction to understand the teachers' understanding of the concept of habit. Finally the experienced teacher realized that he was holding two apparently contradictory beliefs about his students. On one hand, they were doing homework, as he had stated in our fifth meeting; on the other hand, students did not want to work at all, they had the strong habit of not working. His realization of this contradiction made the teacher curious to learn more about his students. An investigation was begun, to get a better picture of the situation.

Reducing the Resistance to Further Inquiry

The beginning teacher decided to switch his problem at the fifth meeting, but by the eighth meeting we still had not started to deal with it. This seemed to me a sign of a covert rejection of the new problem. I started to worry about the lack of good research data, and also about the beginning teacher's wasted opportunities. I decided to plan the ninth meeting to confront the beginning teacher, and chose a lesson taught by both teachers during which I had been present. My field notes from both classrooms served as contrasting reflective materials for our meeting. I hoped that by reading both classroom notes side by side, the beginning teacher would realize his need to change. I would also be able to collect more research data concerning the beginning teacher. This comparison generated an intense reflective interaction among both teachers and myself, and was highly successful. I got interesting research data, and the beginning teacher started to deal with the new problem: the new problem was the writing of a curriculum unit on heat based on his understanding of the conceptual change approach. This strategy eased the beginning teacher's resistance to further inquiry into his classroom practice.

Researcher Procedural Interventions: Unnecessary

My procedural interventions were not as frequent as during the first phase. Group dynamics were clearer to all involved. I did not need to intervene to make inquiry possible. Procedural interventions, important in the first phase, were unnecessary during the consolidation phase of action research.

Researcher Facilitation Interventions: Protecting Teachers' Talk

My facilitation interventions occurred when teachers were involved into either an intense dialogue among themselves, or in expressive monologue.

An expressive monologue was delivered in meeting six, by the beginning teacher. He came to the meeting very excited about a successful class he just taught. I had chanced to observe this special class and was also very excited about it. Since this was his first clear success in managing students' conceptual conflict, we encouraged him to tell us about the experience. He was not only open to the group, but also showed an impressive memory of the details of his interactions with students. The beginning teacher was ready to provide the group with valuable information, and there was a good chance to get quality research data, provided that I protected his talk from any interruption. I did this with many facilitation interventions.

Discussion

The emotional and symbolic dimensions of my intervention patterns were guided by the successes and failures of the teacher's experiments in their own classrooms. When successful accounts were brought to the meeting, my interventions were reflective or facilitative. types. When failures were reported, my interventions were of the provider and reflective kinds. The most emotionally involved interventions were those in which I attempted to change the teachers. These were attempts to "reduce the rigidity of teachers' explanations after failure" and "reducing the resistance to further inquiry." These goal-directed interactional strategies occurred within the context of the teachers' successes or failures, but they aimed at furthering inquiry.

Third Phase of Researcher Experience: Teacher Cohesion Through the Design of a Curriculum Unit

The third phase of group pedagogical problem solving was characterized by a new cohesion between the beginning and the experienced teacher. Although the beginning teacher had decided to switch his problem at meeting five, it was not until meeting ten that the group started to deal with his new problem. He chose the problem of designing and testing a curriculum unit on heat based on the conceptual change approach. The experienced teacher agreed not only to help him design the new unit, but also to test the unit in his own classroom. From meeting ten on, the group dealt with two problems: the homework problem of the experienced teacher, and the curriculum design project of the beginning teacher.

The design of a curriculum unit created such a positive relationship between the experienced and the beginning teachers that researcher-teacher interactions changed completely. The former was participating as a mentor, the latter as a novice to the conceptual change approach. While my role as a researcher declined to that of an external data recorder, I responded as a facilitator to sporadic requests for my opinion. My interventions decreased to 12 percent, while those of the beginning teacher increased to 40 percent (see Table 5-2 and Figure 5-2). My total participation also decreased to half of that in previous phases (Table 5-1 and Figure 5-1). I had to deal with the feeling of rejection; some of my interventions were influenced by this.

Researcher's Facilitation Interventions: Getting Information

My facilitation interventions were usually influenced by a feeling of rejection. The dyad experienced-beginning teacher had become so strong that I had to make an effort to remain part of the group. One way to do this was to intervene with facilitation interventions. These interventions clearly interrupted the flow of their conversation. Nevertheless they allowed me to obtain the contextual information necessary for understanding the curriculum unit design.

Researcher Provider Interventions: Trying to be Useful

My provider interventions steadily decreased during the third phase of group pedagogical problem solving. The experienced teacher had the legitimate authority of an expert within the group. He had rewritten and tested these curriculum units several times in the last six years. Since both teachers were teaching the same curriculum unit in the same school to the same age students, the experienced teacher's help could reach the level of detail and precision requested by the beginning teacher. Some of my provider interventions were prompted by my need to feel useful. I learned that the best way to be useful was to provide specific information from direct observations, and detailed accounts of my personal experience in designing and teaching the unit on heat. I could not have participated with provider interventions if I had not had experience teaching the unit of heat to the same age level students. Despite this, my provider interventions decreased during the last meetings. My personal experience was not sufficient to keep up with the logical and contextual details of the curriculum unit design. I realized that my experience could not be transferred unless I was a full participant in the project.

Researcher Reflection Interventions: Expressing My Opinion

My reflection interventions had two objects. First, I responded to teachers requests for my opinions about the use of specific conceptual strategies in the curriculum unit. Conceptual strategies dealt with were: (a) the use of the ink metaphor to introduce the difference between heat and temperature; (b) asking students to explain the role of a theory in science; (c) asking students to predict the actions and the results of an experiment before going to the laboratory; and (d) the use of drawing to stimulate the articulation of students' views on heat as a fluid. The teachers and I differed on the value of these four strategies. I rejected the first two strategies and defended the last two. As a result of these reflective interactions the teachers introduced strategies a, c, and d, strategy b got lost in the conversation. It was never introduced in the design of the curriculum unit.

Second, my reflection interventions dealt with the teachers' group work in high school physics and chemistry classrooms. My interventions were influenced by the teachers' excitement concerning group work. I could not understand this new and supportive attitude towards group work, and was afraid that this excitement masked the difficulties inherent in the implementation of any new project. I therefore encouraged the teachers to share their feelings towards group work, and their excitement. I wanted to test their awareness of the difficulties of this new task. I hoped that greater awareness would protect them from getting discouraged when the first difficulties appeared.

Researcher Procedural Interventions: Preparing to End the Action Research Experience

I did not use procedural interventions until the end of this final phase. I had to take the lead again to reach closure. The teachers needed to organize next year's project on group work in high school physics and chemistry, and begin writing up the action research they had just experienced.

SUMMARY AND CONCLUSIONS

Researching within an action research paradigm is complex and highly interactional activity. Researcher's talk performs different functions, which have been divided into four areas: procedural, facilitative, provider and reflection. These functions, which have also been called researcher intervention patterns, changed throughout the action research process. The function of researcher's talk is not fixed but depends on the developing interaction among the group members.

Changes in the frequency of researcher intervention patterns indicate the existence of three different phases in group interaction. Erickson (1982) describes communicative events in terms of the social participation and task structures. These structures explain the existence of three different interactional environments in the action research process. In the first phase of "exploration," the researcher experienced the conflicts and tensions inherent in the negotiation of a social participation structure. Participants adjusted their expectations during the first two meetings. Once the social participation structure was accepted, the group created a task structure which characterized the action research. At this point, the researcher's interaction pattern became more procedural and facilitative. In sum, the first phase of action research process is a collaborative exploration of the most appropriate social participation and task structures. These ensured the flow of the action research process.

This second phase of consolidation was characterized by the stability of the social participation and task structures. The fact that both structures had been negotiated did not predetermine the action research. What had been settled was a structure within which teacher inquiry could develop. During the consolidation phase, the symbolic and emotional dimensions of researcher participation fluctuated relative to the teachers' inquiries. The most frequent researcher interventions patterns were of the provider and reflection types. These interventions occurred during critical communicative events which were characterized by high emotional and symbolic involvement from all participants. These occurred during meetings dealing with the success or failure of classroom experiments. Success generated celebration of the values, beliefs and models guiding the teachers. The emotional involvement of all participants was positive and open. Failure generated reflective interactions which questioned the teachers' hopes, wishes and ideals, and the emotional climate was much more negative. Teachers showed rigidity in their explanations, anger and, sometimes, reluctance to pursue inquiry. In order to ensure continued inquiry, researcher participation became more provider and reflective at these crucial moments: "helping in failure," "reducing the rigidity of explanations," "reducing the resistance to further inquiry." These interactions were difficult and emotional but led to overcoming failure, in one way or another.

The third phase of "cohesion" was characterized by a change of task structure, and a consequent adjustment of the social participation structure. The teachers selected a new problem: the collaborative design of a curriculum unit based on a conceptual change approach to the learning of science. This created a new task structure, and also a new relationship among the action research participants. The teachers developed a stronger, more cohesive relationship.

Interaction increased between the teachers, and the researcher became external data recorder and occasional consultant. The changes put emotional demands on the researcher. The cohesion achieved by the teachers signaled the value of action research. It also proved that work on some pedagogical problems is more conducive to building teacher cohesion than work on others.

The role of the researcher within action research is complex and highly interactional. New skills will be necessary if action research becomes an accepted practice within schools. The action researcher needs to develop various skills, including: (a) interacting with teachers in small groups; (b) understanding the mechanisms of conversational interaction; (c) managing the emotional dimensions of inquiry into one's own actions; (d) confronting conflict; (e) adjusting one's role according to changes in the problem under inquiry; (f) providing teaching ideas, when necessary. The new researcher will need a good background in the subject taught by the teachers, skills in small group interaction, and experience in interpreting the dynamics of action research.

CHAPTER 6

TEACHERS' PEDAGOGICAL INQUIRY THROUGH GROUP INTERACTION

> We shall not cease from exploration
> And the end of all our exploring
> Will be to arrive where we started
> And know the place for the first time.
> (T. S. Eliot, Four Quartets, 1971)

INTRODUCTION

Educational Action Research

Action research is considered a third, alternative paradigm in educational research coexisting with the positivistic and interpretive paradigms (Elliot, 1988). Action research is defined as a form of research or self-reflective inquiry carried out by practitioners for the purpose of modifying action (Elliot, 1978; Kemmis, 1985; Carr & Kemmis, 1988; Oja & Smulyan, 1989).

A close look at action research projects, however, reveals variety among different countries and researchers. For instance, Elliot (1978) sees the purpose of action research as to increase teachers' understandings of the following educational situations: problematic situations which are not accepted by the teachers; educational situation which can be changed; and educational situations necessitating a practical response. Oja & Smulyan (1989) state that action research contributes to knowledge in the field, and facilitates policy changes and improvement of practice. Similarly, Carr & Kemmis (1988) identify two main purposes for action research: to improve education and to involve practitioners in that improvement. Improvement happens in practice, in practical understanding, and in social situations. Despite the variation of purposes, all of these definitions agree that action research tries to change practitioners actions and understandings.

Action research projects also differ in the relationship established between teachers and outside facilitators, and on the crucial point of who chooses the problem of inquiry. Based on the different roles played by the outside facilitator, Kemmis (1985), Carr & Kemmis (1988), and Grundy (1982) distinguish between three types of action research: (a) the technical action research, (b) practical action research, and (c) emancipatory action research. Technical action research deals with outsider generated problems or practices to be adopted by the teachers. The action research dynamics constitutes the means towards teacher change. In this context, the relationship between action researcher and outside facilitator is defined as coption. Practical action research deals with teachers own self defined problems and aims to develop teachers' practical reasoning. The outside facilitator acts as a consultant cooperating with an individual or a group of teachers. Practical action research should be a self-reflective process of change. Finally, emancipatory action research deals with the shared problems of a group of teachers in order to identify the critical social theorems guiding educational practices. The teachers have the total responsibility for the monitoring of understanding and change. The outside facilitator is simply one more collaborator within the action research process.

These distinctions are usually not crystal clear in practice. For instance, although most of the action research projects which have received funding from public institutions were initiated by university researchers, teachers have also undertaking practical action research. Examples include the Ford Teaching Project (Elliot, 1976), the ARCS (Action Research on Change in Schools)(Oja & Smulyan, 1989), GIST (Girls into Science and Technology)(Kelly, 1985), and STAR (Science Teacher as Researcher Project)(Shymansky, on going). In these cases, university researchers decided on a research focus, and provided teachers with the facilities and skills to pursue the inquiry. These projects started as technical action research and developed towards a practical action research. In other cases, teachers had the total responsibility to choose and follow up their own inquiries (Hull, Rudduck, Sigsworth & Daymond, 1985). An example of a practical action research program which developed into emancipatory action research is, "Exploring the Problems and Effects of Inquiry Teaching in Science (Henry, 1985)." This project originated with a single teacher and ultimately involved several of them from the same school.

Advocates of action research have emphasized the importance of proper method in following a systematic process of self-reflection and inquiry on action. This process is described as one of spiraling cycles (Kemmis & McTaggart, 1982; Elliot, 1981) or feed-back loops (Ebbutt, 1985) of planning, acting, monitoring and evaluating. Action research method, however, is usually understood as a set of prescribed steps. Ebbutt has pointed out the problems generated by teachers following these steps. The natural dynamics of the inquiry process conflict with the steps prescribed by action research method.

To sum up, action research is a form of educational inquiry undertaken by the same practitioners with the purpose of changing action and thought. Action research differs in its definitions of problems, in who defines them, and in their preferred realtionship between outsiders and teachers.

The Importance of Group Interaction within Action Research

Lewin (1946, 1952), the acknowledged father of action research, incorporated group work into the action research process because of group interaction's power to produce committment and change. Since then, group work has been considered fundamental. Subsequent action research theoreticians have also emphasized the importance of group interaction for validating research findings (Elliot, 1978), sharing explanations and interpretations (Kemmis, 1985), discovering personal and social contradictions which frustrate the process of change (Carr & Kemmis, 1988), and so on: "Collaborative participation in theoretical, practical and political discourse is a key feature of action research (ibid, p. 200)."

Group interaction helps teachers reach a common understanding and consensus, and facilitates homogeneous implementation of actions: "Ultimately, the aim of action research is to involve all these participants in communication aimed at mutual understanding and consensus, in just and democratic decision-making, and common action towards achieving fulfillment for all (ibid, p. 199)." 'Parity', 'democratic participation', 'ethical concerns', and 'equality of status' among others, are all used to described the expected discourse within action research. However, it is not clear how mutual understanding is accomplished, whether consensus is possible, how democratic decision-making takes place, and whether fulfillment for all really occurs. In fact, most of the action research studies confine their reports to the results of the investigation, the general problems and dilemmas of the process (Ebbutt, 1985), and the effects of action research on teachers' growth and professional development (Williams, 1986; Oja & Smulyan, 1989).

Little is known about the specific content and structure of the discourse taking place among teachers and outside facilitators. This imbalance, between the importance given to group interaction and the lack of studies on how it works, is certainly striking. It shows that action research is still at a prescriptive stage. Analysis of action research discourse can provide new understanding of teacher inquiry through group interaction.

FRAMEWORK FOR THE STUDY

The two main conceptual components of action research are inquiry and group interaction for the purpose of change in action and thought. Teachers' inquiry will be called pedagogical inquiry as a way to distinguish it from other forms of practical inquiry undertaken within other professions. This denomination aims at emphasizing the specificity of teachers' inquiry.

Individual Human Inquiry

Individual human inquiry has been developed within various logical, philosophical, psychological and social psychological traditions. The most relevant approaches were reviewed in an earlier chapter. It includes theories of action such as Practical Reasoning (Gauthier, 1963), Dewey's Philosophy of Inquiry (1933, 1938), Soviet Theory of Activity (Vygotsky, 1978 ; Leontev,1972/1981), Genevan Constructivism (Piaget, 1970, 1974/76, 1974/78, 1977;

Cellérier,1983; Karmiloff-Smith & Inhelder,1975), Symbolic Interactionism (Mead, 1938; Blumer 1969), and Action Science (Argyris et al., 1985; Schon, 1983). These theories explain the generation of human action under the constraints of particular problems or conflictive practical situations. Thus, theories of action have mostly developed through the study of human practical inquiry.

The range and precision of the concepts describing human action varies among theories. For instance, Practical Problem Solving describes the phases of action generated by a practical problem as follows: feeling uncomfortable, practical reasoning, decision making, and acting (Gauthier, 1963). Dewey (1933; 1938) identifies the following phases as composing a cyclic process of inquiry: pre-reflective; reflective (intellectualization, hypothesis, reasoning, testing hypotheses in action); and post-reflective. Similarly, Mead (1938) suggests the following phases of every human act: impulse; perception; manipulation; and consummation. Finally, Schon (1983) describes action as repeating phases of puzzlement and reflection in action (reframing the situation, experimenting with the situation, re-starting). Despite their differences, these approaches share common assumptions concerning the recursive nature of inquiry, and the existence of at least three phases involving personal puzzlement, cognitive activity, and action.

These theories of action provide us with a general framework from which to study teachers' actions and talk within practical inquiry. The first purpose of the study presented here is to identify which categories best describe teachers' pedagogical inquiry through group interaction.

Human Inquiry and Social Interaction

The second component of action research is group interaction. Despite the fact that the theories of action mentioned above dealt primarily with individual action, they acknowledged the importance of interaction. Discourse analysis and more specifically conversational analysis have explored interactive discourse: "Both approaches are centrally concerned with giving an account of how coherence and sequential organization in discourse is produced and understood (Levinson, 1983, p286)."

These disciplines, outgrowths of pragmatic linguistics and sociology, provide a research methodology for analyzing teachers' discourse within pedagogical inquiry. Conversation is seen as a form of social interaction. This interaction is the interlinkage of numerous actions performed by actors having either similar or divergent goals and intentions (van Dijk, 1978/1983). The essential feature of interaction is that each individual action must be the condition for the next action performed. The organization of conversations has been extensively studied by discourse and conversational analysts (Sacks, 1972; Sacks,Schegloff &

Jefferson, 1974; Sinclair & Coulthard, 1975; Coulthard, 1977; Schenkein, 1978; Craig & Tracy, 1983; Tannen, 1984).

In order to identify the sequential organization of conversation, analysts have proceeded to identify interactional units, then searched for conversational patterns. These researchers found a high degree of structuration in human conversations. However, most discourse and conversational analyses have only dealt with the organization of talk as it relates to social aspects of interaction. Erickson (1982) has pointed out the need to study the content as well as the social structure of interaction:

> "This is necessary...if we are to develop an interactional theory of cognitive learning and teaching in social occasions (such as lessons) that are interactional learning environments (Erickson, 1982, p. 156)."

Thus, another purpose of the present study emerged from the previous theoretical concern and it is to answer questions such as: What is the organization of teachers' pedagogical inquiry through interaction? What is the structure of teachers' discourse within pedagogical inquiry?. How is individual inquiry changed when immersed within group interaction?

Teachers' Conversations as Occasions for Change

Erickson conceptualizes lessons as "social occasions for learning and teaching (Erickson, 1982, p161)." The present study takes Erickson's approach, understanding teacher's conversations as social occasions for change. These social occasions are immersed within the task and the social structure characterizing teacher's conversations. The task and the social structure constrain interaction among teachers, but within these constraints teachers and researcher may act intentionally and pursue their own individual goals and those of the group. In doing so, conflicts arise and are resolved which represent opportunities for teachers to change. A third purpose of the present study is to identify the occasions for teachers change as a consequence of group interaction.

PURPOSE

The present study investigates high school science teachers' pedagogical inquiry through group interaction. The hope is that a better understanding of teachers and of teachers' action research is gained. The general purpose is divided in three parts:

1. Identify categories for the description of teachers' pedagogical inquiry.

2. Indentify the structure of teachers' conversations while undertaking pedagogical inquiry .

3. Describe the occasions for teacher change through group pedagogical inquiry.

METHODOLOGY

The Communicative Event of Pedagogical Inquiry

The design of the action research experience utilized a model defined by Kemmis (1985), Carr & Kemmis (1988), and Grundy (1982). One experienced teacher, one novice teacher, and the researcher participated in the study. Both teachers taught 10th grade physics, at the same public high school in Barcelona, Spain. The outside researcher initiated the action research project by encouraging these teachers to participate. However, the teachers themselves chose the educational problem for investigation. The outside researcher acted as a collaborator encouraging reflection, providing ideas, sharing observations, and offering contrast.

Communication within the study had an explicit task structure and no clear social participation structure. As for the task structure, the three participants met once a week for two hours between October, 1986 and July, 1987. The purpose of the meetings was to solve pedagogical problems posed by the participant teachers. Each teacher identified a single problem, which was dealt with in alternate meetings. At the end of each meeting both teachers committed themselves to test, in their own classrooms, the conclusions which had emerged through group reflection. Moreover, both teachers observed each other's classrooms and described the intended changes. The researcher also observed both classrooms, and these observations were shared in subsequent meetings. In sum, the task structure, initially set by the outside researcher, created constraints on communication among the participants, including: weekly meetings, commitment towards one action at the end of each meeting, consensus about the implemented solution, and regular classroom observations.

In contrast with other communicative events, the action research experience was initiated without a clear social participation structure. There were no pre-established rules or patterns for the allocation of the rights and obligations of the participants. In this sense, teachers' pedagogical inquiry within this practical action research was a highly spontaneous interactive activity.

Description of Participant Teachers and Researcher

The researcher was introduced to the teachers by the superintendent of the Barcelona school system. As stated above, both teachers taught 10th grade physics at the same high school in Barcelona, Spain. The experienced teacher was male, in his thirties and had 7 years of teaching experience. He headed the physics and chemistry department. He held bachelors and master's degrees in physics, and had done research work towards his PhD in physics before deciding to leave the university. He applied for a position within the public school system to insure a stable income. After two years of teaching physics, he begun developing curriculum units based on a conceptual change approach to the learning of physics and chemistry. At the time he joined the research group, he had developed all the curriculum units for the teaching and learning of 10th, 11th and, 12th grade physics. He showed a strong commitment to the conceptual change approach to the teaching and learning of science.

The novice teacher was also a male, in his thirties who had no experience teaching high school physics and chemistry. He held bachelors and masters degrees in chemistry, and a PhD degree in organic chemistry. He also had decided to leave the university to secure a stable income. The teachers had a good relationship based on trust and friendship. The novice also had a profound respect for the teaching approach developed by the experienced teacher.

The experienced teacher identified the problem of inducing his students to work on complex physics problems at home. He wanted to transform his classroom into a place where students debated their own ideas. His underlying purpose was to enourage independent thinking in his students. The novice teacher identified the problem of managing conceptual conflict within the classroom. Conceptual conflict is a crucial learning strategy within the conceptual change approach. Students are encouraged to articulate their own ideas, conceptions and beliefs about phenomena. Once their views are known, conversational confrontations take place in order to select the best among them.

Data collection

Three sources for data collection were used: (a) researcher's field notes taken during classroom observations; (b) audiotapes and transcriptions of each meeting; (c) the researcher's personal notes made after each meeting with the teachers. The present study deals only with the transcriptions and field notes corresponding to the meetings #1, #3, #5, #7, #8, #10, and #12. These meetings focused on the experienced teacher's problem of inducing his students to work on complex physics problems at home. Meetings lasted about one hour and 45 minutes. They were audiotaped and transcribed by the researcher for subsequent analyses.

Data Analysis and Interpretation

Transcripts of meetings were analyzed in three separated although interdependent ways: (a) identification of units of analysis; (b) identification of sequences of units composing interactional units of a higher order; and (c) description of occasions for teachers' change. These three modes of analysis correspond to the three main purposes of the study.

Unit of Analysis: Pedagogical Inquiry Moves

The first step in analyzing conversations is to identify the correct unit of analysis. This is a piece of meaningful speech to which a function can be associated. The size and boundaries of unit of analysis are chosen according to the specific focus of the analysis. The present study uses a unit of analysis called a "pedagogical inquiry move" based on the "move" units introduced by Sinclair & Coulthard (1975) and Coulthard (1977). Pedagogical inquiry moves are pieces of a single participant's speech having a function within the inquiry process. These moves are usually longer than one sentence. The speech of one participant in one full turn could be composed of one or more pedagogical inquiry moves. For instance, in the following quotation the pedagogical inquiry moves of "evaluation of hypothesis" and "stating hypothesis of solution" can be identified:

> (Evaluation of hypothesis): "It is hard to mark and collect 40 students' homework every day!.(Stating hypothesis of solution): Instead, if you ask them who has done homework? They raise hands, and those we know did a good job, we collect them . . . (BT, M1, 7)."

The researcher refined the system of pedagogical inquiry moves until it could be consistently applied to all data. The final set of pedagogical inquiry moves fully described the process of pedagogical inquiry taking place in action research meetings.

The Structure of Pedagogical Inquiry Conversations

Pedagogical inquiry conversation was analyzed at the levels of overall structure and micro-structure. Overall structure deals with the general organization of the conversation. Studies on discourse analysis have shown that conversations go through very few organizational phases (van Dijk, 1978/1983; Levinson, 1983). Comparison of pedagogical inquiry moves ocurring during the opening, development and close of each conversation indicate the patterns of overall organization.

The micro-structure of conversations was identified by searching for sequencing patterns of pedagogical inquiry moves. Sequencing pedagogical inquiry moves involved identifying the person and the pedagogical inquiry move initiating a sequence, the sequence of interrelated pedagogical inquiry moves, and the person and the pedagogical inquiry move ending the sequence. Graphs have been used to provide clear images of the pedagogical inquiry moves and their sequences within higher interactional units.

RESULTS

Pedagogical Inquiry Moves

The participants discourse within action research has various functions within pedagogical inquiry. The functions associated to participants' pieces of speech are called pedagogical inquiry moves. Each move is one participant's contribution towards finding an educational solution. Pedagogical inquiry moves are actions performed by participants in order to reach the goal set within the group. These moves can be associated with the steps of individual inquiry identified by certain philosophers and psychologists of action. In the present case, however, several people contributed to the inquiry. The pedagogical inquiry moves identified in teachers and researcher's talk were: defining situations, defining goals, explaining, stating action goals, stating hypothesis, evaluating hypothesis, stating solutions, planning solutions, and evaluation of experimenting.

1. Defining Situations

"Defining Situations" moves were statements used to describe students' behavior, classroom events, or any other pertinent information contributing to the description of the educational phenomena. These moves had the function of constructing a representation of a problematic area of teacher's experience.

2. Defining Goals

"Defining Goals" moves were statements pointing at the desired state of the educational situation under inquiry. These moves included teachers' descriptions of ideal classroom or other educational situations considered positive and hence valuable. These moves had the function of maintaining the hope in moments of failure or confusion.

3. Explaining

"Explaining" moves were statements providing reasons or explanations for the undesirability of the current educational situation. These pedagogical inquiry moves showed the causal relationships between psychological and sociological factors, and the eduactional situation. The function of "Explaining" moves was focusing on specific and relevant pheneomena, and providing some explanatory mechanisms for the undesirable situation.

4. Stating Action Goals

"Stating Action Goals" moves were statements responding to the hypothetical questions What needs to be done? What should I be doing?. These moves were based on specific explanations provided by the teachers. They were constituted by the desired subgoals which emerged from these explanations. The function of "Stating Action Goals" moves was orienting teachers towards the modification of one specific area responsible for the undesirable educational situation. Teachers considered action goals as means to achieve their general goal.

5. Stating Hypothesis of Solution

"Stating Hypothesis of Solution" moves were statements proposing specific actions to achieve action goals.

6. Evaluation of Hypothesis of Solution

"Evaluation of Hypothesis of Solution" moves were statements evaluating the adequacy of the hypothesized solutions. These moves provided criteria for the adoption or rejection of actions as solutions to an educational problem.

7. Stating a Solution

"Stating a Solution" moves were statements showing teachers' commitments towards implementing a solution in the classroom. These pedagogical inquiry moves signaled the end of deliberation about hypothesized solutions, and the beginning of a planning phase for action.

8. Planning a Solution

"Planning a Solution" moves were statements responding to the hypothetical question: How can we do it in the classroom?. These moves usually came at the end of conversations, and they selected specific means to implement the stated solution.

9. Evaluation of Experimenting

"Evaluation of Experimenting" moves were statements judging the worth of classroom experimenting. These moves provided an opportunity for teachers to articulate what they had learned. "Evaluation of Experimenting" moves always happened at the beginning of conversations.

Table 6-1 provides a quantitative description of the pedagogical inquiry moves within several action research conversations.

Table 6-1

The Evolution of Pedagogical Inquiry Moves
(value indicates # of instances per meeting)

Pedagogical Inquiry Moves	Meetings 1	3	5	7	8	10	12	Total
Evaluation Experimenting	4	4	11	10	4	1	4	38
Defining Situation	9	12	5	9	6	3	3	47
Defining Goals	4	0	0	1	6	2	0	13
Explaining	11	15	5	11	3	2	0	47
Stating Action Goals	10	6	3	6	2	5	0	32
Stating Hypothesis	17	9	3	8	4	9	2	52
Evaluation Hypothesis	15	8	5	6	1	10	9	54
Stating Solution	2	2	2	3	1	0	1	11
Planning Solution	0	0	2	0	8	0	4	14
Total	72	56	36	54	35	32	23	308

The Content and Development of Pedagogical Inquiry Moves

The content and development of the nine pedagogical inquiry moves introduced above is presented around four functional groups:

1. Teachers descriptions of classroom situations ("defining situations" and "defining goals" moves)

2. Teachers explanations of classroom situation ("explaining" and "stating action goals" moves)

3. Teachers hypothesizing solutions for the educational problem ("stating hypothesis of solution" and "evaluation of hypothesis" moves)

4. Teachers experimenting in the classroom ("stating a solution", "planning a solution", and "evaluation of experimenting.")

Teachers' Description of Classroom Situations

These statements were incorporated into teachers' descriptive repertoires from different sources. Each descriptive statement was associated with a specific source. The sources from which teachers drew information about the classroom situations included: personal experience or critical events in the classroom (M1, M3) ; other teachers' opinions (M3); parents' opinions (M3); research articles (M5); teachers' investigations (M8, M10); teachers' observations (M1, M3, M5).

Classroom situations were never completely or exhaustively described. New descriptions were constantly generated through the conversation of pedagogical inquiry. In the beginning many different sources were used. Slowly, the sources drawn on decreased and became more focused. In fact, the amount of descriptions provided by either the teachers or researcher decreased considerably over time (Table 6-1).

Teachers' descriptions of classroom situations focus on certain particular aspects of situations. They represented particular ways to name specific classroom situations. Various descriptions coexisted in teachers' talk, and were used at different times during the conversation. Descriptions provide the background from which explanations, action goals, and hypothesis of action are constructed. When descriptions were isolated statements about specific aspects of the situation, the hypothesized solutions dealt with these isolated aspects. When descriptions contained more encompassing aspects of the classroom phenomena, the hypothesized solutions were more comprehensive.

Teachers' Explanations of Classroom Situations

Teachers' explanations were of the following types:

(a) Causal explanations of students' behavior

These explanations were statements linking specific causes to specific students' behaviors. No mechanism of relationship between cause and effect was stated by the teachers. Three types of causal explanations were identified:

1. Students' personal factors as causes

> "Students have a real aversion to mathematics or physics (BT, M3, 3)."
> "No, I do not think this is the right interpretation. The students do not do it simply becuase they do not have the habit of doing it (ET, M7, 12)."

2. External sociological or political factors as causes

> "May be they come from an elementary school in which art is emphasized (BT, M3, 8)."

3. Teachers' actions as causes

> "Yes, and then... I also evaluated the problem. May be I should change the wording of the activity, it is not sufficently clear (ET, M1, 6)."
> "In general, there are very few students who work. It is difficult to make them work. It might be that I did not mark homework correctly. I should be more insistant (BT, M1, 7)."

(b) Developmental explanations

Developmental explanations recognize that the classroom situation is the inherent result of change independent from the teacher.

> "It was a disaster!. It did not make any sense (what they did). Well, it is also true that nobody is born with the logical scheme in mind. It is something that needs to be learned, that is difficult (ET, M3, 7)."
> "I have the same feeling, along the year they have started to take things seriously, for some reason. This might also happen in other subjects. They start in one way and later on they become more serious (BT, M5, 8)."

(c) Interactive and cognitive explanations

These explanations introduced both cognitive and social interaction mechanisms to explain students' behavior.

> "I guess there are difficulties inherent within the clasroom structure. As I see, students' interventions are usually one sentence long, ten words . . .ther are better able to put more meaning in this sentence, to

> think more economically, so that it looks more convincing to you (R, M1, 12)."

(d) Metaexplanations

Metaexplanations aimed at monitoring the group's explanations of classroom situations.

> "I do not know, but there is something in them that we are not reaching, right?. We do not know what they think, what they do at home and why they do not work there. What occurrs to me is that we need to confront them, and know what happens (R, M10, 18)."

The teachers and the researcher contributed to the group pedagogical inquiry with different types of explanations. Table 6-2 presents the contributions of each participant.

The researcher specialized in interactive/cognitive explanations and metaexplanations, representing 23.5 percent of the total number of explanation moves. The teachers most often saw students' personal factors as causes; 36 percent of all explanation moves were of this sort.

The number of explanation moves decreased considerably during succeeding meetings (Table 6-1). In the beginning, teachers brought up critical incidents, and rich descriptions of their own classrooms. These usually generated many different explanations to which teachers did not feel particularly committed. Perplexity seemed to provide a positive context for the sharing of many possibilities. Since teachers were not clear about what had happened in their classrooms, they did not feel totally committed to any particular explanation. As time went by

Table 6-2

Teachers' and Researcher's Explanations within Group Pedagogical Inquiry (%) (n = 47)

Types of Explanations	Beginning Teacher (%)	Experienced Teacher (%)	Researcher (%)
Attribution Students' Factors	15.0	21.0	4.25
Attribution Social and Political Factors	2.0	6.5	0
Teachers' Actions	2.0	4.25	2.0
Developmental Explanations	4.25	11.0	0
Metaexplanations	0	0	15.0
Interactive/Cognitive Explanations	0	4.25	8.5

teachers reduced the number of explanation moves and homogenized their content. They became committed to specific explanations. For instance, although eleven explanation moves were made during meeting M7, only three different explanations were put forwards, one for each participant.

The evolution of the different types of explanations is shown in Table 6-3.

The most frequent teacher explanations attributed students' personal factors as the causes of classroom situations. However, some variations can be detected. Meetings that were characterized by conflict or failure in experimenting with classroom solutions showed more causal explanations based on students' personal factors (M3, M7). Instead, successful meetings (M5, M8) showed more developmental explanations. Success and failure in experimenting classroom solutions clearly provided different contexts for the development of explanations in pedagogical inquiry.

After unsuccessful experimenting in the classroom, teachers focused on their students' negative personal factors. For instance, they explained their students' limited motivation for homework with such expressions as "they do not want to do it", "they are resistant to work", "they have the habit of not working", "they do not know what to do", "they do not understand" etc. These explanations were forceful, emotional and difficult to challenge. They

Table 6-3

The Evolution of Explanations within Group Pedagogical Inquiry
(value indicates # of instances per meeting)

Types of Explanations	Meetings 1	3	5	7	8	10	12	Total
Attribution Students' Factors	2	6	1	10	0	0	0	19
Attribution Social and Political Factors	1	3	0	0	0	0	0	4
Teachers' Actions	4	0	0	0	0	0	0	4
Developmental Explanations	0	2	3	0	2	0	0	7
Metaexplanations	1	3	1	1	0	1	0	7
Interactive/Cognitive Explanations	3	1	0	0	1	1	0	6
Total	11	15	5	11	3	2	0	

seemed to be guided by metaphors of "resistance" to teachers' goals.

Teachers explained successful experimenting in the classroom as either the consequence of their own actions or of students' own development. In meeting M5, both teachers agreed that students were working more than they had before. They saw two possible explanations: students were undergoing an internal development towards the better understanding of conceptual physics; students had changed because they had increased pressure on them. The first explanation separated the teacher from the developmental dynamics of the students. From this point of view, teachers' actions represented a way to know about students. The second explanation assumed that the teacher was directly responsible for student change. These two explanations point to the duality inherent in action. Action is an instrument for both knowing and changing the world.

Teachers Hypothesizing Solutions for the Educational Problem

The homework problem generated hypotheses for solution of three different kinds:

(a) change the content and the structure of curriculum activities:

> "The key point is obviously to make students do something which they see is good. This might mean to rewrite the assigned activites, with subquestions making everything simpler (ET, M3, 12)."

(b) change students' learning environment:

"We might want to collect homework, right?. If you collect homework they will feel forced to write something down and you will see it (BT, M1, 12)."
"One thing I did in the past was, without really being aware of it, was to offer the possibility, for those students who said they did not know how to do the activities, to help them in my spare time (ET, M3, 3)."

(c) doing an investigation:

"What we might need is to collect students' written responses and do a small statistics. I can see 50 percent of students not even remembering to work on it (BT, M7, 8)."

Hypotheses of solution were sequentially linked to evaluation statements for their adoption or rejection. A positive or negative evaluation did not absolutely imply that teachers would adopt the evaluated hypothesis for action in the future. Acceptance or rejection of hypothesis of solution indicated the criteria that actions needed to satisfy in order to perhaps be accepted in conversation and implemented in the classroom later on.

Teachers use the following six evaluative criteria to make evaluative judgements on hypotheses of solution:

a) the success of past experiences with the suggested actions: ET had tried group work but students did not know what it meant to reach consensus (M1); BT had collected homework regularly and it had positive effects on his students (M10).

b) beliefs for or against the suggested hypothesis of action: ET rejected the solution of assigning lab experiences for homework because these activities should be done in school (M1).

c) the amount of work involved in implementing the action:

teachers rejected the solution of collecting each student's homework because it took too long (M1, M3).

d) difficulty in foreseeing the full consequences of the suggested action or new role: some hypothesis advocated using psychological techniques for children with special needs. Teachers rejected them on the grounds that they were physicists, not psychologists (M10).

e) teachers' preconceptions of what constitutes the best solution: ET wanted an elaborate and encompassing solution to the homework problem, instead of a disconnected set of relatively effective classroom strategies (M3).

f) degree of persuasiveness in communicating the effectiveness of an action: teachers accepted the cooperative learning approach (Slavin, 1980; 1984) because its presentation included a complete description of the approach and data to support its effectiveness in other contexts (M12).

Teachers and researcher contributions are summarized in Table 6-4. Although the percentage of hypotheses of solutions provided by each participant was similar, the percentage of evaluations differed. While 57 percent of all evaluation moves originated with the experienced teacher, the researcher provided 10 percent. Evaluating hypotheses of solution was primarily the job of the teachers, not the researcher.

Both the stating and evaluating of hypotheses of solution constituted 34.5 percent of all moves within the

Table 6-4

Teachers' and Researcher's Hypothesis of Solutions and Evaluation of Hypothesis Moves within Group Pedagogical Inquiry

Pedagogical Inquiry Moves	Beginning Teacher	Experienced Teacher	Researcher
Hypothesis of Solution n = 52 (%)	31	36.5	32.5
Evaluation of Hypothesis n = 54 (%)	33	57	10

process of pedagogical inquiry, being the most frequent moves (Table 6-1). Unlike descriptions of classroom situations or explanations, teachers' hypotheses of solutions and evaluations did not decrease over time. Their frequency appeared to depend on the success and failure of the classroom experimenting. Meetings following failure in experimenting solutions were richer in these moves (M3, M7, M10). In contrast, meetings following successful experimenting showed a considerable decrease (M5, M8).

Teachers Experimenting in the Classroom

Each meeting was characterized by one "Stating Solutions" move, at least one "Evaluation of Experimenting" move, and at least one "Planning Solutions" move. Since there were seven meetings, the number of stated solutions and evaluations of experimenting was limited to seven. The content and development of the pedagogical inquiry moves as they relate to teachers' classroom experimenting is presented in the next section.

The Structure of Pedagogical Inquiry Conversations

Overall Structure

The overall structure of pedagogical inquiry conversations was composed of three phases:

a) Openings, with "Evaluation of Experimenting" moves. Teachers began meetings with their own evaluations of the previous week's classroom experimenting.

b) Development, with various sequences of pedagogical inquiry moves which eventually lead towards a stated solution.

c) Closure, with "Stating a Solution" or "Planning a Solution" moves. These prepared teachers for further classroom experimenting.

The researcher and the teachers conventionally determined at the beginning of the action research this overall structure.

The Micro-structure

Pedagogical inquiry conversations were composed of sequences of pedagogical inquiry moves. Sequence of moves integrated into a more encompassing interaction unit called a "conversational strategy". Conversational strategies allowed the participants to strive to reach their personal goals. Each pedagogical inquiry conversation was composed of several conversational strategies. The notion of conversational strategy was developed by Craig & Tracy (1983). These authors stressed the importance of goal-directed strategies within natural conversations. Since different participants pursue different and sometimes conflicting goals, conversational strategy allows for a confrontation between participants' goals, and for a creative resolution.

Figures 6-1 through 6-7 in Appendix A show the conversational strategies identified for each of the seven meetings analyzed in the present study. The vertical axes of the graphs represent pedagogical inquiry moves in chronological order: evaluation experimenting, defining situation, defining goals, explaining, stating action goals, stating hypothesis, evaluation hypothesis, stating solutions, and planning solutions. The horizontal axes represent the sequence of pedagogical inquiry moves during the meeting. Each dot on the graph indicates the participant and the function of the pedagogical inquiry move.

Conversational strategies are indicated by lines connecting a sequence of pedagogical inquiry moves. The vertical lines separate each conversational strategy. The boundaries of the conversational strategies composing each meeting were determined by the following indicators: the initiator and his or her personal goal; the sequence of pedagogical inquiry moves; the theme of the interaction; and the outcome of the conversational strategy.

Initiating Conversational Strategies

The micro-structure of conversations identified through graphing conversational strategy reveals a new dimension of the researcher's role within action research. Despite the fact that the researcher talked the least in the action research meetings, she initiated the majority of conversational strategies. Table 6-5 shows the percentage of conversational strategies initiated by each of the participants. The researcher initiated conversational

Table 6-5

Initiating and Closing Conversational Strategies within Group Pedagogical Inquiry

	Beginning of Conversational Strategy (%) n = 38	End of Conversational Strategy (%) n = 38
Beginning Teacher	18	34
Experienced Teacher	21	63
Researcher	61	3

strategies to move from hypothesizing solutions and evaluating hypothesis, to descriptive and explanatory levels of pedagogical inquiry.

The Sequence of Pedagogical Inquiry Moves within Conversational Strategies

Conversational strategies have revealed a patterned sequencing of pedagogical inquiry moves within action research conversations. Action researchers' discourse appears as a sequence of pedagogical inquiry moves, leading from "Defining Situations" to "Stating a Solution. " Table 6-9 shows that an important percentage of conversational strategies are initiated with "Defining situations" or "Explaining" moves. Tables 6-6 and 6-7 show that 38 percent of the "Defining Situation" moves and 13 percent of "Explaining" moves are located at the beginning of conversational strategies. In contrast, only 2 percent of "Defining Situation" moves and 6 percent of "Explaining" moves are located at the end of conversational strategies. Teachers' conversational strategies appear to be initiated by providing descriptions or explanations of educational situations.

"Defining Situations" moves are linked to other "Defining Situation" moves, or to "Explaining" moves. In fact, 43 percent of all moves succeeding "Defining Situation" are more "Defining Situation", and 36 percent are "Explaining" moves (Table 6-6). "Explaining" moves are linked to other "Explaining" moves (32%), to "Stating Action

Table 6-6

Locating Descriptions within Pedagogical Inquiry

	Percentage of Moves Preceeding "Defining Situations" n = 42	Percentage of Moves Succeeding "Defining Situations" n = 42
Beginning Conversational Strategy	38	0
Evaluation of Experimenting	4	0
Defining Situations	36	43
Defining Goals	0	5
Explaining	17	36
Stating Action Goals	5	5
Stating Hypothesis of Solution	0	9
Evaluation of Hypothesis	0	0
End of Conversational Strategy	0	2
Total	100	100

Table 6-7

Locating Explanations within Pedagogical Inquiry

	Percentage of Moves Preceeding "Explanations" n = 47	Percentage of Moves Succeeding "Explanations" n = 47
Beginning Conversational Strategy	13	0
Evaluation of Experimenting	0	2
Defining Situations	36	15
Defining Goals	4	0
Explaining	32	32
Stating Action Goals	9	28
Stating Hypothesis of Solution	6	17
Evaluation of Hypothesis	0	0
End of Conversational Strategy	0	6
Total	100	100

Goals" moves (28%), or to "Stating Hypothesis" moves (17%). In fact, 60 percent of all moves succeeding explanations lead either to more explanations or to stating action goals (Table 6-7).

Pedagogical inquiry moves leading to "Stating hypothesis" were diverse; "Explaining" moves, "Stating Action Goals" moves, "Stating Hypothesis" moves, or "Evaluation Hypothesis" moves equally preceeded tachers' and researcher's stating hypothesis of solution. However, 48 percent of all moves preceeding "Stating Hypothesis" were "Stating Action Goals" and "Stating Hypothesis" moves (Table 6-8). Finally, 73 percent of all moves succeeding "Stating Hypothesis" moves were more "Stating Hypothesis" moves or "Evaluation Hypothesis" moves (Table 6-9). Conversational strategies end with "Stating Hypothesis" (18%), and "Evaluation of Hypothesis" (29%) (Table 6-9).

The preceeding analysis captures quantitatively the global sequencing of pedagogical inquiry moves within conversational strategies. The sequence of pedagogical inquiry moves within conversational strategies is linear. Participants contribute to the construction of the conversational strategies by intervening with their own pedagogical inquiry moves. Conversational strategies proceed from descriptions and explanations of educational situations, to hypothesizing and evaluating solutions. The majority of conversational strategies end with hypothesizing or evaluating hypothesis of solution.

Table 6-8

Locating Hypothesis of Solution within Pedagogical Inquiry

	Percentage of Moves Preceeding "Hypothesis of Solution" n = 42	Percentage of Moves Succeeding "Hypothesis of Solution" n = 42
Beginning Conversational Strategy	2	0
Evaluation of Experimenting	0	0
Defining Situation	8	0
Defining Goals	8	0
Explaining	15	6
Stating Action Goals	27	6
Stating Hypothesis of Solution	21	21
Evaluation of Hypothesis	19	52
Stating Solutions	0	2
End of Conversational Strategy	0	13
Total	100	100

Table 6-9

The Beginning and Ending of Conversational Strategies within Group Pedagogical Inquiry

	Beginning of Conversational Strategy (%) n = 38	End of Conversational Strategy (%) n = 38
Evaluation Experimenting	24	13
Defining Situations	39	8
Defining Goals	8	2
Explaining	16	8
Stating Action Goals	8	0
Stating Hypothesis	2.5	18
Evaluation Hypothesis	2.5	29
Stating Solution	0	11
Planning Solution	0	11
Total	100	100

Pedagogical Inquiry Conversations as Occasions for Teachers' Change

Pedagogical inquiry conversations represents social occasions for teacher change. These social occasions are embedded in the communicative events of conversational strategies. In the present study, change is understood in relation to the tachers' contributions to pedagogical inquiry. Some conversational strategies represent better opportunites for change than others. What follows is a selection of those key communicative events which represent occasions for the change of teachers' contributions to pedagogical inquiry.

Change in Teachers' Descriptions of Educational Situations

The interactive nature of group pedagogical inquiry enriches teachers' classroom descriptions. Teachers bring descriptions of classroom situations related to the pedagogical problem to the group meetings. These come from their own experience, peers' discussion, or readings. Sharing classroom descriptions allows teachers to acquire new desciptive power, as they construct multistatement descriptions of educational situations.

Constructing a Multistatement Description of Classroom Situations

The construction of descriptions by the beginning teacher involved accumulating different accounts of the same situation by other more experienced teachers. This accumulation allowed the decentration necessary for the beginning teacher to construct an external and stable educational reality. It also released tension by allowing him to share responsibility for his classroom problems.

The beginning teacher's descriptions were centered on his own behavior. In the beginning, he was anxious and worried about what was happening in his classroom. All events were a consequence of his own actions. In addition, he doubted his understanding of what was happening in his own classroom:

> "I don't think so, there are many (students)!. I might be wrong. When I ask students some have done it (homework) . . . We might be making a bigg fuss . . . They do something . . . You always have the feeling that they do not do anything (BT, M3, 3)."

The introduction of descriptions from other sources was a relief and a surprise for the beginning teacher. He had not thought that other experienced teachers could have the same problems or would feel the same way about their students as he did. Not only his science teacher colleagues, but also the parents to whom he talked, thought that 9th graders were really terrible. He was starting to construct a picture of his students which was independent of himself:

> "What is amazing is to see that this is general to all our 9th graders. This is so surprising (BT, M3, 9) !"

Coordinating Two Separate Descriptions

To construct descriptions the experienced teacher coordinated different descriptions collected through various sources about the same situation. Conversation and investigation helped him fashion coherent descriptions. These new descriptions used new concepts, which coordinated both apparently contradictory statements.

The experienced teacher brought to meetings strong descriptive statements about his classroom. He clearly stated that his students were not doing any homework. After attempts to change his homework checking strategies succeeded, he came to realize that more students were doing homework than he had thought. Despite this, the experienced teacher continued to state that the situation was not optimal. Students were still not doing homework. Prior to meeting #5, he read an article by Elliot which exerted a strong influence on him. This article concluded that high school students do simple but not high level thinking activities in the classroom.

The experienced teacher introduced this new statement into his descriptive repertoire. He had now developed two descriptions of the same situation; one came from personal experience, and the other from persuasive reading. These descriptions were articulated in the meetings at different times. They coexisted within the teacher's mind, but they were not integrated within one system. Both were equally true for the teacher. The researcher felt uncomfortable with this apparent contradiction which was not noticed by the teacher. Through conversation the teacher confronted the contradiction which in turn generated further investigation:

"This could be something to be done later on, however it is surprising to realize that I do not have a holistic picture. Before I was saying that students were doing easy activities, and right now I say that students do not work. I might be wrong. I do not know what is the solution. Both things seem to me equally right (ET, M7, 13)."

Each teacher brought different descriptions of the same classroom situations and adopted new descriptions gathered from group members or from written sources. This variety of descriptions is a natural consequence of having multiple sources of information, and of the interactive nature of conversations. However, these descriptions sometimes contained contradictory statements which went unnoticed by the teacher. Group interaction provided the context to face the contradiction and increases the chances to resolve it through further inquiry.

The Change of Teachers' Explanations

Group interaction provided the context for teachers and the researcher to construct their own explanations of problematic classroom events, and to confront contradictions between explanations. These changes occurred within different conversational strategies along pedagogical inquiry. What follows is a brief account of three occasions for changes in teachers' explanations.

Explaining Critical Classroom Events in a Different Way

The experienced and beginning teachers engaged in mentoring interactions, the former providing explanations for the latter. In conversational strategy # 2 in M8

(Appendix A), the beginning teacher was very upset, having discovered that many of his students had cheated on a homework assignement. The action goals he suggested conveyed forceful images of pressure, stopping what was going on, breaking students' attitudes and so forth.

The experienced teacher did not think that the situation was so alarming. He suggested that the novice consider cheating a part of students' developmental process in learning to think. In the beginning students had not done anything, not even cheated. Slowly, they overcome this resistance by cheating. Later on they might become more involved in the task.

Although the beginning teacher was reluctant to accept this developmental explanation, it helped him articulate the problem of whether to consider cheating a normal practice or a practice to be eradicated. Mentoring exposed the beginning teacher to new explanations. He began to see his classroom as an evolving entity with an independent path of development.

Failing to Construct an Homogeneous Explanation

The beginning and the experienced teachers did not reach the same explanation at the end of the pedagogical inquiry. In conversational strategy # 5 in M7 (Appendix A) the experienced teacher epoused the explanation that students were not doing homework, because they had not developed the habit of working on open, complex activities. Instead, the beginning teacher gave the explanation that students did not know what to do when faced with open complex activities. The action goals related to these two explanations lead to two different and incompatible solutions. The "habit" explanation suggested an action goal of pressure and breaking students' habits, with the teacher persisting in his old attitude. The lack of students' understanding explanationn led to the action goal of facilitating their task, by reducing the cognitive demands of the activity. This, in turn, obviously contradicted the basic goal of the experienced teacher, to stimulate students' thinking through open complex activities. Neither teacher changed their explanations over time; they remained unreconciled along this controversial conversational strategy. Group interaction did not induce one, homogeneous explanation for the homework problem.

Confronting a Contradiction Between Explanations

In conversational strategy # 6 during M7 (Appendix A) the researcher challenged the experienced teacher's explanation. He persisted in maintaining that students' lack of involvement in homework was caused by a habit of not working. This explanation was indistinctly applied to either of the following two descriptive statements: students do not do anything and students do easy but not complex activities. The "habit" explanation was originally developed to explain the first descriptive statement, then imposed on the second, without really explaining it. Through the conversational strategy, the researcher confronted the experienced teacher with the apparent contradiction between the two explanations: "students have a habit of not working"; and "students have the habit of working on easy activities."

In each of these cases, group interaction allowed teachers to consider other explanations, and to apply these explanations to specific descriptive situations. The beginning teacher had the opportunity to see the cheating problem from a developmental perspective, while the experienced teacher reconsidered the general applicability of the "habit" explanation. Both teachers ended the pedagogical inquiry with different explanations.

The Change of Teachers' Hypothesis of Solutions

Group interaction allowed teachers and the researcher to introduce new hypotheses of solutions to reject or accept them through evaluation statements; to change these evaluations through group interaction; and finally to adopt them as solutions. What follows is a brief account of three occasions for the change of teachers hypothesizing solutions to a pedagogical problem.

Mentoring Interactions: The Source for the Beginning Teacher's Acceptance of Hypothesis of Solution

Mentoring interactions provided the context for the interchange and evaluation of hypothesis of solution. In these mentoring interactions the experienced teacher provided the novice with hypotheses of solutions, and helped him evaluate them. For example, conversational strategies #4 in M1, #3 in M3, and #1 in M5 showed such mentoring interactions. These conversational strategies originated from the beginning teacher's concerns, or from specific requests for action after experiencing critical events in the classroom. The beginning teacher was usually open to the experienced teacher's suggestions for action, to the point that he adopted them as solutions in most mentoring conversational strategies. The trust and respect established between the two teachers ensured a positive channel of communication. Very seldom would the beginning teacher reject an hypothesis of solution coming from the experienced teacher. This was the only source of ideas for action available to the beginning teacher.

In conversational strategy # 2 in M12, the beginning teacher spoke of his dislike for Slavin's articles on cooperative learning and motivation (Slavin, 1980; 1984). Before interacting with the experienced teacher, the beginning teacher said:

> "I could not read it,....what he said, the differences he made...he does not proposed a final solution to motivate students (BT, M12, 14)."

The experienced teacher, however, liked Slavin's articles and provided a reasoned evaluation of them. After listening to the experienced teacher's evaluation Slavin's group work and discussing it, the beginning teacher was more open becuase he saw group work from another point of view:

> "The way you are approaching it is very interesting. For next year, we should do a good planning of group

work in order to make it work. We should do a rigorous organization of group work from the very beginning (BT, M12, 14)."

The beginning teacher's acceptance of an hypothesis of solution brought up by the experienced teacher appeared to be based on the trust and respect build into their relationship.

Beginning Teacher Interventions: A Balance in Confrontational Interactions

The beginning teacher also provided hypothesis of solution in response to the experienced teacher's requests for help. Although his hypothesis were not related to specific teaching strategies, they provided ways to overcome interactional confrontation and reach some degree of balance. For instance, when the experienced teacher put forth two contradictory explanations, the beginning teacher suggested a further of the facts aat issue (conversational strategies #4 and #7 in M7). Similarly, the novice suggested the experienced teacher stop trying to make student do open, high level thinking activities, in response to the frustration emerging from repeated failures (conversational strategy #3 in M7).

Confrontation Between the Experienced Teacher and Researcher: Reducing the Rejection to an Hypothesis of Solution

Interactions between the experienced teacher and the researcher at the level of stating and evaluating hypotheses of solutions were more confrontational than interactions at other levels of pedagogical inquiry. The experienced teacher had strong preferences for particular hypotheses of solutions, and frequently rejected those brought up by other group members. He held strong beliefs about the best solutions to the homework problem. The researcher tried to open up the experienced teacher to other hypothesis. For instance, in conversational strategy #8 during M1, the experienced teacher rejected group work as a viable solution to the problem. He based this rejection on unsuccessful experiences in the past. The researcher started a conversational strategy to learn what had gone wrong in the experienced teacher's attempts to use group work. The researcher found that group work had been unsuccessful because students' could not achieve consensus through small group interaction. However, the experienced teacher did not sustain a similarly rigorous notion of consensus when he was interacting with the whole class. The researcher reduced his resistance to group work by suggesting he compare his definitions of consensus This forced the experienced teacher to confront an internal contradiction.

In sum, group interaction provided a context for teachers to consider new hypotheses of solutions, to develop evaluative criteria, and to modify their initial evaluation of solution hypotheses. The beginning teacher was open to new hypothesis of solution and new evaluation when they came from the experienced teacher. In contrast, the experienced teacher held strong beliefs on the adequacy of particular hypothesis of solutions. Modification of the experienced teacher's evaluations was undertaken by pointing up contradictions in his own thought.

The Changing of Teachers' Classroom Experiments

Teachers' experiments underwent two phases. The first was adoption of a solution, at the end of a meeting. Two conventional constraints, external to the teachers, strongly influenced the adoption of particular solutions: (a) the need to adopt one solution by the end of each meeting, and (b) the need for the teachers' to agree on a single final solution. These constraints were set up at the beginning of the inquiry and they were accepted by the teachers. These constituted the basic determinants of the task structure of group poedagogical inquiry (Erickson, 1982).

The second phase was the evaluation of the experimenting in the classroom. Evaluation usually took place at the start of the subsequent meeting. The teachers' personal views of their actions in the classroom provided the information needed to understand what they really did in the classroom. Evaluations also gave teachers the opportunity to compare results and learn from each other.

A comparison of teachers' adoption of solution and the evaluation of these solutions revealesd conflict between the social and the personal dimensions of teachers' experimenting a solution in the classroom. In fact, what teachers said they would do, at the end of each meeting, was sometimes different of from what they did in the classroom.

In order to capture teacher conflict in dealing with the social and personal dimensions influencing their adoption of solutions, both phases will be presented together. Analysis of this conflict will help us to understand what constituted a solution for each teacher, and how group interaction provided the occasion for teacher change.

The Beginning of Group Pedagogical Inquiry

Adoption of solutions. The adoption of solutions for the beginning and experienced teachers was the outcome of different conversational strategies. The beginning teacher adopted solutions based on mentoring conversational strategies with the experienced teacher. The beginning teacher usually began the mentoring conversational strategies by expressing a concern or posing a problem in the implementating of an action. The experienced teacher responded with help, making the mentoring interaction possible. The beginning teacher appeared to have a personal agenda which was manifested within the mentoring conversational strategies. What the beginning teacher said he would do, corresponded to what he actually implemented in the classroom. The solutions attempted in his classroom were specific strategies for homework checking: Collecting certain students' homework everyday as a solution to their not listening when he had commented on the results of the homework problem on the board (M1); collecting the same students' homework every day as a way to exert pressure on a group of lazy students (M3).

Social constraints of the pedagogical inquiry appeared to exert stronger pressure on the experienced teacher, especially at the beginning of the group pedagogical inquiry. The experienced teacher's adoption of a solution usually came about through a conversational strategy taking place at the end of a meeting. One the one hand, through the conversational strategy he appeared to have been persuaded to adopt a solution he had first rejected. On the other, the meeting was drawing to close, and he had to adopt some solution to test in the classroom. Although he articulated the adoption of specific solutions during M1 and M3, he also manifested reluctance and doubt as to their effectiveness:

> "This looks like a good idea, rewrite an activity with this underlying plan, may be, stating first to search for past knowledge, second to make them contrast with his own schema, and third.... I do not know whether this would be a good framework (ET, M1, 17)."

> "O.K., I am ready to this and that, the lessons out of school hours and so on, this is O.K.... but there is something missing, I don't know. I assume that when you solve a problem you find yourself with this. I will find the solution. Plus, I like to do it this way. Like this... have you ever plyed chess?(ET, M3, 16)."

Evaluation of experimenting in the classroom. The experienced teacher never implemented these solutions articulated at the close of M1 and M3. Although they were stated at the end of the meeting he did not think of them as real solutions to his problem. However, he did implement the strategies of maintaining homework checking along with the beginning teacher. The constraints of the conversational strategies, and the need to adopt a solution at the end of each meeting, appeared to guide his articulation of a solution. However, since he was not sure about this, and teachers were required to adopt consensus solutions, he finally implemented the same solutions he had offered to the beginning teacher. Thus, both teachers experimented with the same action, even though it was not a solution to the experienced teacher's problem.

While the beginning teacher was looking for specific actions to solved specific problems of how to make students work, the experienced teacher was looking for a more encompassing actions. The implementation of a series of actions, in the hope that the multiplication of their effects would solve the problem, was not an attractive solution for the experienced teacher. He was searching for a structural solution rather than a compendium of strategies which would increase the probability of reaching a solution.

The social constraints of the group pedagogical inquiry exerted pressure on the experienced teacher to adopt a solution which he did not, in fact, consider appropriate. Despite this, he adopted the solution of the beginning teacher. This new focus on his already implemented homework checking strategies allowed him to increase descriptions of students' reactions to homework. Whereas the beginning teacher received help in constructing classroom strategies, the experienced teacher became aware of some previously unnoticed students' behaviors. Experimenting in the classroom allowed the beginning teacher to construct a compendium of teaching actions, while enriching the experienced teacher's perceptions of students. Although the action implemented was the same, it was guided by a different purpose and had different effects on the teachers. Both teachers experienced growth: at the action level, for the beginning teacher; and at the cognitive level, for the experienced teacher.

The Development of Group Pedagogical Inquiry

The adoption of a solution. A change in the teachers' adoption of solutions was observed from meeting five on. The experienced teacher started to adopt the solutions which had been developed specifically for his problem. He implemented the actions decided on through group interaction. In contrast, the beginning teacher appeared to adopt solutions as the result of the social constraints established through group interaction. His implemented solutions no longer correspond to his adopted solutions.

The experienced teacher's adopted solution included changes in the content and structure of the homework activities assigned to his students. His goal was to explore students' reactions to open and complex physics activities. The beginning teacher adopted the same solution , but under the constraint of finding a solution before the meeting ended. For the next three meetings, both teachers conducted an investigation of students' responses to the homework assignment of open physics activities.

Although the activity was the same, both teachers worded it differently. The experienced teacher worded it openly and without any guidelines, whereas the beginning teacher intrduced several guiding steps. These actions were the result of each teacher's individual explanations of students' lack of involvement in homework. The experienced teacher thought that students were not doing open complex activities becuase they did not want to think. He hoped his persistence in assigning them more open, complex activities would eventually reduce their resistance to thinking. Instead, the beginning teacher explained this phenomena by asserting that students did not understand what they had to do. The wording of activities using guiding statements would help them to understand and they would ultimately do the homework. The experienced teacher wanted students to think at home through complex physics activities, whereas the beginning teacher wanted students to do homework.

In sum, the social constraints of group pedagogical inquiry exerced pressure on the beginning teacher to adopt an homogeneous solution which was not appropriate. He resolved this conflict by changing the wording of the homework activity according to his personal goals and explanations of the pedagogical problem. In contrast, the experienced teacher adopted the solutions which were according to his goals and explanations of the homework problem.

Evaluation of a Classroom Investigation. Evaluating classroom investigations through group interaction presented learning opprotunities to both teachers, despite discrepancies in their implemented solutions. As a consequence of investigating students' responses to open, complex physics problems, the experienced teacher realized that it was not enough to force students to think through homework problems. His investigation revealed that, although most students were willing to complete the requirements, they were not willing to think hard about the problems. The investigation resulted in a better understanding of the truth of two previous, apparently contradictory, statements about his students: students do homework; students do not do open complex activities.

The beginning teacher learned both from his own investigation, and from the contrasting results of the experienced teacher's investigation. From his own investigation, the beginning teacher learned that homework problems which included guiding steps in their wording were more effective in allowing students to complete them. In fact, more students completed homework in his class than in the experienced teacher's class. In addition, the beginning teacher learned that an unexpectedly high percentage of his students were cheating. All his subsequent investigations were guided by a concern to identify cheaters.

By comparing his own results with those of the experienced teacher, the beginning teacher realized that nothing could be learned about students' thinking from activities that were not open. Although his wording of the homework activity resulted in more students completing it, he did not know what they were thinking. The guiding steps introduced into the wording of the activity prevented students from developing their own ways of thinking. Through the evaluation of the research group, the beginning teacher could relate the structure of an activity to his students' thinking.

This growth in the beginning teacher's understanding was reflected in his subsequent efforts to understand the meaning of each activity. For instance, during meeting M8 both teachers spent more time over wording the activity to be assigned to students than they had during earlier meetings. One conversational strategy for planning a solution was guided by the beginning teacher's questions concerning the meaning and main conceptual difficulties of the activity. He wanted to better understand the open, complex physics activity himself, so he could use it more effectively in the classroom:

> "ET- What we need to do is to find another problem. There is another problem similar to the gravitation problem, but it is very difficult to mark. Then, there is the problem of the boat. If they have not understood the principle of inertia they will not be able to solve it. Well, historically they had many difficulties with this problem as well, it was incredible!
>
> BT- How did you frame the problem of the boat? But this answer is a short one, right? What would you consider in here? What would be a positive answer? It falls at the same place.

ET- No, this is not an answer, you need to reason about it.

BT- It falls in the vertical because the stone has the same horizontal speed as the boat . . . what would you expect as an answer? (ET & BT, M8, 10)."

Despite differences in their investigations of students' responses to homework activities, these investigations represented occasions for change for both teachers. The experienced teacher made a place for two apparently contradictory beliefs about students, while the beginning teacher obtained new information about students' attitudes towards homework. In addition to this, the group evaluation of his investigation provided an opportunity for the beginning teacher to make the connection between the wording of an activity and student thinking during its performance. The social constraint forcing adoption of an homogeneous solution provided a unified focus for the investigations. Within this focus, each teacher acted according to his own goals and definition of the problem. The evaluation of solutions provided a forum in which to compare individual actions, and modify them.

<u>The End of Group Pedagogical Inquiry: Adoption of a Group Work Project</u>

After five meetings, the teachers felt deeply discouraged about the possibility of making students think through open, complex physics activities at home. Both teachers realized that challenging students with thought provoking activities was not enough to make them think at home; that is, to create independent thinkers. They began to play with the idea that this goal was impossible. However, the strength of the experienced teacher's goals, and his images of students as independent thinkers, maintained their hope in finding a solution. Repeated failure throughout the group pedagogical inquiry provided an opportunity for the experienced teacher to develop and enrich his model of a classroom to further conceptual change; and to better understand the important role played by students' homework.

The adopted solution came from the researcher, who passed out a persuasive article on group work and students' motivation to learn. The teachers did not implement group work immediately. They played with the idea of group work, imagining their students working in groups and planning the details of implementation. For the first time, the teachers began planning for an educational project which involved more than changing teaching strategies, or the content of activities. The structure of their teaching was being transformed. This was, after all, the kind of solution the experienced teacher had hoped to find: a broad change in his way of teaching, which addressed within one, homegeneous system all the problems he had previously defined. Developing homework for conceptual change represented the initial step in restructuring the experienced teacher's conception of a classroom.

CONCLUSION

Group pedagogical inquiry can be described in terms of a discrete set of nine functional categories, called pedagogical inquiry moves. These moves constitute logical steps towards solving teachers' problems, and can be combined into four general functions: defining the situation; explaining it; identifying hypotheses of solution and evaluating them; and finally, experimenting the adopted solutions.

Group pedagogical inquiry is a spiral process, with cycles begun in one meeting finishing in the next. During this project, the content of teachers' pedagogical inquiry moves changed over time. Teachers' descriptions became richer over the first half of the inquiry, as they drew information from new sources. Then, the variety of descriptions decreased, as the teacher inquiry became more focused and dependent on small investigations. The same trend was identified for teachers' explanations. At the beginning explanations were more abundant; then, slowly, teachers became committed to single explanations. Success and failure in experimenting solutions led to differences in teachers' explanations. Failure generated teacher explanations of students' resistence whereas success generated explanations of students' change. Teachers attributed students' resistence to negative personality traits. In contrast, their explanations of students' positive change were developmental. This finding indicates that action results strongly influence the construction of pedagogical knowledge.

The frequency of teachers' hypotheses and evaluations of solutions and their evaluation did not change substantially during the inquiry. As with other pedagogical inquiry moves, teachers' hypotheses and evaluations of solutions differed, according to success or failure in classroom experiments. More hypothesizing activity was found in meetings after failure, than in meetings after success. The evaluation of hypotheses of solution indicated teachers' adherence to specific actions; these evaluations were the key elements for guiding argument and interaction.

Teachers' experimental classroom solutions also changed during the inquiry. In the beginning, the experiments were discrete homework checking strategies aimed at changing the learning environment. Later, the solutions began focusing on the content of activities assigned to students. Investigations were also conducted for the purpose of resolving contradictions. The final solutions integrated concerns over content and concerns with the learning environment, by attempting classroom restructuring.

The organization of interaction within group pedagogical inquiry has been described with reference to the structure of inquirers' discourse. Pedagogical inquiry conversations have been shown to have an overall structure and a micro-structure. The micro-structure of pedagogical inquiry conversations is best described as a sequence of conversational strategies, each constituted by a linear sequence of pedagogical inquiry moves. Group participants built conversational strategies by contributing one or more pedagogical inquiry moves to the construction of a linear sequences. The sequence of pedagogical inquiry moves within each conversational strategy began with descriptions and explanations, and ended with hypotheses, evaluations or statements of solution. Conversational strategies were goal directed. The outsider/researcher specialized in starting new conversational strategies. Teachers' pedagogical inquiry discourse was found to occur within communicative constraints set forth by the overall structure and the micro-structure.

Group interaction strongly influenced teacher change during the pedagogical inquiry process. For both teachers, change was shown to be a consequence of critical interactions within conversational strategies.

The beginning teacher changed as a consequence of accepting the experienced teacher's descriptions, explanations and hypotheses of solution, through mentoring conversational strategies. At first, he appeared to be in the process of constructing a repertoire of descriptions, explanations and actions which had proven successful for the experienced teacher. By the end of the inquiry, however, he had developed an independent explanation which stood in opposition to those of the experienced teacher. The beginning teacher changed by constructing new actions and expanding his repertoire of descriptions and explanations.

The experienced teacher changed as a consequence of conversational strategies which induced him to confront internal contradictions. Change for the experienced teacher involved a congitive restructuring of isolated and sometimes contradictory descriptions, explanations and educational goals.

Classroom experimentation revealed the teachers' internal conflict between the personal and the socially agreed actions. Teachers found personal ways not to implement actions they disagreed with. Despite this, sharing the results of different experimented solutions proved an excellent occasion for teachers change.

APPENDIX A

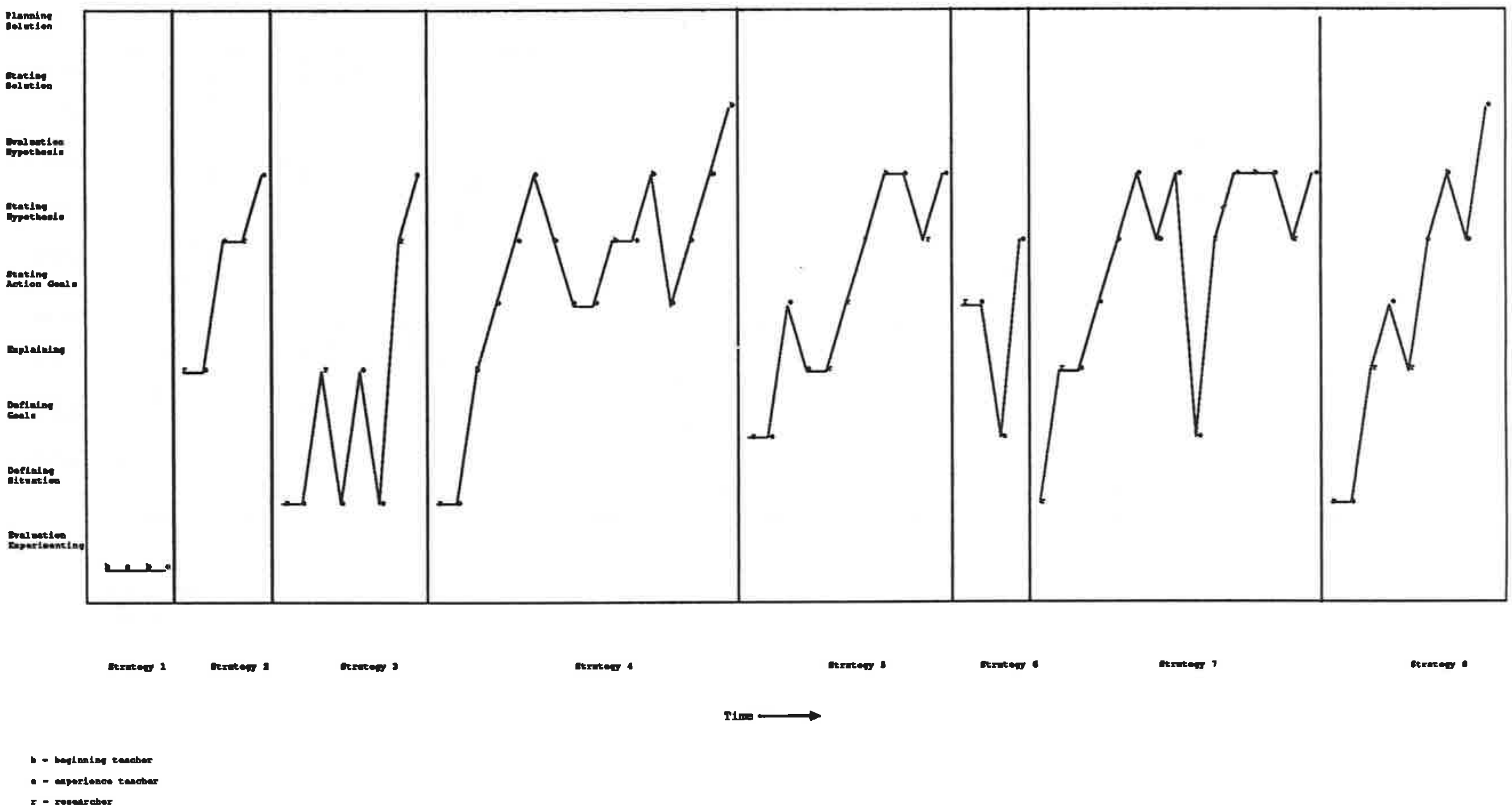


Figure 6-1. Conversational Strategies in Group Pedagogical Inquiry (Meeting 1).

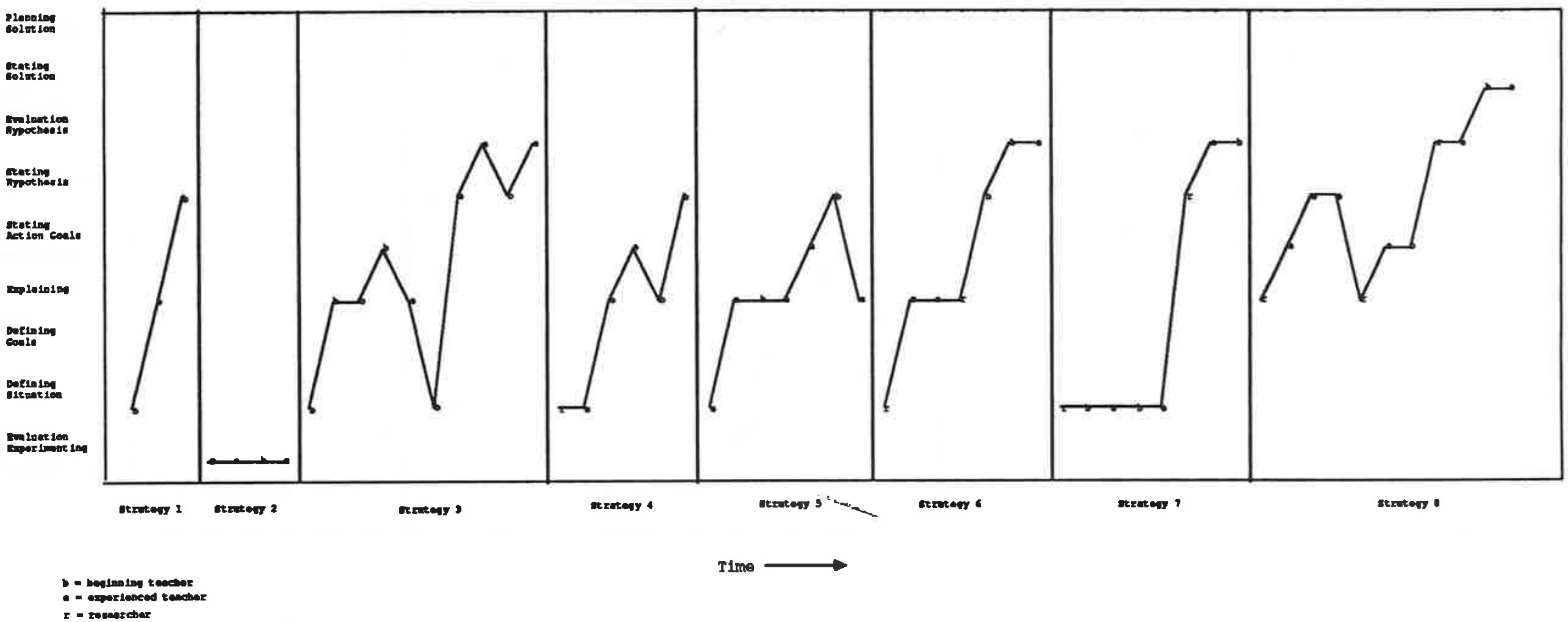


Figure 6-2. Conversational Strategies in Group Pedagogical Inquiry (Meeting 3).

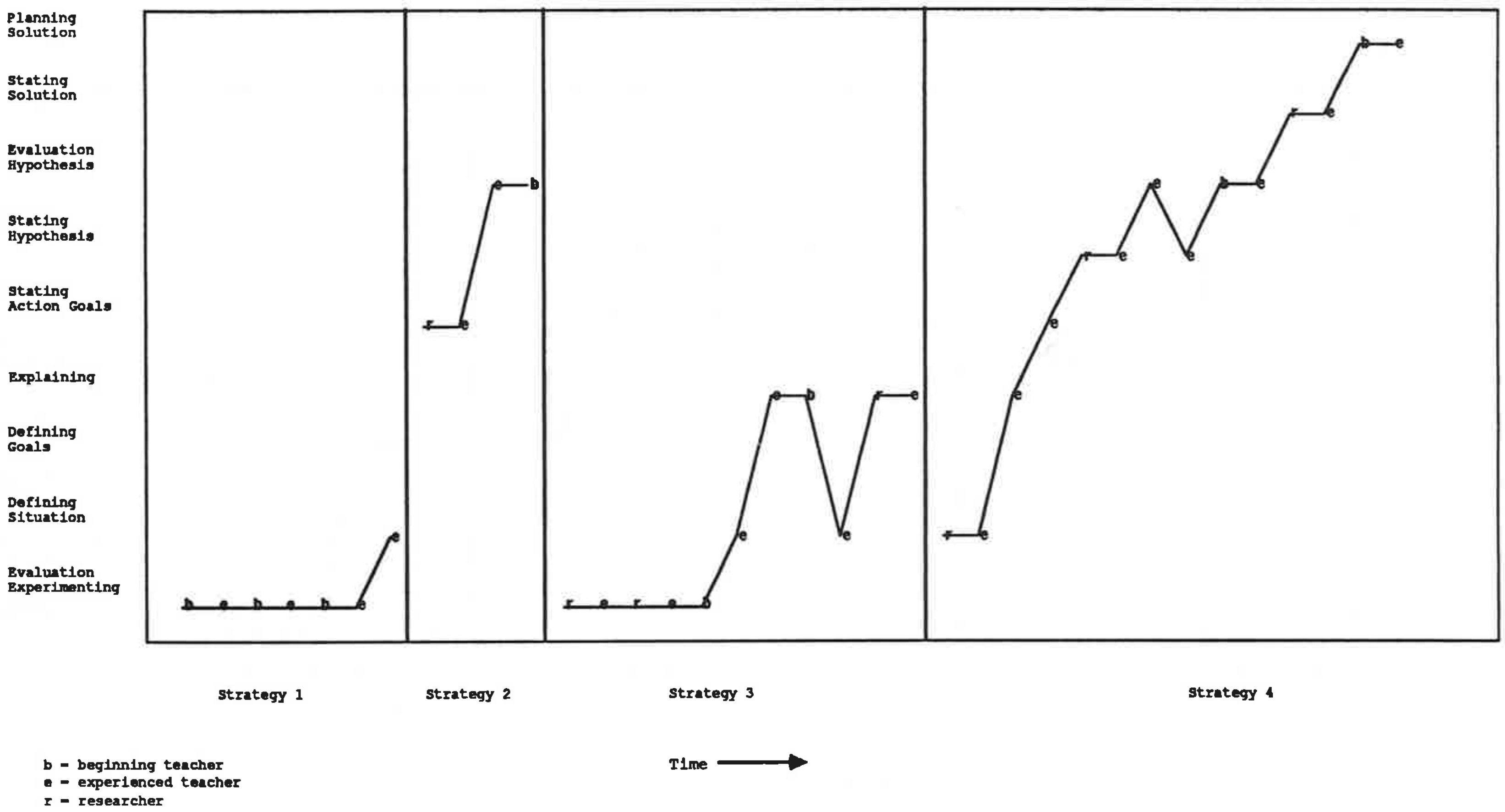


Figure 6-3. Conversational Strategies in Group Pedagogical Inquiry (Meeting 5).

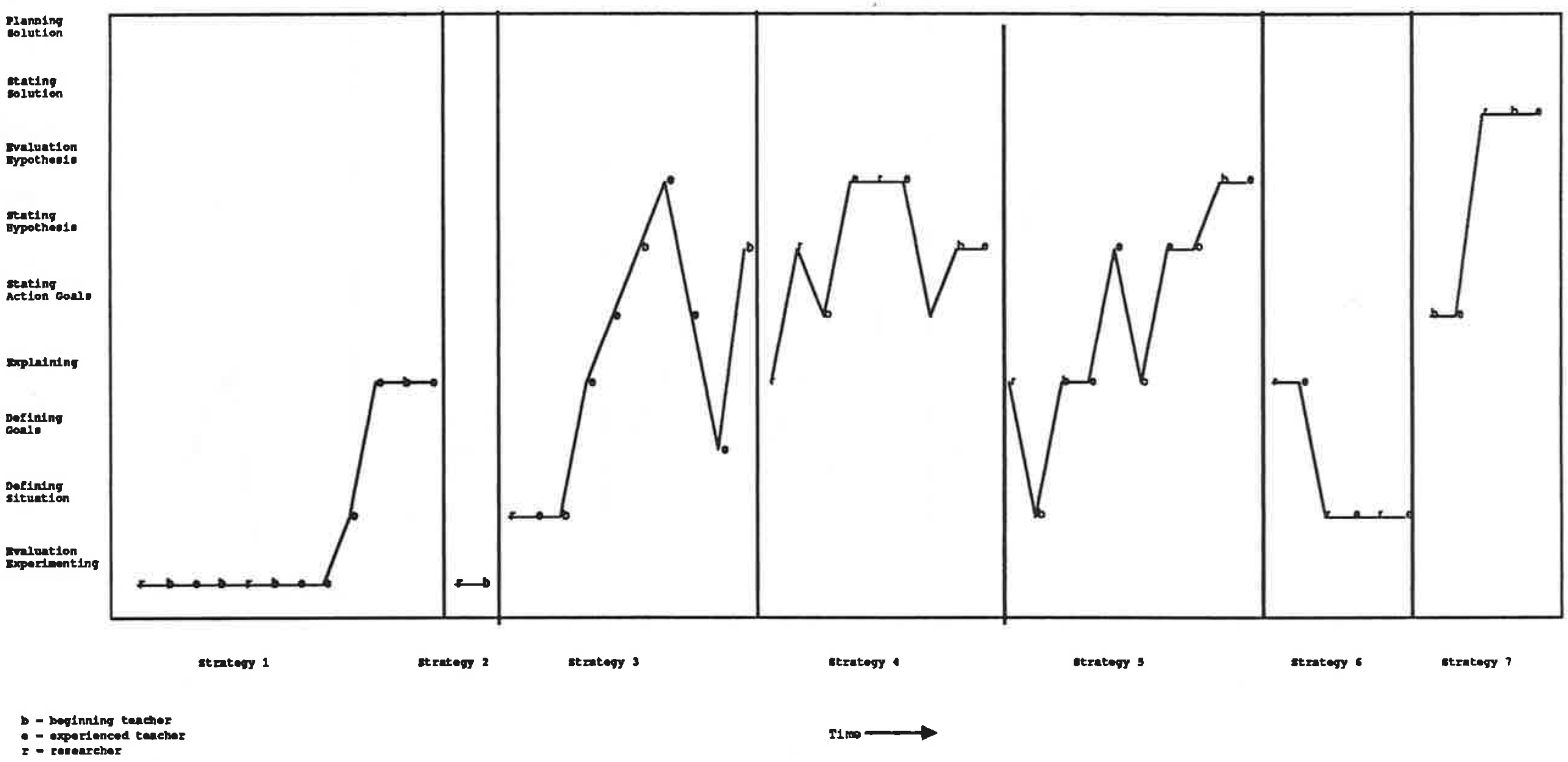


Figure 6-4. Conversational Strategies in Group Pedagogical Inquiry (Meeting 7).

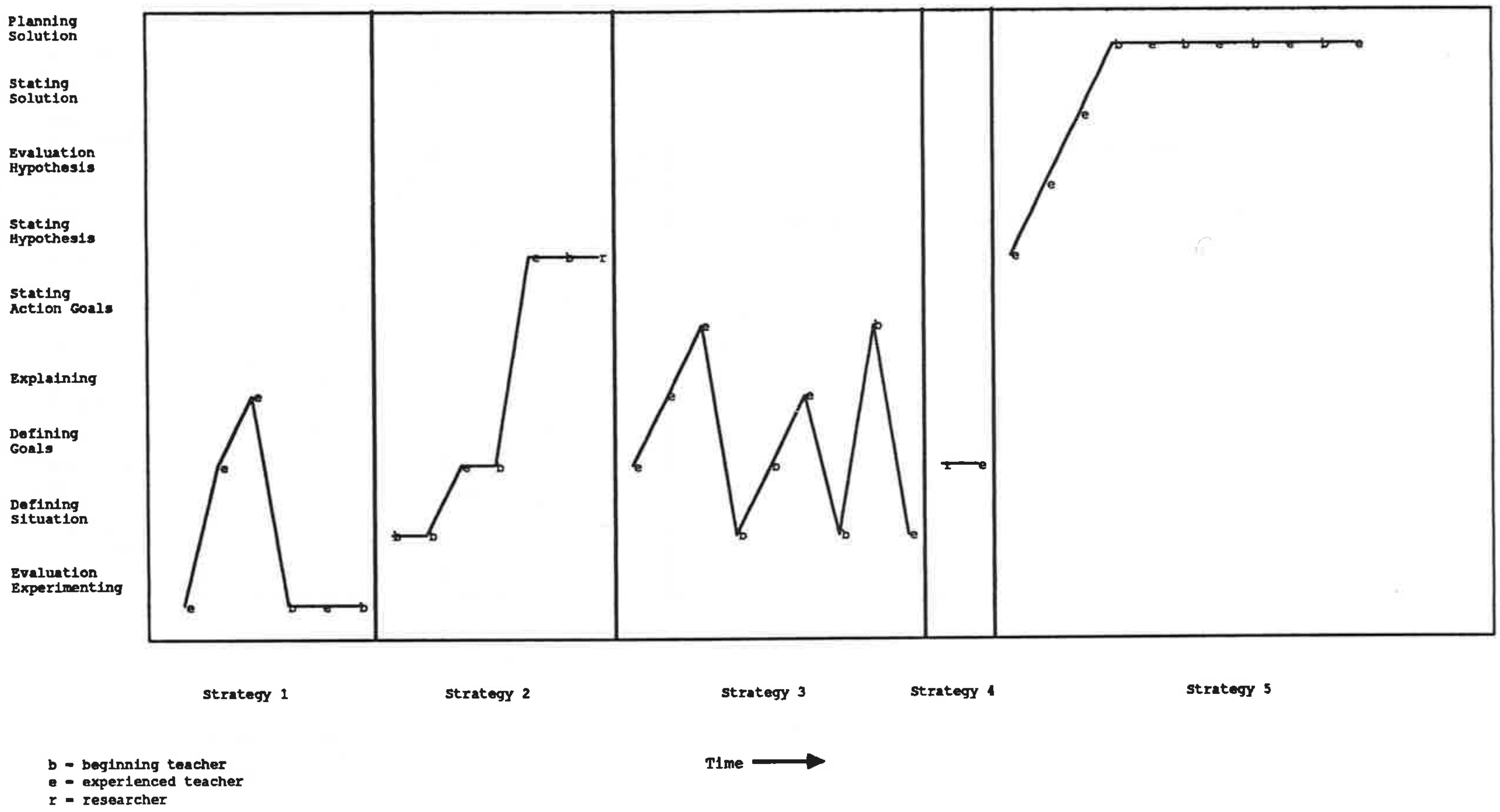


Figure 6-5. Conversational Strategies in Group Pedagogical Inquiry (Meeting 8).

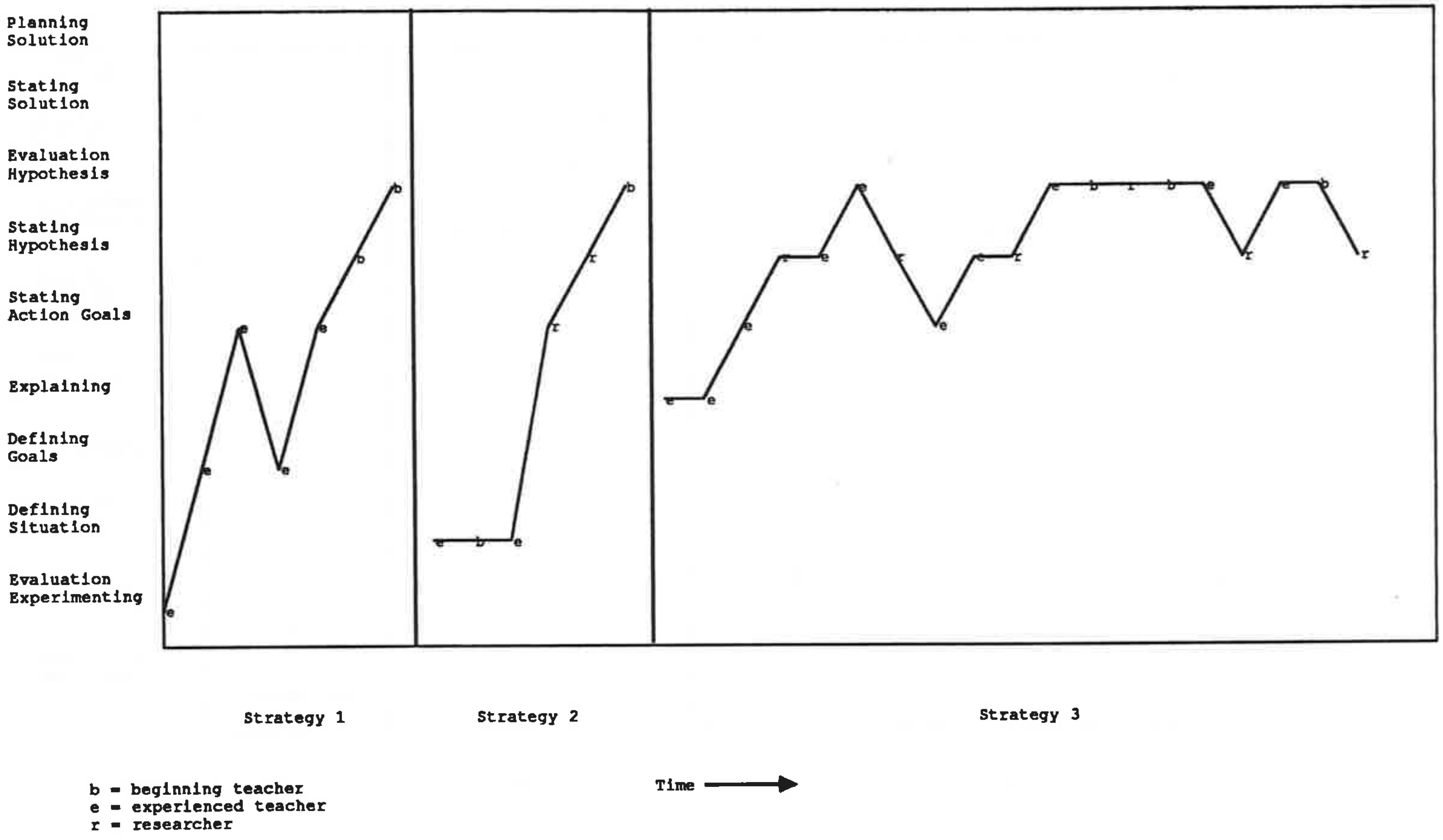


Figure 6-6. Conversational Strategies in Group Pedagogical Inquiry (Meeting 10).

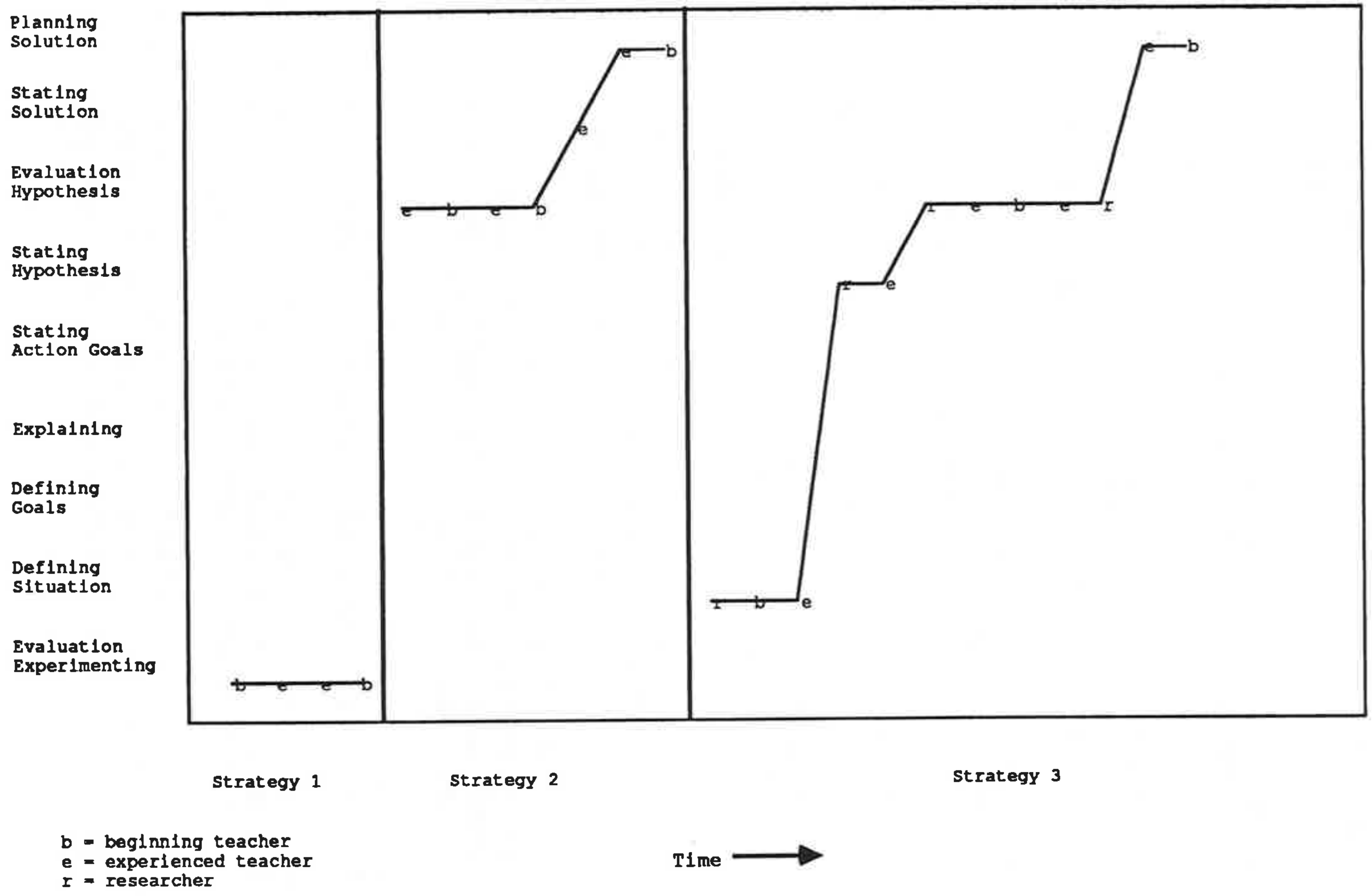


Figure 6-7. Conversational Strategies in Group Pedagogical Inquiry (Meeting 12).

REFERENCES

Allender, J.S. (1986). Educational research: A personal and social process. Review of Educational Research, 56(2), 173-193.

Argyris, C., & Schon, D. (1974). Theory and practice: Increasing professional effectiveness. San Francisco: Jossey-Bass.

Argyris, Ch., Putnam, R., & Smith D.M. (1985). Action Science. Concepts, methods, and skills for research adn intervention. San Francisco: Jossey-Bass.

Aristotle. (1962). The nicomachean ethics (2nd revised ed.) (H. Rackham Transl.). Cambridge, Massachusetts: Harvard University Press.

Austin, J.L. (1962). How to do things with words. London: Oxford University Press.

Bales, R.F. (1950). A set of categories for the analysis of small group interaction. American Sociological Review, 15, 257-263.

Bales, R.F., & Strodtbeck, F.L. (1951). Phases in group problem solving. Journal of Abnormal and Social Psychology, 46(4), 485-495.

Ball, S. (1989). "Self doubt and soft data: Social and technical trajectories in ethnographic fieldwork". Qualitative Research in Education Conference, University of Georgia, Athens, USA, January 1989.

Bennis, W.G., & Shepard, H.A. (1956). A theory of group development. Human Relations, 9(4), 415-57.

Berg, D. N. (1988). Anxiety in research relationships. In Berg, D.N., & Smith, K.K. (Eds.). The Self in Social Inquiry. (2nd Ed). Newbury Park: Sage.

Berg, D.N., & Smith, K.K. (1988). The clinical demands of research methods. In D.N. Berg, & K.K. Smith. (Eds.). The Self in Social Inquiry. (2nd Ed). Newbury Park: Sage.

Bion, W.R. (1959). Experiences in groups. New York: Basic Books.

Bloom, B.S. (1953). Thought processes in lectures and discussions. The Journal of General Education, 7(3), 160-169.

Blumberg, A. (1970). A system for analyzing supervisor-teacher interaction. In A. Simon & G. Boyer (Eds.), Mirrors for behavior V3. Philadelphia: Research for Better Schools.

Blumer, H. (1969). Symbolic interactionism. Perspective and method. Berkeley: University of California Press.

Brandewie, E. (1969). Comments on the problem of ethical integrity in participant observation. Current Anthropology, 10 (5), 512-23.

Brown, A. (1987). Metacognition, executive control, sel-regulation in F.E. Weinert, & R.H. Klurve (Eds.), Metacognition, motivation and understanding. Hillsdale, N.J.: Lawrence Erlbaum.

Brushlinskii, A.V. (1987). Activity, action and mind as a process. Soviet Psychology, 25(4), 59-81.

Calderhead, J. (1986). Developing a framework for the education and analysis of teacher's verbal reports. Paper presented at AERA, San Francisco.

Carnegie Forum. (1986). A Nation Prepared: Teachers for the 21st Century. New York: The Carnegie Forum on Education and the Economy.

Carpenter, T.P., Fennema, E., Peterson, P.L., & Carey, D.A. (1987). Teachers' pedagogical content knowledge of students' problem solving in elementary arithmetic. Journal of Research in Mathematics Education, 19(5), 385-401.

Carr, W., & Kemmis, S. (1988). Becomming critical. Education, knowledge and action research. London: The Falmer Press.

Castel, C., Espinet, M., & García, P. (1988). "Los deberes": Una experiencia de investigación en la acción en las aulas de bachillerato. Paper presented at Jornadas the investigación en la escuela, Lleida, Spain, May 1988.

Cazden, C.B. (1986). Classroom discourse. In M.C. Wittrock (Ed.), Handbook of research on teaching. New York: Macmillan.

Cellérier, G. (1983). Guidance of action by knowledge. In R. Groner, M. Groner and W.F. Bischof (Eds.) Methods of Heuristics. Lawrence Erlbaum: Hillsdale, NJ.

Chandler, B. (1971, February). Levels of thinking in supervisory conferences. Paper presented at the annual meeting of the American Educational Research Association, New York. (ERIC Document Reproduction Service No. ED 049 186)

Cicourel, A. V. (1981). Note on the integration of micro- and macro- levels of analysis. In K. Knorr-Cetina & A. V. Cicourd (Eds.) Advances in Social Theory and Methodology, Boston: Routledge & Kegan Paul.

Clark, C.M., & Peterson, P.L. (1986). Teachers' though processes. In M. Wittrock (Ed), Handbook of research on teaching. New York: Macmillan.

Confrey, J. (1978). Conceptions of Mathematics survey. Unpublished manuscript, Mount Holyoke College.

Connelly, F.M., & Clandinin, D.J. (1986). On narrative method, personal philosophy and narrative unities in the study of Bteaching. Journal of Research in Science Teaching, 23(3), 15-32.

Conners, R.D. (1978). Analysis of teacher's thought processes, beliefs and principles during instruction. Doctoral Dissertation. The University of Alberta.

Corey, S.M. (1953). Action research to improve school practices. NY: Teachers College, Columbia University Press.

Coulthard, M. (1977). An introduction to discourse analysis. Harlow, Essex: Longman.

Craig, R.T., & Tracy, K. (1983). Conversational coherence. Beverly Hills: Sage Publications.

Devreux, G. (1967). From Anxiety to Method. The Hague: Mouton.

Dewey, J. (1933). How we think. Boston: Heath.

Dewey, J. (1938). Logic: The theory of inquiry. NY: Holt.

Dijk, T.A. van. (1983). La ciencia del texto. Un enfoque interdisciplinario (The science of text. An interdisciplinary approach)(S. Hunzinger, Trans.). Barcelona: Paidos. (Original work published 1978)

Dijk, T.A. van. (1984). Texto y contexto. Semantica y pragmatica del discurso. (Text and context. Exploration in the semantics and pragmatics of discourse). (J. Domingo Moyano, Trans.). Madrid: Catedra. (Original work published 1977).

Dijk, T.A. van. (1985). Discourse analysis as a new cross-discipline. In T.A. van Dijk (Ed.), Handbook of discourse analysis (V1). London: Academic Press.

Ebbutt, D. (1985). Educational action research: some general concerns and specific quibbles. In R.G. Burgess (Ed.) Issues in educational research: Qualitative methods. London: The Falmer Press.

Eisenhart, M.A.; Shrum, J.L.; Myers, L.J. (1985). Teaching as a complex beliefs system: Implications for understanding teachers educational reform. Paper presented at AERA, Chicago.

Elbaz, F. (1981). The teacher's practical knowledge report of a case study. Curriculum Inquiry, 11(1).

Elliot, J. (1976). Developing hypothesis about class-rooms from teachers' practical constructs: An account of the work of the Ford Teaching Project. Paper presented at AERA, San Francisco.

Elliot, J., Sutton, C., & Harding, J. (1978). What is action research in schools? Journal of Curriculum Studies, 10(4), 355-357.

Elliot, J. (1981). Action research: Framework for self-evaluation in schools (TIQL working paper No 1). Cambridge Institute of Education.

Elliot, J. (1988). Educational research and outsider-insider relations. Qualitative Studies in Education, 1(2), 155-166.

Elstein, A.S., Shulman, L.S., & Sprafka. S.A. (1978). Medical problem solving. Cambridge, MA: Harvard University Press.

Ericcson, K.A., & Simon, H.A. (1980). Verbal reports as data. Psychological Review, 87, 215-251.

Erickson, F. (1982). Classroom discourse as improvisation: Relationship between academic task structure and social participation structure. In L.Ch. Wilkinson (Ed.), Communicating in the classroom. New York: Academic Press.

Erickson, F. (1986). Qualitative methods in research on teaching. In Wittrock, M.C. (Ed.), Handbook of research on teaching. New York: Macmillan.

Ferrini-Mundy, J. (1986). Mathematics teachers' attitudes and beliefs: Implications for in-service education. Paper presented at AERA, San Francisco.

Florio-Ruane, S. (1987). Sociolinguistics for educational researchers. American Educational Research Journal, 24(2), 185-197.

Gage, N.L. (1972). Teacher effectiveness and teacher education; the search for a scientific basis. Palo Alto, CA: Pacific Books.

Gauthier, D.P. (1963). Practical reasoning. The structure and foundations of prudential and moral arguments and their exemplification in discourse. Oxford: Oxford University Press.

Gick, M.L., & Holyoak, K.J. (1983). Schema induction and analogical transfer. Cognitive Psychology, 15, 1-38.

Gil, D., & Martinez-Torregrosa, J. (1983). A model for problem-solving in accordance with scientific methodology. European Journal of Science Education, 5 (4), 447-455.

Glasersfeld, E. von. (1984). An introduction to radical constructivism. In P. Watzlawick (Ed.), The Invented Reality. New York: Norton.

Glasersfeld, E. von. (1987). Constructivism. In A. Lewy (Ed.), The International Encyclopedia of Education. Oxford/New York: Pergamon Press.

Glasersfeld, E von. (1989). Abstraction, re-presentation, and reflection. An interpretation of experience and Paiget's approach. In L.P. Steffe (Ed.), Epistemological foundations of mathematical experience. Hillsdale, N.J.: Erlbaum.

Glazer, M (1972). The research adventure. Promise and problems of field work. New York: Random House.

Glickman, C. D., & Bey, T. M. (In Press). Supervision. In R. Huston (Ed.) Handbook of Research in Teacher Education. Macmillan: Association of Teacher Educators.

Goetz, J.P., & LeCompte, M.D. (1984). Ethnography and qualitative design in educational research. Orlando, FA: Academic Press.

Goodman, J. (1986). Constructing a practical philosophy of teaching: A study of pre-service teacher's professional perspectives. Paper presented at AERA, San Francisco.

Grundy, S. (1982). Three modes of action research. Curriculum Perspectives, 2(3), 23-34.

Gumperz, J.J. & Hymes, D. (Eds.). (1964). The ethnography of communication (Special issue). American Anthropologist, 66(6).

Hashweh, M.Z. (1986). Toward an explanation of conceptual change. European Journal of Science Education, 8(3):229-249.

Henry, J. (1985). A critical analysis of action research-based in-service education: Four case studies, unpublished Ph.D. thesis, Geelong, Victoria, Deakin University.

Hewson, P.W. (1981). A conceptual change approach to learning of science. European Journal of Science Education, 3(4):383-396.

Holloway, E.L. (1982). Interactional structure of the supervision interview. Journal of Counseling Psychology, 29, 309-317.

Holmes Group. (1986). Tomorrow's Teachers: A Report of The Holmes Group. East Lansing: The Holmes Group, Inc.

Huberman, M. (1985). What knowledge is of most worth to teachers? A knowledge use perspective. Teaching and Teacher Education. 1(3):251-262.

Hull,C., Rudduck,J., Sigsworth,A., & Daymond, G. (1985). A room full of children thinking: Accounts of classroom research by teachers. York: Longman.

Hymes, D. (1972). Models for the interaction of language and social life. In J.J. Gumperz & D. Hymes (Eds.), Directions in sociolinguistics: The ethnography of communication. New York: Holt.

Inhelder, B., & Piaget, J. (1958). The growth of logical thinking from childhood to adolescence. New York: Basic Books Inc. (original work published 1955).

Janesick, V.J. (1979). An ethnographic study of a teacher's classroom perspective: Implications for curriculum. Michigan State University. Institute for Research on Teaching.

Jarvie, I.C. (1969). The problem of ethical integrity in participant observation. Current Anthropology, 10(5), 505-8.

Kagan, D.M. (1988). Research on the supervisors of counselors- and teachers-in-training: Linking two bodies of literature. Review of Educational Research, 58(1), 1-24.

Karmiloff-Smith, A., & Inhelder, B. (1975). If you want to get ahead, get a theory. Cognition, 3(3), 195-212.

Kelly, G.A. (1955). The psychology of personal constructs. New York: W.W. Norton.

Lakoff, G., & Johnson, M. (1980). Metaphors we live by. Chicago: The University of Chicago Press.

Kelly, A. (1985). Action research: What is it and what can it do?. In R.G. Burgess (Ed.), Issues in educational research: Qualitative methods. London: The Falmer Press.

Kemmis, S. (1985). Action research. In T. Husen & T.N. Postlethwaite (Eds.), International encyclopedia of education: Research and studies. Pergamon Press.

Kemmis, S. & McTaggart, R. (1982). The action research planner. Victoria, Deakin University.

Khun, T.S. (1978). La revolución copernicana. Barcelona: Ariel.

Labov, W., & Fanshel, D. (1977). Therapeutic Discourse. Psychotherapy as conversation. New York: Academic Press.

Lampert, M. (1986). Teaching about thinking and thinking about teaching. Journal of Curriculum Studies. 16(1), 1-18.

LeCompte, M.D., & Goetz, J.P. (1982). Problems of reliability and validity in ethnographic research. Review of Educational Research, 52(1), 31-60.

Leinhart, G., Weidman, C., & Hammond, K.M. (1987). Introduction and integration of classroom routines by expert teachers. Curriculum Inquiry, 17(2), 135-176.

Leontev, A.N. (1981). The problem of activity in psychology. In J.V. Wertsch (Ed.), The concept of activity in soviet psychology: An introduction. NY: M.E. Sharpe, Inc. (Original work published 1972).

Leontev, A.N. (1981). The problem of activity in psychology. In J.V. Wertsch (Ed.), The concept of activity in soviet psychology: An introduction. NY: M.E. Sharpe, Inc. (Original work published 1972).

Levinson, S. (1983). Pragmatics. Cambridge: Cambridge University Press.

Lewin, K. (1946). Action research and minority problems. Journal of social issues, 2, 34-46.

Lewin, K. (1952). Group decision and social change. In T.M. Newcomb & E.L. Hartley (Eds.), Readings in social psychology, New York: Holt.

Lincoln, Y.S., & Guba, E.G. (1985). Naturalistic Inquiry. Beverly Hills, CA: Sage.

Manning, P.K. (1987). Structuralism and social psychology. Studies in Symbolic Interaction, 8, 93-119.

Marland, P.W. (1977). A study of teachers interactive thoughts. Unpublished doctoral dissertation. University of Alberta, Edmonton, Canda.

Mead, H. (1934). Mind, self and society. Chicago: The University of Chicago Press.

Mead, H. (1938). The philosophy of the act. Chicago: The University of Chicago Press.

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

Munby, H. (1984). A qualitative approach to the study of a teacher's beliefs. Journal of Science Education, 21(1), 27-38.

Munby, H. (1986). Metaphor in the thinking of teachers: An exploratory study. Journal of Curriculum Studies, 18(2), 192-209.

Nisbett, R.E.; Ross, L. (1970). Human inference: Strategies and short-comings of social judgment. Englewood Cliffs, NJ: Prentice-Hall.

Nisbett, R.E., & Wilson, T.D. (1977). Telling more than we can know: Verbal reports on mental processes. Psychological Review, 8 , 231-259.

O'Neal, S. (1983, April). An analysis of student teaching cooperating teacher conferences as related to the self-concept, flexibility, and teaching concerns of each participant. Paper presented at the annual meeting for the American Educational Research Association, Montreal. (ERIC Document Reproduction Service No. ED 234 030)

Oja, S.N., & Smulyan, L. (1989). Collaborative action research: A developmental approach. London: The Falmer Press.

Osborne,R., & Freyberg, P. (1985). Learning in Science. The implications of children's science.

Peterson, P.L. (1988). Teachers' and students' cognitional knowledge for classroom teaching and learning. Educational Researcher, 17(5), 5-14.

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

Piaget, J. (1970). Genetic epistemology. NY: Columbia University Press. (Original work published).

Piaget, J. (1976). The grasp of conciousness. Cambridge, MA: Harvard University Press. (original work published 1974).

Piaget, J. (1977). Recherches sur l'abstraction réfléchissante VI & II. Paris: Presses Universitaires de France.

Piaget, J. (1978). Success and Understanding. Cambridge, MA: Harvard University Press. (original work published 1974).

Polanyi, M. (1966). The tacit dimension. New York: Doubleday and Company, Inc.

Posner, G.J., Strike, K.A., Hewson, P.W., & Gertzog, W.A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66(2): 211-227.

Reason, P., & Marshall, J. (1988). Research as a personal process. In D. Bond & V. Griffin (Eds.), Appreciating adults learning. From the learner's perspective. London: Kogan Page.

Rossum, E. J.van; Deijkers, K; Hamer, R. (1985). Students' learning conceptions and their interpretation of significant educational concepts. Higher Education, 1 , 617-641.

Sacks, H. (1972). An initial investigation of the usability of conversational data for doing sociology. In D. Sudnow (Ed.), Studies in social interaction. New York: The Free Press.

Sacks, H., Schegloff, E., & Jefferson, G. (1974). A simplest systematics for the organization of turn-taking in conversation. Language, 50, 696-735.

Schein, E. (1969). Process consultation: Its role in organizational development. Reading, MA: Addison-Wesley.

Schenkein, J. (Ed.). (1978). Studies in the organization of conversational interaction. New York: Academic Press.

Schon, D.A. (1983). The relective practitioner: How professionals think in action. New York: Basic Books, Inc.

Schon, D.A. (1987). Educating the reflective practitioner. San Francisco: Jossey Bass.

Schwab, J.J. (1978). Science, curriculum, and liberal education. Chicago: The University of Chicago Press.

Searle, J.R. (1969). Speech acts. London: Cambridge University Press.

Shavelson, R.J.; Atwood, N.K.; Borko, H. (1977). Experiments on some factors contributing to teacher's pedagogical decisions. Cambridge Journal of Education, 7, 51-70.

Shavelson, R.J., & Stern, P. (1981). Research on teacher's pedagogical thoughts, judgements, decisions and behaviors. Review of Educational Research, 51(4); 55- 98.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(1), 4-14.

Shulman, L.S., & Elstein, A.S. (1975). Studies of problem solving, judgement, and decision-making: Implications for educational research. In F.N. Kerlinger (Ed.), Review of Research in Education (V3). Itasca, IL: F.E. Peacock.

Sinclair, J. McH. (1973). Linguistics in colleges of education. Dudley Journal of Education, 17-25.

Sinclair, J. McH., & Coulthard, R.M. (1975). Towards an analysis of discourse. London: Open University Press.

Slavin, R.E. (1980). Cooperative Learning. Review of Educational Research, 50 (2), 315-342.

Slavin, R.E. (1984). Students motivating students to excel: Cooperative incentives, cooperative tasks, and student achievement. Elementary School Journal, 85 (1), 53-63.

Smith, K.K. (1988). Epistemological problems in researching human relationships. In Berg, D.N., & Smith, K.K. (Eds.). The Self in Social Inquiry. (2nd Ed). Newbury Park: Sage.

Smith, K.S. (1985). Social reality as mind-dependent versus mind-independent and the interpretation of test validity. Journal of Research and Development in Education, 19(1), 1-9.

Smith, K.S. (1988). The evaluator/researcher as person vs. the person as evaluator/researcher. Educational Researcher, 17(2), 18-23.

Smulyan, L. (1988). The group process of collaborative action research. Educational Research Quarterly.

Soltis, J.F. (1987). Reforming teacher education: The impact of the Holmes group report. New York: Teachers College Press.

Spradley, J.P. (1979). The ethnographic interview. New York: Holt, Rinehart & Winston.

Spradley, J.P. (1980). Participant observation. New York: Holt, Rinehart & Winston.

Stenhouse, L. (1980). Curriculum research and development in action. London: Heinemann Educational.

Taggart, R., & Kemmis, S. (1982). The action research planner. Victoria, Australia: Deakin University.

Tannen, D. (1984). Conversational style: Analyzing talk among friends. Norwood, NJ: Ablex Publishing Corporation.

Thomas, S.N. (1986). Practical reasoning in natural language (3rd Ed.). Englewood Cliffs, NJ: Prentice-Hall.

Tobin, K., & Espinet, M. (1989). Impediments to change: An application of peer coaching in high school science. Journal of Research in Science Teaching, 26(2), 105-120.

Tobin, K., & Espinet, M. (in press). Teachers helping teachers to improve high school mathematics teaching. School Science and Mathematics.

Tobin, K.; Espinet, M.; Byrd, S.,& Adams, D. (1988). Alternate perspectives of effective science teaching. Science Education, 72(4), 433-451.

Toulmin, S.E. (1964). The uses of argument. Cambridge: Cambridge University Press.

Vygotsky, L.S. (1978). Mind in society. Cambridge: Harvard University Press.

Wehling, L.J., & Charters, W.W., Jr. (1969). Dimensions of teacher beliefs about the teaching process. American Educational Research Journal, 6, 7-30.

Weller, R.H. (1971). Verbal communication in instructional supervision. New York: Teachers College Press.

Williams, D. (1986). Action research: A vehicle for instructional improvement and the professionalization of teaching. Georgia Educational Leadership, 2(1), 15-20.

Wittrock, M.C. (1986). (Ed.), Handbook of Research on Teaching (3rd Ed.). New York: McMillan.

Wright, G. H von. (1967). The logic of action. A sketch. In N. Rescher (Ed.), The logic of decision and action. University of Pittsburgh Press.

Yinger, R.J. (1986, April). Examining thought in action. A theoretical and methodological critique of research on interactive teaching. Paper presented at the annual meeting of the American Educational Research Association.

Yinger, R.J. (1987a, April). By the seat of your pants: An inquiry into improvisation and teaching. Paper presented at the annual meeting of the American Educational Research Association, Washington, D.C.

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

Yinger, R.J., & Clark, Ch.M. (1981). Reflective journal writing: Theory and practice (Occasional Paper No 50). East Lansing, MI: Michigan State University, Institute for Research on Teaching.

Yinger, R.J., & Clark, Ch. M. (1982). Understanding teachers'judgments about instruction: The task, the method, and the meaning (Research Series No. 121). East Lansing, MI: Michigan State University, Institute for Research on Teaching.

Yinger, R.J., & Clark, Ch.M. (1985). Using personal documents to study teacher thinking (Occasional Paper No. 84). East Lansing, MI: Michigan State University, Institute for Research on Teaching.

Zeichner, K., & Liston, D. (1984, April). Varieties of discourse in supervisory conferences. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.