

QUALITATIVE RESEARCH: DATA ANALYSIS FRAMEWORK GENERATING GROUNDED THEORY APPLICABLE TO THE CRISIS IN SCIENCE EDUCATION

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Abstract

The shortage of qualified teachers, and the quality and quantity of the science taught in precollege institutions are two focal issues in today's national crisis in science education. This article delineates aspects of qualitative research having the potential of providing guidance to change agents in designing effective strategies to mitigate the crisis. A discursive approach to qualitative research involving the method of collecting and simultaneously analyzing data known as "grounded theory" is described. Role theory and schools as organizations composed of interactive subsystems are defined as suitable frameworks within which to analyze data.

Background

Researchers, policy makers, and practitioners across the United States are delineating the parameters of today's crisis in science education and calling for change in "current policies, practices and standards" (AAAS, 1982).

The shortage of qualified teachers, and the quality and quantity of the science content taught are two focal issues of this national need for change (Klein, Note 1). Another issue is the loss of qualified and experienced teachers.

In many states, e.g., Florida (Task Force, Note 2), Texas (TEA, Note 3), North Carolina (NC, Note 4), and California (California State Department of Education, 1982), policy makers have proposed recommendations aimed at retaining qualified and experienced science teachers and changing the instructional mode and the content of the curriculum. Experience gained by science educators during the past 20 years suggests that facilitating such change requires a better understanding of the change process in schools than we have had in the past. It "is not a matter of simply selecting a new program and plugging it in" (National Science Foundation, 1979, p. 177).

Purpose

The purpose of this article is to focus attention on some aspects of qualitative research that have the potential of providing guidance to change agents in designing effective strategies to bring about desired changes in science education. The method of collecting and simultaneously analyzing data to develop "grounded theory," which is central to qualitative research, will be

described. The perspective of role theory and schools as organizations composed of interactive subsystems will be proposed as useful frameworks within which to analyze data.

Phenomenology

Social phenomenology is the basis for the method to be described. "The phenomenologist views human behavior—what people say and do—as a product of how people interact with their world . . . the phenomenologist attempts to see things from that person's point of view" (Bogdan & Taylor, 1975, p. 14). The theoretical basis for this phenomenologic approach is symbolic interaction.

Symbolic interaction is a way of looking at behavior whereby . . . an individual interprets and defines another's actions, words, or gestures and then bases his actions upon those definitions.

The theory suggests that to understand the workings of a group or organization (such as the science classroom) we must also understand how they (those in these social units) define their world . . . (p. 67)

The imaginations people have of each other, themselves, and every aspect of their world are the solid facts of society. In looking at his world, man is subjective. He selectively perceives, interprets, and places meaning upon his world and then acts accordingly. The solid facts of society are these perceptions, definitions, interpretations, and meanings. (Dodge & Bogdan, 1974, p. 68)

When using a phenomenological approach, it is necessary to retain the subjects own words because they provide important insights into how they define their world (Dodge & Bogdan, 1974, p. 69).

Grounded Theory

The research method discussed in this article is described by Glaser and Strauss (1967) and has been labeled a discursive approach to qualitative research (Smith, 1982).^{*} In this method the data gathered during the study direct the design of each step of the study as it evolves. The categories, themes, and subsequent hypotheses that emerge are "grounded" (have their initial foundation) in the data themselves. This process is used for hypothesis generation rather than hypothesis testing. The proposed outcome of this research method is the generation of hypotheses which will eventually be tied together in theory. The procedure is suitable for social units of any size, ranging from men and nations to small organizational units such as a science class in a school.

Glaser and Strauss (1967) detailed various operations for generating grounded theory including:

. . . the discovery of important categories and their properties, their conditions and consequences; the development of such categories at different levels of conceptualization; the formulation of hypotheses of varying scope and generality; and . . . integration of the total theoretical framework . . . [the] search for comparisons involving the discovery of useful comparison groups is essential to the generation of theory. (p. 169)

^{*}In an earlier article in the JRST series on qualitative research methods Smith (1982, p. 633) described the discursive researcher this way: "Briefly, the discursive researcher perceives the primary audience and reference group as the scientific community and thus adopts standards of reliability, validity, and replicability. Therefore, systematic procedures are used for analysis of data and triangulating findings by means of multiple methods and multiple perspectives. Formal statements of empirically and logically derived findings, models, and perhaps theory are the products, and these make up the final report."

This is an inductive reasoning process employed to generate hypotheses and theory, in contrast to the logicodeductive process employed most commonly for quantitative research studies aimed at testing and/or verification of hypotheses.

Qualitative methodology uses as data the subjective experience of people, and the data are rich in description. Subjective refers to the subject's perception of his/her world; it is not used in the sense that the researcher projects his/her own perception on the respondents.

Thus a major segment of a qualitative report should be devoted to descriptions of the school world the subjects live in, as they see it. Two appropriate procedures employed to gather data are open-ended interviews and participant observation. In both, the investigator is the research instrument. Thus there is always the question of bias entering the study.

The honest researcher, who is competent, systematic, and has integrity, exercises care in avoiding conscious biases and reducing bias arising out of sloppy techniques (total elimination of bias can probably never be affected). He must be super critical in his analysis of data, and he must present known biases when publishing his data. However, not all biases are conscious or can be known in any type of field research, participant observation included. Because the researcher must be concerned with the reliability of his research instrument, namely himself, he must always be on guard with regard to his own colors of observation. Too much concern, however, can lead to nagging doubts and a crisis of self confidence. Too much introspection can also divert the researcher's attention away from the objects and events he is observing, or he may start pressing too hard to squeeze data from the setting and in this way contaminating the setting and/or biases the data (Dodge, Note 5).

Bogdan (Note 6) describes validity in generating grounded theory as "ah-ha" validity, meaning one sees insights one did not see before. Glaser and Strauss (1967) point out that categories must be pilot tested to ensure validity and the relevance of formal categories to the data. An affirmative answer is needed to each of these questions: Do the categories fit and work? Are they clearly indicated by data? Do they explain, predict, and interpret anything of significance?

Reliability is measured qualitatively by the fidelity with which respondents see their world. Indicators of reliability that can be checked in a qualitative study include (but are not limited to): (1) inconsistencies in a subject's statements, (2) the context of the data, (3) the social desirability of the subject's presentation of self, and (4) the number of subject's statements that do not fit into the researcher's conclusions.

A check on reliability that is useful is to summarize interpretations that have been made, and present them at a later date to the subjects for verification. Several subjects' perceptions can be compared to each other in order to identify likenesses and differences and then make comparative analyses.

Two major aspects in evolving grounded theory are the constant comparative method and theoretical saturation. The constant comparative method involves the process of joint collection and analysis of data while constantly comparing segments of data within groups and between groups. Incidents are compared with previous incidents in the same and different groups. Group comparisons are conceptual and comparisons are made between diverse and similar evidence.

The purpose of these comparisons is to gain insights that can be transformed into relevant categories, properties, and hypotheses. The deliberate cultivation of insights can be enhanced by the researcher calling upon his/her related personal experiences prior to, within, and without the research. Insights may also be gleaned from the experience of others and from existing theory. Throughout the duration of the research inquiry, insights need to be cultivated.

The constant comparative method is a means to stimulate the emergence of insights grounded in the data which lead to: (a) simultaneous grouping of the issues surfaced by respon-

dents into categories, (b) the identification of properties in these categories, and (c) the provision of clues for possible relationships among categories.

The intended result of the constant comparative method is the suggesting and generating, but not provisional testing of many categories, properties, and hypotheses about general problems. The properties may be causes, conditions, consequences, dimensions, types, processes, etc. It is expected that a broad range of acceptable indicators for categories and properties will develop. The constant comparative method is not intended to establish universality or proof of suggested causes or properties. Consequently, this method requires only the saturation of data, not consideration of all data.

When the data being found by the researcher no longer provides new information to develop properties of a category, the category is said to be saturated. This is the category's theoretical saturation point, which is the criterion for judging when to stop sampling different subjects related to a specific category. Once the researcher sees similar instances repeated many times, he/she can become empirically confident that collection of further data will not add anything new to the category.

When categories are saturated and clues relating categories are noted, the researcher can integrate categories, propose hypotheses, and tie hypotheses into theory.

Role Theory

Role theory has provided some researchers a structural framework for analyzing and tying together the data gathered in field studies.

Guskin and Guskin (1970) studied change and the adoption of innovation in schools and wrote about them from this perspective.

Role perspective attempts to explain behavior by noting how a person's actions derive from his social position and from the obligations and privileges of his position. . . [Role theory assumes] that organizational or societal expectations control the actions of individuals in a given position in much the same way as the script controls the performance of actors in a given role. This contrasts with the personality-theory assumption that an individual's behavior can be accounted for by his unique characteristics. (p. 1)

These writers point out that there is a way to establish whether the behavior being viewed is more a result of the role demand than of the personality. If one finds that most of the people in the same position and situation behave in the same way, while any one person behaves differently when participating in different positions, one may identify the person's behavior as role performance.

Guskin and Guskin (1970, p. 4) note that performance of the role of the teacher may be any or all of the following: "(1) teacher behavior which is a result of what others (society, peers, administrators) demand of him/her, (2) teacher behavior which results from teacher beliefs about what a teacher should do, or (3) the behavior common to most teachers in specific settings such as the classroom."

Katz and Kahn (1966) designed a theoretical model of the factors involved in the taking of organizational roles (see Fig. 1). It is useful to apply this model to the role of the teacher in the organization designated as the school when investigating factors that influence a teacher to change his/her role.

The focal person, the teacher, is the recipient of information from the role sender. The role senders are members of the teacher's role set. They commonly consist of school administrators and other officials (i.e., members of Boards of Education), students, parents, and other teachers

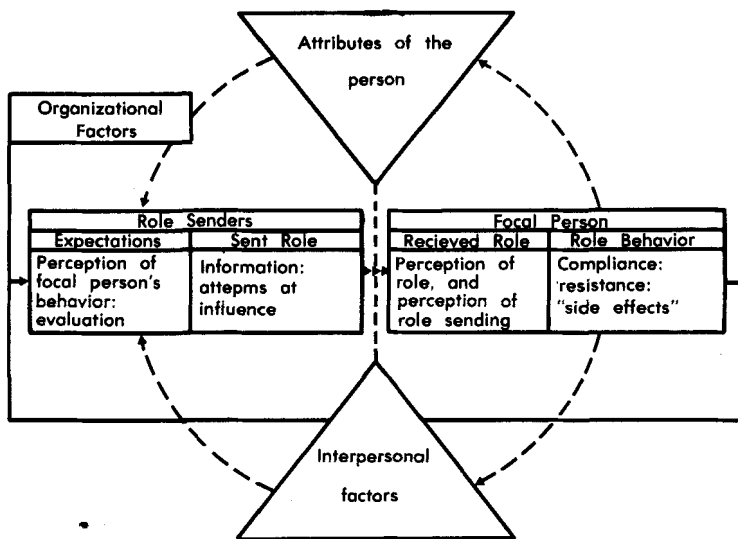


Fig. 1. A theoretical model of factors involved in the taking of organizational roles (Katz & Kahn, 1966, p. 187).

(peers). The expectations of the role senders are perceived by the focal person and referred to as the received role. Received role is the teacher's perception of the role-sendings addressed to him/her, including those he/she "sends" to himself/herself. Behaviors will be based on the teacher's interpretation of the sent role. In other words, the teacher's role behaviors are the response to complex information and influence received. Other factors influencing this process are attributes of the teacher, interpersonal factors, and organizational factors.

In today's schools, science teachers are the recipients of messages sent from state legislatures, state education agencies, and others as a result of national concern about the condition of science education. These messages call for changes in teachers' attitudes and philosophy, in addition to new goals, instructional approaches, and content. Teachers are aware that innovations intended to correct reported teaching inadequacies will be introduced to schools. These innovations will make new demands on them that will constitute changes in the teacher's role.

Guskin and Guskin (1970) addressed the issue of changes in teacher's role to facilitate innovation in relation to role expectations.

... the adoption of an educational innovation is affected both by the nature of the school as an organization and by the individual's own behavior pattern. Teachers, like all other role incumbents, will tend to resist changes in their accustomed role unless there are concomitant changes in the role expectations and regulations governing their behavior. (p. 148).

Role conflict occurs when there is simultaneous occurrence of two (or more) roles sent, and compliance with one would make more difficult compliance with the other. The following types of role conflicts have been identified by Kahn and others:

(1) **Intersender.** Expectations sent from one sender are in conflict with those from one or more other senders. This might be disagreement in role expectations of the person in the role (focal person, self-sent role) and important other persons, or between two other important persons or groups in the role set, e.g., pupils, parents, administrators, and teacher trainers do not wholly agree on appropriate behavior for teachers.

(2) **Interrole.** Sent expectations for one role are in conflict with those for another role played by the same person. In other words, conflict in demands from important others for two overlapping roles, e.g., person as department chairperson and classroom teacher.

(3) **Intrasender.** Inconsistencies exist in expectations held by another person or group. The expectations from a single member of a role set may be incompatible, e.g., administrator says students should have more laboratory experience while cutting back on supply budgets and teacher preparation time.

Sections (1), (2), and (3) describe conflicts in the content of the sent role. Different roles being sent create conflict for the focal person. In addition, there are two other types of role conflict.

(4) **Person-role.** When role requirements violate the needs, values, or capacities of the focal person, an incompatibility between the personal style and role expectation surfaces.

(5) **Role overload.** There is an incompatibility of role expectations with reality demands or possibilities. This is a complex-emergent type conflict combining aspects of conflict between role senders and conflict between senders and the focal person.

Conflict and ambiguity seem to be emergent problems arising from the demand for successful conformity under conditions of ceaseless and accelerating change. Conditions of conflict and ambiguity are not merely irritating, but in persistent and extreme form, they can be identity-destroying (Bogdan, Note 6). These conditions are observable at present and are one probable cause of the burn-out phenomenon seen among science teachers today.

Psychological factors causing stress may force qualified experienced teachers to leave teaching as much, or more, than the disparity between their salaries and salaries in the marketplace.

Considering the large number of science teachers who exhibit symptoms of stress and burn-out, the great number who have left teaching, and the negative image society conveys of teachers, it is particularly important to learn more about those situations which put this type of psychological stress on a science teacher. The interaction of the science teacher with the human and physical environment of the school and related community is an area in which role conflicts may be expected to occur. Knowledge in this area may be useful in minimizing the added stress that can be expected when teachers are confronted by multiple demands for change.

Thus, in order to address the question of what happens to a teacher when he/she is confronted with the need for a role change, one must identify the role changes perceived by the teacher, and identify the teacher's perception of the effect these role changes have on him/her. The phenomenological approach may, therefore, provide insight to ways to encourage and persuade science teachers to make needed changes in their behaviors.

Schools as Organizations

It is reasonable to approach a discussion of schools as organizational systems when using the Katz and Kahn model to study the role of teachers.

Schools as organizations are fraught with contradictions. Significant new topics are added to curricula while teachers' nonteaching responsibilities are increased and funding is cut for materials, inservice, and teacher preparation time. "Members of various groups, such as college professors, central office administrators, and principals hold views about content and methods of teaching influenced by their positions. There seems to be major differences in orientation between classroom teachers and many of those who are supported to help them do a better job" (NSF, 1979, p. 177). Objectives and goals within a specific discipline are frequently in conflict, as are the messages parents, students, and administrators commonly send in relation to the goals and objectives within a discipline. Schools are expected to facilitate progress while maintaining existing societal and multicultural values. Teachers are told to administer accountability tests,

many of which emphasize aspects of science teachers value least. What administrators verbalize as important is often not consistent with the behavior they exhibit.

Seen within the perspective of role theory, these and other conflicting messages would contribute to science teachers experiencing role conflict, identity crises, stress, burn-out, and subsequently leaving teaching.

Schmuck et al. (1972) present several postulates about the nature of the school organization in general as a system.

Schools are constituted of components—individuals, facilities, books, and so on—which are further organized into subsystems when staff members design curricula, make decisions, allocate jobs, and evaluate programs. Such subsystems include, for example, classrooms, resource rooms, multipurpose rooms; departmental groups, special committees, building staffs; and building maintenance personnel, business office personnel, and administrative cabinets. A single component such as a particular person can of course, function in more than one subsystem . . . (p. 2)

Schools like other living systems, display varying degrees of openness in communication. Normally, administrative cabinets for example, communicate with the school board, curriculum committees are in contact with outside innovators, and teachers' professional organizations communicate with similar organizations elsewhere. Through these interactions, schools are constantly bringing new elements from outside into the internal organization. Strain within schools occurs when one subsystem (such as the curriculum division) brings new practices into the district and another subsystem (such as the school-building staff) resists trying the new practices . . . (p. 3)

The usefulness of every subsystem is maximized if each subsystem is optimally open to influence from every other subsystem . . . Our hypothesis is that such inadequate communication concerning role conflict prevents the persons involved from making effective plans for improvement. (p. 3)

Schmuck et al. (1972) and Guskin and Guskin (1970) discuss some school organizational characteristics that have bearing on the teacher's professional role. Although schools are goal directed, persons who work in schools whose goals are vaguely stated cannot recognize when the goals are being reached. The school as an organization exhibits a low degree of division of labor. The typical school organization lacks effective integration of roles even where there is a division of labor. Providing appropriate rewards to teachers is difficult because of their low visibility. Consequently, behaviors most critical for implementation of classroom innovation are not visible to others, and teachers are not rewarded.

The deleterious effect of inadequate psychic rewards was highlighted at a convocation called by the National Academy of Sciences to discuss the problems comprising today's crisis in science education. At that meeting, speakers called for strategies to provide public recognition for teachers (NAS, 1982).

Application

The methods described above were used in a study of five teachers who were implementing a new curriculum (Spector, Note 8). The purpose of the study was to understand the factors which influenced the teachers' behaviors during the implementation of the new curriculum.

The innovation required significant changes in teachers' behaviors for one-quarter of their professional day. The changes culminated in new roles for the teachers. They changed from the

role of information giver in the expository teaching of high school biology, to the role of facilitator in an audio-tutorial college biology course taught in the high schools.

Participant observation and ongoing open-ended interviews were used to collect data during a week-long university training workshop, three succeeding interviews, and three full day site visits during the academic year.

Data were collected and simultaneously analyzed from the perspectives of role theory and schools as organizations. As categories, themes, and hypotheses emerged, they were presented to the respondents for verification. Prior to the final round of interviews, each of the hypotheses was also reviewed by up to 30 teachers informally at science education meetings throughout the state. Those statements with which teachers could identify from their own experiences were kept and further explored with the respondents in the study. Finally, these hypotheses "grounded" (with their initial foundation) in the data were tied together into a theory and a structural model designed to illustrate the theory.

The model suggests a group of factors which influenced the teachers to test new behaviors, to repeat new behaviors, and to make enough changes so their behaviors became congruent with those demanded by their roles in the new curriculum. The model posits that to the extent that teachers perceived potential for gaining satisfaction from making changes demanded by an innovation, they were willing to change their behaviors. Further, that a successful innovation depends on teachers making enough behavioral changes so their role behaviors become congruent with the role demands of the innovation.

Summary

The present crisis in science education requires that policy makers and practitioners know what happens to teachers when role change is required for an innovation. This is central to the success of many innovations. The stress which teachers presently endure due to role conflicts and organizational dysfunction may be increased in the near future when teachers are asked, or told, by their state and local education agencies to implement innovations in their classrooms designed to bring science programs from their existent state to the desired state for the 1980s and beyond.

It is the thesis of this article that using qualitative methods and analyzing data from the perspectives of role theory, and schools as organizations will provide insight to generate relevant grounded theory. That theory can provide a basis for action that is needed by change agents to design effective strategies than can minimize stress and maximize innovation.

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