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ABSTRACT

This document provides a research study of a 10-year elementary school teacher science staff development project, "The Science in Rural California Teacher Enhancement Project." The study investigated the long term effects on teacher participants 3 to 5 years after project contact: beliefs about science, confidence levels about teaching science, teaching practices, and professional practices. Subjects included approximately 150 elementary school teachers from the 9 northeastern counties of California who attended Science in Rural California during years 1989-92, about 50 each year. The study group was 76 percent female, and averaged 35-40 years of age and 14 years of teaching. Long term effects of the study group were compared against 79 incoming participants to the same project during 1994-95. Both quantitative and qualitative methods were used (questionnaire, interview, journal samples). The study found little difference in beliefs about science between the long term effects (study) group and the control group. However, significant differences in teacher confidence about science, teaching practices, and professional practices were found to be continuing among members of the study group, 4 to 6 years after project contact. Findings supported the successful project design of 21 days of contact time spread over 13 months and the project's many participant support practices. Seven appendices provide project descriptions, study group questionnaire and control group questionnaire, blue print of the questionnaire, interview-guiding questions, questionnaire item analysis and Likert statement analysis, sample interview confirmation letter and site principal letter. (Contains 48 references.) (Author/ND)

LONG TERM EFFECTS STUDY: PARTICIPANTS OF THE SCIENCE IN RURAL CALIFORNIA TEACHER ENHANCEMENT PROJECT

A Thesis

Presented to the

Faculty of Simpson College

Redding, California

In Partial Fulfillment

of the Requirements for the Degree of

Master of Arts

in Education

by

Stephen R. Essig

May 1995

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Stephen R Essig

May 15, 1995

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LONG TERM EFFECTS STUDY: PARTICIPANTS OF THE SCIENCE IN RURAL CALIFORNIA TEACHER ENHANCEMENT PROJECT

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ABSTRACT

Long Term Effects Study: Participants of the Science in Rural California Teacher Enhancement Project provides a research study of a ten year elementary teacher science staff development project. The study compares the long term effects on teacher participants three to five years after project contact: beliefs about science, confidence levels about teaching science, teaching practices, and professional practices. Subjects included approximately 150 elementary school teachers from the nine northeastern counties of California who attended Science in Rural Califorung during years 1989-92, about 50 each year. The study group was 76% female, averaged 35-40 years of age and 14 years of teaching. Long term effects of study group were compared against 79 incoming participants to the same project during 1994-95. Both quantitative and qualitative methods were used (questionaire, interview, journal samples). Study found little difference in beliefs about science between long term effects (study) group and control group. However, significant differences in teacher confidence about science, teaching practices, and professional practices were found to be continuing among members of the study group, four to six years after project contact. Findings support the successful project design of twenty-one days of contact time spread over thirteen months and the project's many participant support practices.

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This paper is based upon work supported by the National Science Foundation under Grants Numbers ESI-9154813 and TPE-8954586.

This paper is dedicated to those 300 elementary teachers who touched my life as they struggled to learn a new way of teaching. They were open, took risks, persevered, and had fun while growing. Not only did they become better teachers but their continuing efforts are a testimony to the wonder of the learning process, the importance of science and the spirit of true educators.

Stephen R. Essig, third director of SIRC

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THE PROBLEM

Introduction

Science Education in the United States is in a period of reform. Since the late 1970's dozens of reports and studies have been issued by government and private groups. In 1983 A Nation at Risk declared that American education had become victim to a rising tide of mediocrity. The Science Report Card of the National Assessment of Educational Progress of the Educational Testing Service noted in 1988 that average science proficiency across the grades remained distressingly low. A loud alarm has been sounded by reports: the lack of scientific literacy among American adults, the sad state of collegiate and precollegiate science education, the poor ranking in science of American students against their foreign counterparts, and the evaporation of science instruction at the elementary school level. The reports all conclude that the conventional method of science education is failing.

"A national survey conducted in 1978 pointed out that elementary teacher's preconceptions concerning their qualifications for teaching science were consistent with the amount of time they spent teaching it. The results of this survey also indicated that elementary teachers teach science an average of 17 minutes per day as opposed to about 90 minutes per day for reading" (Enochs & Riggs, 1990. p. 5). Another report found the average time prescribed by districts across the nation as 30 minutes per day for elementary classrooms with much less time actually being used. Still another report found that fewer than half the students in the nation were likely to have "... a single elementary year in which their teacher would give science a significant share of the curriculum and do a good job of teaching it" (Stake & Easley, 1978, p. 19) .

Subsequent to these national reports and studies describing the problems of science education, a multitude of other reports and studies were issued with recommendations about what needed to be done. The American Association for the Advancement of Science's Science for All Americans, and its subsequent Benchmarks for Science Literacy, the paramount reports of this reform, outline an ideal content for future science education. A review of this pair and the other reform documents reveals a central theme of quality staff development. "Although modern proposals for educational reform vary widely in their scope and content, nearly all emphasize the need for high quality staff development" (Guskey & Sparks, Complexities in evaluating the effects of staff development programs, 1991, p. 1). If the way in which students are learning science must be changed, then the way in which teachers teach science must be altered as well.

The nine northeastern counties of California, attempting to address science reform for their region, applied to the National Science Foundation in 1988 and again in 1991 for two K-8 Teacher Enhancement grants. For a continuous period of seven years (until 1996) a total of 2.2 million dollars matched by $200,000 of local educational funds will be spent for elementary science staff development. This K-8 science staff development project is called Science In Rural California (SIRC). (Consult Appendix A, pages 157-160 for a project description.)

Beginning in the early 1980's, in California and across the United States, a milieu of school reform appeared upon the scene of education. This reform activity, as followed in the literature, can be described as a movement occurring in three waves. Wave I was top down in nature, involving legislative solutions to school reform. In California, the monumental reform bill, Senate Bill 813, lengthened the school year and day, set higher standards for student graduation and teacher credentialing, and set the stage for curriculum reform which led to a decade of new frameworks for every subject area. The first wave was the immediate response to the national reports advocating reform. The SIRC project was born in the era of Wave I with support and direction from the assistant superintendents of its nine counties.

Later in the 1980's, when the rules for reform had been set in place from the top, a bottom up stage, Wave II, began. This wave focused on the process of education and was heavily involved in creating a professional climate, allowing shared decision making and collaboration and a place for the voice of educators. Teachers became more important participants in the writing of the new California curriculum frameworks. Mentor teachers set about their work, and state curriculum training projects in all subject areas were set up across the state. The focus of this wave of reform was the teacherpractitioner, providing processes and projects for improvement of teacher skill and self-esteem. This was the time when the SIRC project ended its infancy with state curriculum funds and received its first National Science Foundation grant. SIRC had also evolved into a Wave II project. Less dependent on its county offices, it was led by a teacher as director assisted by its own cadre of teacher participants serving as trainers.

With the new decade of the 1990's, the tide of the school reform movement broke into a Wave III; this time focusing on the student. Leaving behind what the school program or the teachers were doing, this current wave centers on what the learner is doing. Student outcomes, relevance of education to future citizenship, scientific literacy, authentic assessment, thinking processes and higher order thinking skills, applied and problem based learning, scientific inquiry, developmental learning and constructivism are all descriptors of this new student based reform. SIRC began exploring these areas before they became central to Wave III reform and these issues are now encompassed in its training program. SIRC, which began in response to Wave I and national reports, matured as a Wave II teacher development project and, while preserving teacher improvement as its core goal, has now shifted full throttle into the Wave III, student centered, reform movement.

Science in Rural California and projects like it have sprung up in every region of the country. Scores of science training and inservice projects for teachers are providing inspirational motivation and influencing the instructional methods of thousands of teachers. Models for staff development have been created, implemented, evaluated, and researched. Nationally, there are many, many regional and statewide teacher training projects in science going on. This has been predominately focused on K-8 during the 1980's and is including secondary schools as well in the 1990's.

The national reports agree that extensive staff development is the agreed upon tool for the reform of elementary science. By implementing intensive and quality staff development, teacher instruction will be directly improved and the goal of enhanced student learning in science achieved as well.

The national reports contain a consensus for the changes that need to take place to reform science education. Concerning student learning, the reports agree that:

1. All students, not just a talented few, need in-depth understanding of science.

2. Children learn more readily and remember longer when they can actively construct their own knowledge.

3. Young people build critical thinking skills and scientific habits when they are allowed to become scientists through the process of inquiry and exploration.

4. Students gain more coherent understanding of the big ideas of science when these ideas are presented to them in developmentally appropriate ways and in a revisiting cycle of increasing sophistication (Kober, Edtalk, 1991, p. 6).

Concerning the reform of instruction and teaching, data collected in the Science Report Card found that 82% of elementary teachers felt well qualified to teach reading, 67% to teach mathematics, and only 15% to teach earth or physical sciences (National Assessment of Educational Progress [NAEP] 1988). In outlining what teacher science staff development should cover, the national reports showed consensus for these goals for teacher staff development:

1. Active learning. Students must be allowed to do science.

2. Depth of content. Students must study less in greater depth.

3. Varied groupings. Instructional groupings must be varied between group studies and independent work.

4. Real-world connections. Students must connect science concepts with the natural world and the effects of science and technology on their daily lives.

5. Prior learning. Links between new information and what students have learned inside and outside of school must be made.

6. Interdisciplinary approach. Instruction must link the content of the various disciplines of science along with the other subject/content areas (Kober, p. 7).

While these reports outlined consensus ideas about what needed to be addressed through staff development in the reform of learning and teaching, a grave problem with staff development in non-urban areas was brought up by a California report, Staff Development in California. This report strongly raised the issue of special considerations for rural staff development:

> In the absence of any comprehensive and cost-effective strategy for overcoming problems of distance, teachers and administrators in the state's vast rural area enjoy fewer professional development opportunities than their counterparts who have easier geographical access to staff development providers. (Policy Analysis for California Education [PACE], 1987)

A national report, The Present Opportunity in Education reemphasized the need for staff development in elementary science education. It also underlined the rural access problems mentioned in the California report.

1. More science teachers must be prepared to instruct students in more than one field of specialization. Priority must be given to the improvement of the science teaching competence of the elementary school teacher.

2. The physical sciences are poorly taught in many school districts. A complete reformation of elementary science curricula is needed.

3. Resources should be concentrated on improving elementary school science.

4. Resources should be focused on the inner city schools and on school districts in rural areas. (The Triangle Coalition for Science and Technology Education, 1988)

What is the point of the reform reports? Science education, especially elementary science education needs reform. Staff development is the tool to achieve this reform. Rural areas have unique problems including weak economic bases, communication and geographical barriers, long distances from educational and cultural centers and fewer resources to establish quality science staff development programs.

The Science in Rural California Project grant was written to address these reported needs of learning, instruction, and rural staff development for elementary science education. Over the course of the implementation of the first SIRC teacher enhancement grant and now in the implementation of a second renewal grant, the project has eight basic components for change that it proposed and continues to espouse:

1. A focus on making science staff development available to female elementary teachers with a goal of at least 60% female participants each project year. While females represent the majority of practicing elementary teachers, as a group they have been traditionally under-represented in science career fields as well as science academic backgrounds as educators.

2. A team approach with 2 to 4 teachers participating from a single school site along with the site administrator's co-participation in several of the training dates. This provides collegial and administrative support for change.

3. An emphasis on cooperative learning as an instructional method that research supports as more effective in promoting student learning and more effective in promoting

science learning.

4. An emphasis on developmentally appropriate instruction and curriculum, matching student thinking skills with instruction instead of teaching over students' heads.

5. Creation of a ripple effect by requiring teacher participants to share their learning with 3 days of local staff inservice.

6. Support for participants in ensuing years with a monthly newsletter and at least 3 alumni staff development days.

7. An emphasis on "hands-on" science curriculum with the underlying belief that science is a process of inquiry, not the mastery of a body of knowledge. Science is best learned by "doing" science.

8. Instilling a confidence in the teaching of science among elementary teachers.

In summary, the national focus in this decade of science reform, now in Wave III, is on improving student learning by improving teaching through staff development. The SIRC project with its eight components is attempting to accomplish this reform at our regional level. Several questions are before us: Surely enough time has gone by to see what has been accomplished? What changes in science instruction are occurring? What has been accomplished in student learning? Is SIRC succeeding with its eight components? What other changes in teacher beliefs and methodology have resulted? These questions are the purpose of this study.

A study of the long term results of a complex undertaking like staff development is difficult. How successful can one be at changing the beliefs, behaviors and practices of highly educated adults like teachers? If one can succeed in making changes, how long will it take? And what kind of evaluation instrument(s) will succeed at revealing the results of such a humanly intricate endeavor? "Staff development program evaluation is obviously more complex than it may appear at first glance, especially if the purpose of the program is to produce significant, lasting improvements in student learning outcomes" (Guskey & Sparks, 1991, p.16).

Statement of the Problem

With hundreds of millions of dollars being spent nationally in this effort and three quarters of a decade already invested, the questions are: What have these efforts accomplished? What are the changes in science teaching that are taking place and will they be lasting? Who has studied or documented the intended and unintended changes of staff development in the science education reform effort?

The SIRC project leadership believes that significant changes have occurred among its project participants and that these changes continue beyond the project contact time and are growing. What are the long term effects among SIRC participants?

Purpose of the Study

The purpose of this study is to examine the long term changes in teaching beliefs and instructional practices among the teacher participants of the Science in Rural California Project from the project years 1989-92.

This time period represents the three project years of the first National Science Foundation grant: 1989-90, 1990-91, 1991-92. Each project year had approximately 50 teacher participants. This study is interested in documenting the changes in beliefs about science and the teaching of science and the continuing, lasting changes in teaching methodology among the 150 teacher participants of these three project years.

A review of existing research literature during the last 10 years about teacher staff development in general and in elementary science in particular will be made to build a broad framework against which to compare the findings of this study. In summary, this study will investigate the long term and lasting changes in beliefs and instructional practices that have occurred among past SIRC project participants.

Questions to be Answered

This particular study will seek answers to the following seven questions:

1. What do incoming SIRC participants believe about science?

2. Did the project change its participants' beliefs about science toward the definitions of science found in AAAS and other reform documents?

3. If teacher confidence is the central issue as to

whether science instruction occurs at the elementary level or not, what has SIRC accomplished in raising participant confidence about teaching science?

4. What are the teaching practices of incoming SIRC participants?

5. How have these practices changed once participants become alumni of the SIRC project?

6. Did required administrator involvement and the team approach to participation in the project enhance the development of participants?

7. Did leadership and growth as professionals occur among participants?

Importance of the Study

The findings of this study should be useful, first of all, to the National Science Foundation and other large organizations like it that fund projects to improve science education and other school curricular projects. By identifying success at changing belief and practice, the groundwork for further investigation about those project components that contributed to these successes has been laid. Further research can be conducted to identify those project elements worthy for consideration and replication in other projects.

This study should also be of interest to the education research community. As this researcher found, few studies exist that document staff development effects beyond one year. This study contributes to the paltry research body on long term effects.

Finally, this study should have meaning to the nine county offices of education which supported this project and other stakeholders in education reform in California. Insight into meaningful change among its teaching force should be useful in planning future staff development and school reform.

Assumptions

For this study the following assumptions were made:

1. Teachers are highly trained professionals with sufficient integrity to answer questions honestly.

2. Teachers also possess the self-awareness to be able to respond meaningfully about themselves in the past.

3. A single year's group of participants within the project is sufficiently large and comes with a sufficiently similar mix of personalities and prior experiences to be validly comparable to another.

4. The number of project contact days and the organization and format of these days under the preceding NSF grant project were similar to the current successor grant project. It is, therefore, assumed that a valid comparison of effects can be made between participants of the previous project with participants of the current project.

5. Valid and adequate data could be obtained through the use of survey techniques, interview, and reading of participant journals.

Delimitations

This study was delimited in the following manner:

1. Only full time participants of the Science in Rural California project were subjects for this study. No other project, its participants or teachers at-large were involved.

2. The study was conducted in one state, the northern non-coastal third of California. All teacher participants are employed in the nine counties of the California Region 2 Curriculum Committee and Knocti Unified in Lake County.

3. Only teacher participants were subjects of the project. Administrators, student teachers, and less than full time participating teacher alternates were excluded.

4. The study group of this research were participants under the previous three year NSF grant project, commonly called SIRC 4, SIRC 5, and SIRC 6, project years 1989-92.

5. The control group was comprised of participants of the third year of the existing NSF grant project, known in this region as SIRC 9, project year 1994-95.

Limitations

This study was limited in the following manner: There was one large internal limitation regarding data gathering for this study. The study group (SIRC, Years 4-6) had minimal pre- and post- data collected during these years by the project. The data collected for annual reporting to NSF were almost entirely participants' journal entries, had insufficient depth, and were unquantifiable for this study. The after contact data necessary for this study had to be collected from the study group two to four years after the participants' project experience. Regarding in-depth before contact data, this study was limited to using the current year incoming project participants (SIRC, Year 9) as the control group to gather needed data to establish a baseline for comparison.

Two external factors limit this study. First, the SIRC project was intended to create a "ripple effect," changing the climate for reformed science instruction throughout the project region. Sixty-four schools in the region had teacher teams involved by the end of year six of the project. One hundred and nineteen schools had been involved in the project by the beginning of year nine. Also during the time period between the project involvement of the study group and the control group, the State of California issued a new Framework for Science, adopted new elementary science materials, and launched a statewide focus and emphasis on science instructional reform. Influences upon the current year nine control group from both this ripple effect and from statewide science reform are certainly present. Logic would suggest that the presence of these two influences would tend to upgrade the background of the current control group, thereby, minimizing the extent of changes found in the study group. The possible influences of this ripple effect and of statewide science reforms have been side-stepped in this study. While these two influences have been noticed at work, to quantify and calibrate them in order to somehow compensate for their effects is viewed as so impossible to achieve as to be impractical to attempt. During this study, these effects have been oted when discovered but no discounting for them has been taken.

Definition of Terms

In order to clearly communicate with the reader of this study, it is necessary to define the terms that will be explored in the literature review, in the conduct of research and in discussing findings: attitude, belief, cooperative-collaborative groups, confidence, developmental, hands-on, inquiry, instruction, science, staff development, and student learning. In the literature review, some terms are defined in the context of the review.

Attitudes. Attitude is a position or bearing indicating feeling or mood. "Attitude...is a general positive or negative feeling toward something" (Riggs & Enoch, 1989, p.4). A person may believe in something and have a negative attitude toward it while another who believes in the same thing may have a supportive feeling.

Belief. A belief is a persuasion of the truth or an intellectual assent. Belief is "...information that a person accepts to be true" (Koballa & Crawley, 1985, p.?23). Belief is an act of will as opposed to an emotion as in the definition of an attitude.

Cooperative-Collaborative Groupings. In reference to teaching pedagogy, cooperative groups are units of two or more students working together for a common purpose. Collaborative groups are units of two or more students working for a common purpose but with the roles and expected tasks of each member of the group understood before hand. Collaboration more closely resembles teamwork in the sport setting. Each individual has a specific job that contributes to the success of the team. Cooperation only designates singleness of purpose. Only one individual need to exert any effort in a cooperative venture, the rest can just go along.

Confidence. Confidence means a state of mind free from diffidence, doubt, misgivings. It stresses faith in oneself and in one's power. (Webster's collegiate dictionary)

Developmental. Development is "the act, process or result of developing." Develop is "to enfold gradually..; to form or expand by a process of growth" (Webster). In education, developmental refers to a gradual process of growth marked by recognizable stages.

Hands-on. This educational term refers to the instructional practice of allowing individual students or groups of students to use real objects and to engage in interactions and processes with real objects to gain knowledge and understanding.

Inquiry. "Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world. Inquiry defines a manner of teaching that enables the student to conduct scientific inquiry" (National science education standards, 1994, I-14, 5).

Instruction. Instruction comprises the acts and practices that a teacher uses to promote an atmosphere of learning for students. It includes many types of interaction: direct communication of teacher to student, of student to teacher, of student to student, of student from activity, and personal and shared reflection.

Science. Science is a way of knowing that is characterized by specific features, such as empirical criteria, logical argument, and skeptical review (National science education standards, I-11, 5). Underlying the work of scientists are several beliefs: "One is that by working together over time, people can in fact figure out how the world works. Another is that the universe is a unified system and knowledge gained from studying one part of it can often be applied to other parts. Still another is that knowledge is both stable and subject to change" (Benchmarks for scientific literacy, 1993, p.5).

Staff Development. Staff Development is defined as a teacher training project or program that is purposeful, planned, subject specific, long term, with follow up support. Traditional one or two day inservice workshops for teachers with multiple themes and sessions are not viewed as staff development for the purposes of this study. State, local, and national conference attendance would be similarly eliminated by this definition. A staff development program in science would be a plan for a year or more to expose a defined group of teacher participants to a set number of hours or days in content and methodology and then contain a support system, direct or indirect, to assist them in implementing the new knowledge back in their classrooms. "....staff development is considered to be a multifaceted process. As such, it is envisioned to include not only initial training, but also the readiness activities that precede training, the practice and coaching that take place during training, as well as the follow-up and support activities that take place during training" (Guskey & Sparks, p. 8). "The emerging mode of staff development addresses broader and more complex issues, is provided over longer time periods with considerable ongoing assistance, is linked to strategic directions of the district and the school, and is targeted to specific issues rather than across an array of disconnected areas" (Odden & Marsh, 1988, p. 598).

Student Learning. Student Learning is defined as the acquisition of skills that lead to the gaining of knowledge. It is an active verb. Students are responsible for their own learning and must be actively engaged in it. In the old definition of learning and in the conventional method of teaching science that the national reports condemned, learning was defined as a passive acquisition of factual knowledge by the student. In the reform of science, student learning is the active acquisition of skills that can be applied in a new situation and can be applied to new knowledge. It is associated with the slogan: "Hands-on -- Minds-on." It is optimum when the skills can be applied to current ˙˙oblems in society rather than traditional textbook science ›blems.

Organization of the Study

Chapt‹ r II consists of a review of related literature, exploring: traditional principles of staff development, student centered staff development, adult learning stages, variables considered by other science staff development projects and their evaluations, the teaching and professional development standards of the new National Science Standards. In Chapter III, there is a description of the study sample, the instrumentation used, its development, data collection techniques and data analysis procedures. Chapter IV is a description of the findings and a discussion of the results. Thoughts of participants in both groups are cited to give insight into the findings. Chapter V is a summary of findings, with conclusions and recommendations for further study. The study concludes with references and appendices.

CHAPTER II

LITERATURE REVIEW

Introduction

In order to examine SIRC as a successful staff development project with lasting effects on its participants, a backdrop or template of successful staff development needs to be constructed. What are the components that make a staff development project change its participants? What are the factors and variables that must be considered?

In order to build this template of a successful staff development project, a literature review was conducted. The review began with a search of the Education Research Institute Center's (ERIC) document service. Over 38,000 articles were found on the topic of Elementary School Science; over 28,000 articles were found on the topic of Teacher Improvement; and over 6,400 articles were found on the topic of Inservice Teacher Education. By combining these three topics, a list of some 250 articles was found and more than 60 were actively investigated.

The Literature Review revealed many ideas considered important for evaluating a staff development project for elementary teachers and for science staff development projects in particular. These ideas can be organized into four generalizations that are useful in building a template for researching the lasting success of SIRC. The literature review, will therefore, be organized around these generalizations. The first generalization found from studies of other projects is a set of traditional, time tested evaluation principles for staff development. A new, student centered model for evaluating staff development projects is the second generalization. Adult developmental learning becomes the third, with different models being reviewed. The final generalization is a collection of several variables and evaluation methods chosen by other science staff development projects for their own project assessments that seemed important to this researcher for contributing to the investigation of the SIRC project. The literature review will conclude with an examination of the Science Teaching and Professional Development standards from the new draft National Science Education Standards.

Traditional Principles of Staff Development Evaluation

A review of the evaluation sections of more than a dozen science staff development projects from the 1980's revealed three traditional general principles. In the past, staff development outcomes have generally been limited to studying the knowledge, attitudes, and behaviors of participants. Quantitative instruments have been developed in connection with science staff development programs for pre- and post-assessing what elementary teachers know in science, their attitudes about science and the teaching of science, and the kinds of instructional practices that they have used or are attempting to implement. These principles seem centered in Wave II of the reform movement. Staff development during this period was teacher centered. Teacher attitude toward the changes of instruction that staff development programs wished to make was of particular concern in this era.

Attitude & Behavior: Teacher Efficacy

Frank Crawley and Thomas Koballa at the University of Texas along with Brenda Johnson at the University of Michigan have applied the theories of reasoned action and planned behavior to staff development in science. The theory of planned behavior superseded the theory of reasoned action in the work of Ajzen and Fishbein. In Understand Attitudes and Predicting Social Behavior (1980), Ajzen and Fishbein studied the effects of attitude on human behavior. In their theory of reasoned action, individuals do not act on the basis of attitude directly. Each individual must exercise will in performing a behavior or not, even when positive attitudes exist toward the behavior. In order to produce a behavior, the individual needs to gain control of the will to act on positive attitudes. Extending this theory of reasoned action, Ajzen and Fishbein developed their subsequent theory of planned behavior and tried to identify the steps an individual with incomplete control or non-positive attitude must exercise in order to produce intended behavior. Both of their theories use mathematical models to show correlation between attitude and will.

Crawley, Koballa, and Johnson used the very mathematical variables of Ajzen's and Fishbein's theory of planned behavior to evaluate the activities of two summer institutes for teachers of science. How persuasive were the summer institutes? Did the teachers learn more science? Did the teachers intend to use the science knowledge gained at the institute? Did the teachers use institute material to improve class instruction by teaching science investigations? (Johnson and Crawley, 1991). With lots of mathematical calculations, they showed significant changes in attitudes and behavior among institute participants. This is an interesting mathematical technique for research. But this purely quantitative evaluation puts these authors in complete control of deciding which variables to investigate. It also does not communicate the depth of human feeling or thoughts toward these changes. Adding qualitative interviewing of subjects to their research would speak louder and have actual anecdotal support for the "significant differences" their numbers denote.

Researchers Iris Riggs and Larry Enochs (1989), building upon the work of Bandura on teacher efficacy, designed and validated a twenty-five item questionnaire, the Science Teacher's Efficacy Belief Instrument (STEBI). Bandura's work on teacher efficacy proposes that behavior is based on belief and that belief is reinforced by attitude. Effective action results when people believe certain behaviors will produce desirable outcomes and when they have self-efficacy (attitude) in their own ability to perform the necessary behaviors. A negative attitude (low self efficacy) will prevent the desired action from taking place even if the person desires the action because a belief in the ability to perform the new behaviors is necessary. Bandura (1977) poses a matrix of human action based on the two axes of high-low outcome expectancy and high-low self-efficacy (Figure 1). Persons with high self-efficacy and high outcome expectancy are assured and will produce the desired changes in their behavior over time. Persons, on the other hand, with low self-efficacy and low outcome expectancy are those in need of immediate gratification because they neither possess the

Figure 1 Bandura Self Efficacy Matrix

Self Efficacy	Outcome Expectancy: High	Outcome Expectancy: Low
High	assured	intensity frustration
Low	intensity frustration	immediate gratification

belief nor the patience to see an outcome produced over time. Those persons with high efficacy and low outcome expectancy or high outcome expectancy and low self-efficacy will pursue a change in behavior with high intensity at first but will end in frustration. These persons have the self-confidence to begin a change of behavior (high outcome expectancy) or the belief of the value of the change (high self efficacy) but are lacking in the other necessary area to become assured or successful in the behavior.

Riggs and Enoch used the STEBI to assess the personal beliefs about science teaching and learning of the individual participants in their staff development projects. Their purpose was to develop a better understanding of teacher behavior. By identifying attitudes, they could in turn develop methods to improve elementary teacher science inservice by devising strategies to raise outcome expectancy or self efficacy and, therefore, change teacher behavior. "Effective science instruction is crucial at all levels of school, especially the elementary level. If students are to be prepared, they must be exposed to teachers who devote time and effort to science instruction--teachers who are high in science teaching self-efficacy and outcome expectancy" (Riggs & Enoch, 1989, p. 16).

The STEBI serves as an example of a quantitative instrument to evaluate the three traditional, Wave II, staff development principles of teacher belief, teacher attitude (efficacy) and teacher practice.

A New Model for Staff Development

Thomas Guskey and Dennis Sparks (1991) propose a new model for evaluating staff development outcomes: assessing the effects of the staff development on students and student learning outcomes. This research and model that follows is an example of Wave Three of the school reform movement, centering on students and the learning process rather than on teachers.

To Guskey and Sparks, extending the evaluation of staff development programs to student learning is desirable but extremely difficult. Simply adding achievement evaluation of the students of participating teachers to the assessment of the staff development program will not work. The relationship between staff development and improved student outcomes is extremely complicated. A variety of factors, some outside of the control and some within the control of those designing the staff development, needs to be considered. Both internal and external factors to the staff development may influence the relationship of the staff development's outcome and the achievement of students. In "Complexities in Evaluating the Effects of Staff Development Programs (1991)," these authors generalize three factors and propose a model for planning and evaluating staff development. The factors are quality, content, and context.

Quality

The first factor, quality, summarizes the manner in which the staff development is implemented. The authors describe quality as the sum of three sub elements of the staff development: instrumentality, congruence, and cost. Instrumentality is that part of quality that provides for participants a clear vision of the goals and the practices the staff development wants to impart. In order for the staff development to change teacher practice and improve the achievement of students, Guskey and Sparks believe that what is to be accomplished be "instrumental" and specific. The second sub element of quality is congruence. Will the new practices being presented to teachers align with what they already believe and practice in their classrooms? This sub element returns the discussion to the issue of teacher efficacy. In order to change belief and practice, teacher participants must see the fit between what they are doing now and what the proposed changes want them to do in the future. The final sub element is cost, but not cost in a financial sense. In their context of quality for staff development, Guskey and Sparks believe that teachers must be given the opportunity to measure the personal burden and plan for the time and effort required to implement the innovations. Do the teachers see the benefits as outweighing the personal costs? The three sub elements of instrumentality, congruence and cost that define quality staff development deal very concretely with the teacher centered issues in Wave II of school reform.

Content

Content is the next factor described by Guskey and Sparks for assessing the effectiveness of staff development against improved student outcome. Is the innovation being sought by the staff development research based? To these two researchers, it is not enough for the innovation to be recommended by research. The research must also present a body of evidence of successful implementation of the innovation's practices. For the content of staff development to improve student performance, it must be research based, field tested, and have a record of successful implementations. While sounding like Wave I school reform with a research based call for improvement, content in these researchers' definition is not top down but tempered by some Wave II considerations of teacher needs in understanding, accepting, believing as well as practicing the innovation.

Context

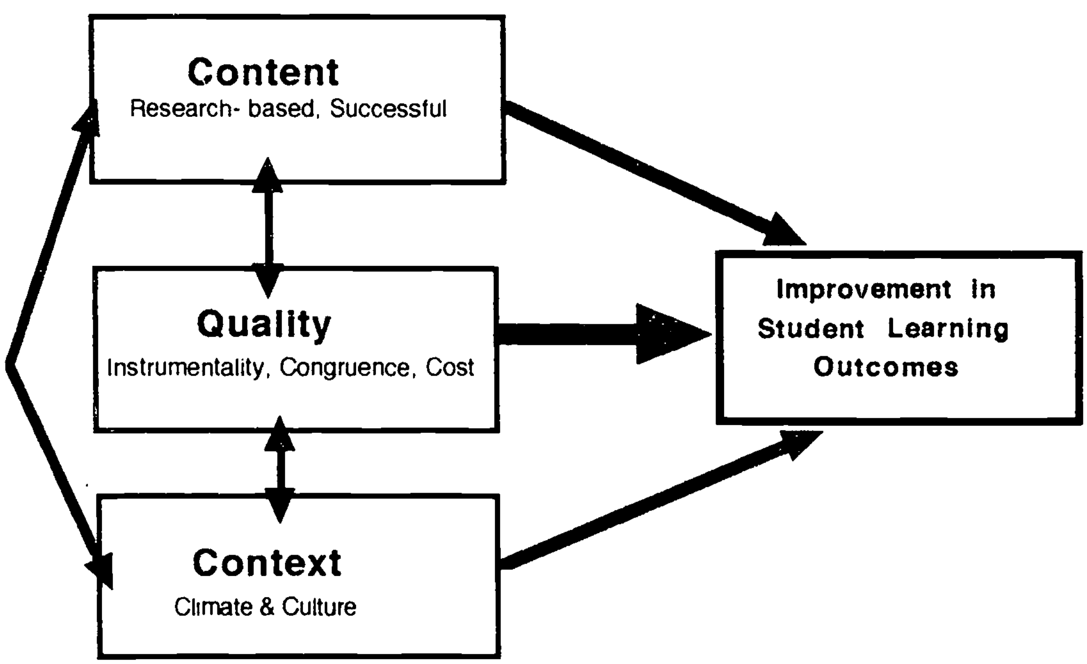
The final factor in Guskey's and Sparks' model is context. They describe context as the organizational climate and culture within which the staff development takes place and within which the teachers teach and implement the learnings from staff development. Their research summary suggests several important points that contribute to a successful "context" for staff development: administrative support, collegiality, experimentation, trust and shared decision making. Does strong administrative support exist? Without support from site and district administrators, the changes proposed cannot be implemented. Administrative involvement as co-participants in the staff development is suggested as a strong method of establishing administrative support. Secondly, does a spirit of collegiality and experimentation exist in the organization? Guskey and Sparks speak of effective staff development that improves student achievement in those organizations where school climate allows staff to support each other in peer activities and where the risk of trying something new is allowed. Will a person's performance be rewarded or downgraded because they are attempting the change?

Finally, is there trust and shared decision making? Is the implementation top down? Or is there a spirit of trust that will allow staff development participants to work through their stages of concern, to problem solve separately and together, and to be involved in designing and accepting the stages of site implementation.

A chart (Figure 2) visualizes the three factors of Guskey and Sparks model of effective staff development and the interactions among the factors that lead to positive outcomes for students. The points and size of the arrows suggest the direction and the vigor of the interactions between these internal and external factors.

Figure 2

Guskey and Sparks' Factors in a Model for Staff Development



This model shows the relationship between staff development and student outcomes as well as the external factors that influence the relationship. This is an interactive model. Quality has a primary effect on student outcome. Through clear understanding of the proposed outcomes of the staff development, teachers can successfully measure the congruence of desired practice to present practice and weigh the personal cost. Quality has an indirect effect on the other two factors as teacher understanding and acceptance will influence both the implementation and the culture of the school. Content and context, the other two factors have both primary and indirect effects. The quality of the staff development program can have strong positive effects on student outcomes only if the content supports the quality. Even if content is supportive, an adverse climate and context at the site can prevent implementation of the innovations.

This model's three factors of content, quality, and context have implications for the research investigation. The content of the SIRC staff development was research based. What effects did the planned quality of the training year have on participants? What effects did the context of SIRC required team support and administrative support have? Was the culture of each school and district open to the innovations in science teaching that the SIRC project conveyed?

Thomas Guskey's work touched on efficacy research by pointing out its place among the three traditional factors of staff development evaluation: belief, attitude, and practice. Guskey, seeking to evaluate staff development in relation to positive student outcomes (from a Wave III perspective) proposed to add the factors of quality, content, and context to these traditional three. The review of Guskey's in addition to Riggs' work gives additional factors to consider in conducting this research project.

Adult Developmental Learning

The next set of ideas found in the literature review relates to adult learning stages. Three separate models of adult learning stages were found which may prove helpful in building a second construct for researching lasting change among SIRC participants.

Sharon Oja's Four Stages

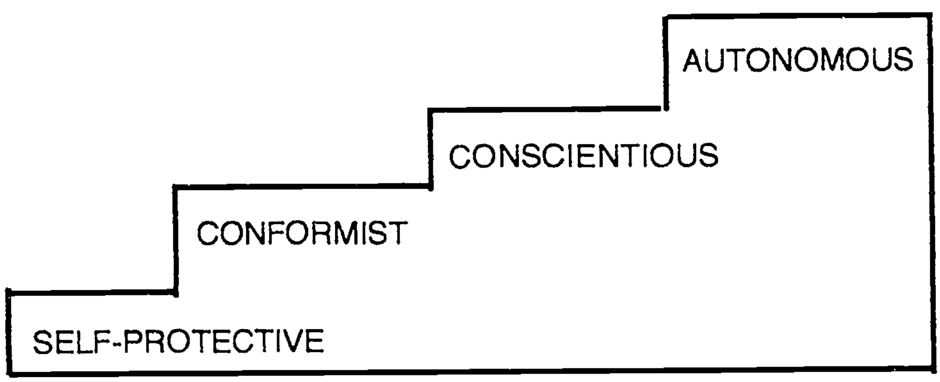
The first author to be reviewed is Sharon Oja of the University of New Hampshire who proposes four stages of adult development. In her research she compared the theoretical work of Jean Piaget, Lawrence Kohlberg, Jan Loevinger, and David Hunt who all posit a sequence of hierarchical, invariant stages of human development. All of these theorists indicate that each subsequent state is considered a better framework for managing one's life in a complex society. Higher stages of development include the ability to understand more points of view, the ability for greater perspective taking, and more complex thinking and problem solving abilities. Crediting Jan Loevinger's work, Oja names her four stages of teacher development as self-protective, conformist, conscientious, and autonomous (1990). These stages are visually illustrated in Figure 3 below.

Self-protective stage. Oja characterizes teachers at the self-protective stage as impulsive, fearful, rigid, dependent, distrustful, manipulative, and authoritarian. A self-protective teacher is unable to manage student aggression and student anger. This teacher may develop a generalized negative response to students and to the job of teaching. Exploitation and the manipulation of others may be the only way a self-protective teacher may function.

Conformist stage. The second developmental stage is the conformist teacher and is characterized by rule-orientation, reverence for conventions, status concern, concern for social acceptance, need for belonging. A conformist teacher sincerely wants to help the student and to be liked by students. As a consequence, this teacher may deal with student aggression and anger by feeling rejected, unappreciated, and frustrated. This need for acceptance by each student diminishes the teacher's commitment to all students. Regarding colleagues and school authorities, as the name implies, the conformist teacher is fearful of being different and is highly concerned about the expectations of others.

Conscientious stage. The third stage of teacher development is the conscientious stage. This teacher has a strong sense of accomplishment and achievement and has the ability to set and evaluate long term goals. A conscientious teacher is characterized by responsibility, goal orientation, self criticism, efficiency, and inner standards. This teacher has a self awareness of operating separately from the group and can recognize multiple alternatives in problem solving. Because this teacher has an over exaggerated sense of responsibility and, perhaps, over idealistic goals, when the conscientious teacher cannot solve all of a student's problems, he/she may feel frustrated, become emotionally exhausted, and feel diminished self worth.

Figure 3 Oja's Four Stages of Adult Development



Autonomous stage. The fourth and final stage is the autonomous teacher. This teacher has developed an understanding and tolerance for conflicting needs and duties. Characterized by flexibility, concern with self-fulfillment, creativity, interdependence, toleration for complexity, ability to see and use many options and alternatives, the autonomous teacher has an awareness of the broader social context of school and of his/her own limitations and responsibilities. This teacher values mutual interdependence with colleagues. Recognizing individual differences in students and particularly aware of contingencies, exceptions, and psychological causes of behavior, the autonomous teacher is able to see multiple points of view, synthesize alternatives, and prioritize courses of action in working with students and the school system.

Oja's work with other researchers at the University of Minnesota verified their hypothesis that teachers at the higher, more complex stages of human development were better in classroom effectiveness than peers at lower stages. With this high stage to high effectiveness correlation, Oja and her colleagues began designing and testing a staff development program to promote higher stage development for lower stage teachers. Oja concludes her research in suggesting that teacher staff development recognize the developmental stages and match participants with challenges appropriate to their stage of development.

Barbara Spector's Five Stages

Another model of adult stages of development is proposed by Barbara Spector of the University of Southern Florida. Unlike Oja's psychological theory base, Spector discovered her stages through inductively analyzing her own qualitative educational research with over 300 classroom science teachers. She calls her five stages: Induction, Adjustment, Maturation, Mid-career Crisis, Leadership (1989).

Induction stage. In this stage, the new teacher focuses on survival. Inexperienced, feeling unsure and insecure, this first stage teacher does not want to make decisions, prefers to be told what to do, and is not concerned about the rationales for instructional designs. This science teacher is textbook bound and avoids laboratory activities. Regarding teaching methodology, this teacher frequently imitates the styles of his/her college professor with strong lecture-demonstration. Reasoning is mostly deductive and individual student needs are ignored. This stage one teacher perceives the classroom as the sole sphere of influence and has an adversarial "we/they" role with colleagues. The only risks this teacher takes are the inadvertent violations of school and workplace culture, because the culture has not yet been learned. This new teacher must wrestle with the conflict of the seemingly unbridgeable chasm between what was learned in teacher education and what can be implemented in the classroom. As a consequence, this teacher's focus is on the "how to" of everything. The "why" is a concern for later.

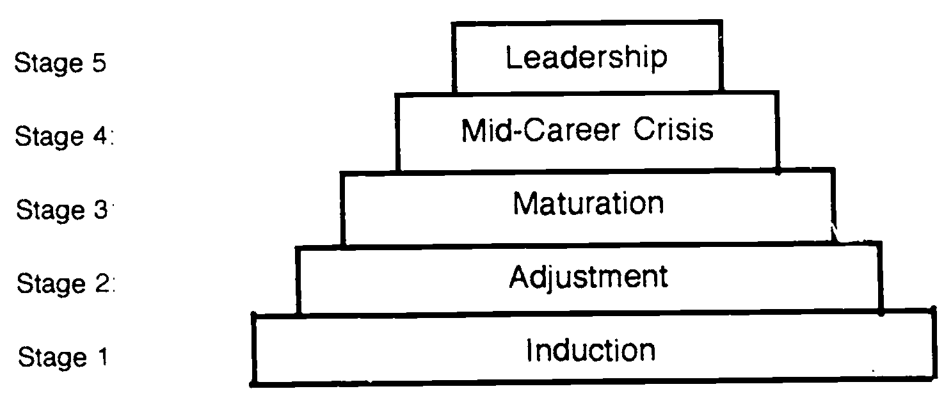
Adjustment. The second stage is a time when the teacher focuses on presenting subject matter. These enthusiastic teachers are becoming more adept at planning and organizing materials. Knowing that there is a philosophical base, they are disinterested in developing one of their own. Covering the material is foremost in their minds. Depending on a textbook, they are more apt to do laboratory activities but not in a student exploration mode. Labs are generalizations and proofs of material already covered. They begin to use some alternative options for delivering instruction on a single subject. Stage two teachers see the classroom as their sphere of influence. While intolerant of the system, they do not see that its blocks can be circumvented. With students, they begin to recognize individual student differences, but only respond to them outside of class. In this stage, they begin to explore collegial relationships and feel comfortable with the role of colleague and peer. Teachers in stage two believe that they alone know how students can learn effectively in school and in their classrooms. They are intolerant of other views and of suggestions by outsiders that there might be other ways.

Maturation. This is stage three in Spector's stages of professional development. The teacher at this stage focuses on the variations in students' needs and on the impact he/she can have on students. Feeling secure and confident, this teacher is well-skilled in delivering instruction and organized enough to self evaluate and improve. Flexible, open to new ideas and methods, this teacher is eager to learn new skills to meet the diverse needs of students.

A teacher in stage three has many ways to teach a single concept and has built up significant collections of materials and methods. Having developed a personal belief system, this teacher enjoys making decisions about teaching and curricula based on philosophy. Aware of the complexities of students, a teacher at this stage can diagnose, remedy problems, and innovate. They begin to trade-off content fact for depth of student understanding. The individual child as learner takes precedence over presentation of content, and classwork begins to be related to students' lives. Some experimentation with inductive reasoning takes place, as well as multiple lab activities with student choice and teacher constructed activities.

The stage three teacher sees his/her sphere of influence as the classroom and the student. This teacher insists on having a say in department decisions and contributes ideas and resource collections to peers. Not afraid of risk taking, he/she will actively seek and try innovations. Having developed many options in professional growth to date, a stage three teacher will find ways to circumvent situations that used to block teaching such as lack of proper laboratory equipment. Students' positive response to individualization of need encourages this teacher and promotes more risk taking and innovation. Each success contributes to the confidence of the emerging philosophical base of this teacher.

Figure 4 Spector's Five Stages of Teacher Development



Mid-Career Crisis. Teachers at this fourth stage focus on themselves and their survival. Suddenly, they experience a discomfort about teaching. The classroom is isolating. They seek adult interaction, variety, and career advancement. Decision making is difficult for the mid-career crisis teacher. Personal frustration is fueled by sensitivity to student need and leads to vacillation. Stage four teachers stop creating options, relying on those they have or reverting to a few tried and true. Sometimes, they go to the extreme in trying outrageous methods in an attempt to revitalize the classroom. They extend their influence out of the classroom by seeking out other adults, but these relationships waver between reaching out and pulling back. Conflicts between personal philosophy and reality are painful. They tire of circumventing the system and wonder whether risk taking is worth the effort. Many get so frustrated that they leave the profession.

Leadership. Teachers in this fifth and final stage focus on the science education enterprise. They are confident, knowledgeable, secure, flexible and believe that their classrooms, professional and personal lives are running smoothly. Stage five teachers cherish their autonomy. They take pride in making decisions based both on personal belief and a strong educational philosophy. Laboratory activities are analyzed carefully for congruence with intended learning outcomes. Not dependent on any single resource, they reach out to the external community for resources and thrive on new ideas and change. These teachers have an outstanding ability to design learning experiences for all kinds of students. Higher order thinking, inductive and deductive reasoning, experiential learning, exploratory laboratories, field activities dominate their teaching. They expand their sphere of influence beyond the local geographical area, collaborating with teachers from other schools, states, and professional associations.

Teachers in leadership actively help their peers through conducting workshops and publication in professional journals. Having resolved their mid-career crisis, they feel that they are in control. Students provide emotional support, but stage five teachers survive on the feedback of other teachers that they are assisting to grow, develop, and implement innovations.

Spector closes her analysis of her vast teachers observations with the recommendation that teachers need to be reflective of their own needs and stage of development. Once an individual reaches an understanding of where he/she is in the stages of development, then a teacher can adopt realistic expectations and effective problem solving strategies to cope with a changing professional environment and find strategies to move to the higher stage.

Steven Covey's Maturity Continuum

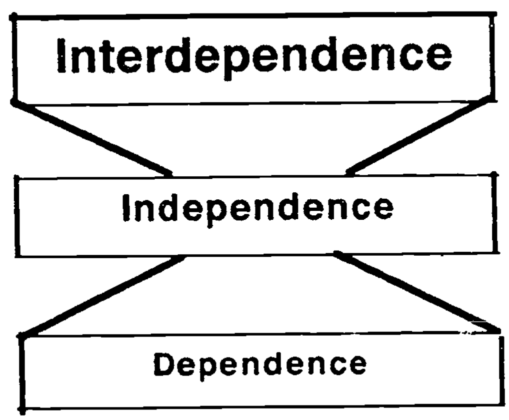
There is a third model of adult developmental stages found in the popular literature that is worthy of comment. In The Seven Habits of Highly Effective People Stephen Covey presents a maturity continuum with three stages. Not citing the sources for the idea of his maturity continuum, Covey describes maturity as "an incremental, sequential, highly integrated approach to the development of personal and interpersonal effectiveness....from *dependence* to *independence* to *interdependence*" (1989). Covey, describing the interdependence of the natural world and ecological systems, points to a parallel in human life. "Life is, by nature, highly interdependent" (1989, p. 51). His detail of three stages in the maturity continuum is as follows:

> 1. On the maturity continuum, *dependence* is the paradigm of *you* -- *you* take care of me; *you* come through for me; *you* didn't come through; I blame *you* for the results.
>
> 2. *Independence* is the paradigm of *I* --*I* can do it: *I* am responsible; *I* am self-reliant; *I* can choose.
>
> 3. *Interdependence* is the paradigm of *we* -- *we* can do it; *we* can cooperate; *we* can combine our talents and abilities and create something greater together" (p. 49).

Dependent people need others to get what they want. They are paralyzed, disabled or limited physically, rely on others for their sense of worth and emotional security, or they want someone else to do their thinking for them.

Independent people can take care of their physical needs on their own. Mentally, independent people think their own thoughts and can move from one level of abstraction to another. They are creative, analytical and organizational in thinking and can express themselves understandably to others. Emotionally, independent people are validated within and can function without the need of being constantly liked or treated well.

Figure 5 Covey's Maturity Continuum



Interdependent people are physically self-reliant and capable, but realize that people together can accomplish far more than any one could accomplish alone. Emotionally, interdependent people have great self-worth, but recognize the need for love, for giving, and for receiving from others. Intellectually, interdependent thinkers know that they need the best thinking of others to join with their own. An interdependent person has the opportunity to share self deeply and meaningfully with others and has access to the resources and potential of other human beings.

In the last several pages we have seen three models of adult stages of development or maturation. These have implications for this study by providing a construct to question interviewees about their personal and professional growth. The next area of study found in the literature is the evaluation procedures used by other science staff development projects.

Several Evaluation Variables from Other Science Staff Development Projects

Gender

The gender differences between male and female elementary teachers is a variable to consider in designing and evaluating elementary science staff development. Most research (including all the national reform reports cited in the beginning of this paper) indicate that male elementary teachers as a group have more science content knowledge and positive attitudes about teaching science than their female counterparts. Riggs (1991) using the STEBI instrument mentioned in the review above, compared both the self-efficacy and outcome expectancy of male and female pre-service and inservice teachers. There were 330 inservice teachers in her study; 12% of the inservice teachers were male. There were 210 pre-service teacher candidates in her study; 13 % of the pre-service teachers were male. The data shows slightly higher (statistically insignificant) outcome expectancy or belief scores for both groups of male teachers. However, the self-efficacy or attitude scores show a significantly higher score for both groups of males. In the self-efficacy model, female teachers will have more frustration with science innovation as they doubt their ability, lack confidence (low self-efficacy) to implement the desired innovations (outcome expectancy).

Bitner (1992) does similar research with a group of 80 pre-service candidates. Noting that the expected gender differences between male and female candidates exist before course work with the candidates, her findings show that a good course in hands-on methods and the constructivist learning theory brought the findings of the two groups at the conclusion of coursework to statistical insignificance.

An Individual Case Study

Mary Lee Martens (1989) did a year long case study of an individual teacher dedicated to learning to teach science as a problem solving activity. "What are the factors that either facilitate or inhibit the transition of teachers from a traditional ....approach....to the teaching of science in a problem solving manner?" (p.10) She found three internal factors that prevented the teacher from effectively transitioning from the traditional didactic approach of science teaching to science as "problem solving." The first came from the teacher. This teacher (whom Martens named Jane) could not get out of the mode of needing to see the students "get it right" and find "the" answer. In other words, the didactic methods of other areas of the school content could not be overcome when transferring to the teaching of science. The second factor came from without but had become personalized. Jane was viewed as an exemplary teacher by the school administration. Her classroom control was viewed a strength of her performance. Jane had so internalized this perception of herself that she could not let go of her developed degree of student control. This inhibited her giving up some of the control to students which becomes necessary in the use of problem based methodology. The final inhibiting factor was an intellectual one. Jane continued to think of science as a body of facts rather than a process of thinking and learning. Since Jane could not overcome the dichotomy between her thoughts about science and the new teaching methodology she was trying to implement, she was not successful.

Hands-on Science

Research on "hands-on" teaching methodology in science was conducted by Haury and Rillero (1992). Their research compiled ten questions most frequently asked by elementary teachers interested in acquiring hands-on skills:

1. What is hands-on learning and is it just a fad?
2. What are the benefits of hands-on learning? How do I justify a hands-on approach?
3. How does a hands-on science approach fit into a textbook-centered science program?
4. How can practicing teachers gain experience with hands-on?
5. Where do I find resources to develop hands-on activities?
6. How is hands-on learning evaluated?
7. What are some strategies for helping students work in groups?

8. How does or should the use of hands-on materials vary with the age of students?

9. Hands-on science can be expensive. How do I get materials and equipment?

10. Where do you keep materials and equipment once you get them?

Evaluation Methods Used by Other Science Staff Development Programs

Brenda Johnson (1989) used the teacher efficacy model outlined earlier in this review and a list of 20 characteristics of excellent teachers developed in research of noteworthy science programs to evaluate the attitudes of participants in a 1988 two week summer institute. Using a six month follow-up questionnaire, she surveyed the 15 participants from this Sioux Falls institute for perceptions of their motivation to learn. Comparing the institute participants' responses to the national research group's responses (from the study of the characteristics of excellent teachers in excellent programs), she found responses similar. This finding led Johnson to conclude that these 15 teachers were on the road to becoming excellent science teachers due to their involvement in the institute.

The New Mexico Rural Science Education Project offered two week summer institutes to elementary teachers linking them to natural history resources in their area, taught new methods, and helped them develop activity kits. This institute was a collaboration between local agency resource people, the education system, and local natural science museums. Dacus and Hutto (1989) conducted year end evaluations of the first two summer institutes and found them successful.

The Center for Excellence for the Enrichment of Science and Mathematics Education at the University of Tennessee at Martin developed an intensive program to improve elementary teacher skills in science. This project involved site teams of a primary and intermediate teacher and administrator. The project involved 240 hours of contact time. It espoused the "hands-on" approach of science instruction. Teacher leadership development was emphasized by a site developed field project to be planned and implemented by the participating teams at their own sites. Prather and Hartshorn (1989) evaluated this project at the end of the project year and found the program to be successful in changing teacher science content knowledge, science attitudes, computer literacy, "hands-on" skills, and to have increased student achievement at the participating sites.

In Maryland, the Carroll County Public Schools (1985) conducted a staff development program to implement a new "hands-on" science program, expand time devoted to science, and to increase the science content knowledge of teachers. The program was evaluated within a year of its completion. Data indicated that teachers implemented this new program at a rate and depth that exceeded what is customarily found in national studies.

Again in New Mexico, a six day math-science summer institute for elementary teachers was studied by Hatfield and Lillibridge (1991). The institute focused on recruiting minority educators, the use of "hands-on" teaching methods, and improvement of attitudes about science and mathematics. Pre- and post- assessments were conducted during the institute. The results indicated that institute focuses were successful. In addition to knowledge, attitude, and methodology improvements, the researchers also found that creativity was sparked, alternative uses of common instructional materials were realized, ways to overcome limited materials budgets explored, and resources for more hands-on materials discovered. The researchers did site visits within several weeks of the institute and observed that the majority of institute participants were still enthusiastic about their new knowledge, were implementing learning, and disseminating what they learned to other staff members.

A three year project to improve teacher education was conducted by five school districts in Franklin County Ohio and the University. This program dealt with assisting beginning teachers to be more effective by pairing them with experienced mentor teachers. Evaluation with district administrators, with mentors, and inductees was conducted at the end of each project year by Zimpher and Rieger (1988). Evaluation was qualitative with a short list of open ended best-worst questions.

PIES, the Program to Improve Elementary Science, was conducted in Pennsylvania. Unlike the previous programs examined, PIES occurred during the school year as a university class. Addressing the perceived needs for content improvement among elementary teachers in physical science and earth science and for gaining experience with hands-on instruction, gathering materials and connecting with resource people, this university class offered three units of graduate credit for 15 weeks of three hours per week (45 hours of contact time) at 18 sites throughout the state. Each semester group of the five year project was evaluated with a Likert type scale investigating attitude changes and then comparing the results with two control groups. The first control group, the average control group, was a group of similar teachers who had not attended the PIES training. The second control group, the motivated science group, was a group of similar teachers who belonged to the Pennsylvania State Science Teachers Association but had not attended PIES. The evaluation results documented by Zielinski and Smith (1990) showed that each group of the 18 PIES sites had attitude improvement, that attitudes were positively higher than the average control group and similar to the attitudes of the motivated science group.

Before concluding this review of literature about effective staff development, professional growth, and other science staff development project evaluations, it will be useful to review the Science Teaching Standards and the Professional Development Standards of the new 1994 draft National Science Education Standards published by the

National Research Council (1994). These standards are focused on a central issue, scientific literacy. How can education be reformed to promote "knowledge and understanding of scientific concepts and processes required for participation in civic and cultural affairs, economic productivity, and personal decision making" (page I-12).

National Science Standards

The discussion of Science Teaching Standards begins with examination of several assumptions that lead to the creation of the teaching standards cited below. Focusing on the importance of the role of the teacher, the first assumption is that learning is greatly influenced by the teacher-student relationship, by the teacher's vision and beliefs about science, and by how it is taught. Second, the process of learning must be understood by teachers both in the dynamic ways human beings construct knowledge for themselves as individuals and in groups and in the developmental ways that students think and change in their thinking. Finally, it must be assumed that teachers are life long learners, open, constantly inquiring into the nature of science, their students and their teaching practices.

Science Teaching Standards

Six national standards for Science Teaching are cited (National Research Council, Chapter II):

1. Teachers of science plan an inquiry based science program incorporating a framework of year long and short-term

goals, selecting content and curricula that fit the interest, knowledge, skills and experience of students, using teaching strategies that develop understanding and develop a community of learners, working together as colleagues within and across grade levels and disciplines.

2. Teachers guide and facilitate learning, focusing and supporting inquiries, orchestrating discussion, giving students responsibility for their own learning, responding to student diversity, encouraging the participation of all, and modeling the skills of inquiry with curiosity, openness, and skepticism.

3. Teachers engage in ongoing assessment of their teaching and student learning by systematically gathering student data, analyzing this data to guide teaching, by guiding students in self-assessment, and by using student data and observations and interactions with colleagues to improve teaching.

4. Teachers, allowing student involvement in the design, manage learning environments that provide students with the time, space, and resources needed to learn science through extended, flexible, and safe settings with multiple text, scientific, and technological resources.

5. Teachers develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning. This is accomplished through displaying and demanding respect for all students, involving students in decisions, requiring responsibility of students for

decisions, nurturing student collaborations, and by modeling the skills, attitudes, and values of scientific inquiry.

6. And finally, teachers actively participate in the ongoing planning and development of the school science program with teacher voice in time and resource allocation and the design of professional growth activities.

Professional Development Standards

There are four professional development standards. The first three can be summarized as learning science, learning to teach science, and learning to learn. The fourth standard addresses quality professional development (Chapter III). The underlying assumption of these standards is that all professional development of teachers for undergraduate pre-service to in-service prepare teachers to understand and use the techniques and perspectives of inquiry. Also assumed is the complete shift of conventional staff development of technical training for specific skills to career long opportunities for intellectual growth.

1. The professional development of teachers of science requires learning science content through the perspectives and methods of inquiry. Traditional undergraduate and pre-service science courses must be replaced with courses creating science experiences, significant current science topics, involving scientific literature, media and technology, building on each teacher's current attitude and skills, using the inquiry process, and nurturing collaboration.

2. Professional development of teachers of science requires integration of the knowledge of science, of learning, of pedagogy, and of students, and application of that understanding to the teaching of science. Learning to teach science must take place in actual classrooms, recognize the developmental level of the teacher candidate, and must use inquiry, reflection, modeling and guided practice.

3. The professional development of teachers of science enables them to build the knowledge, skills, and attitudes needed to engage in lifelong learning. Science learning encompasses regular and frequent individual and peer reflection on classroom practice, use of reflection tools, sharing, mentoring, other collegial supports, access to research, and opportunities to conduct research in science and science teaching.

4. Pre-service and in-service professional development programs for teachers of science must be coherent and integrated. Quality staff development has clear and shared goals. Understanding and skills are built over time, reinforced, and practiced. Development programs allow for individual differences among participants. Collaboration must be modeled by the program providers. Continuous program assessment is used to improve and evaluate.

Summary

In this literature review, the three traditional principles of staff development were examined first: teacher belief, attitude and behavior. Secondly, a new student centered model for evaluating staff development was reviewed exposing three new principles (content, quality and context) of staff development as variables that affect student improvement. Next, three different adult development learning scales were studied, indicating that teachers like all other groups of human adults are not all alike in their growth and maturation. Fourth, gender, case study and hands-on issues in science staff development were reviewed along with a summary of the what and the how of several contemporary science staff development projects' self evaluations. Finally, the new national standards for Science Teaching and for Professional Development of Science Teachers have been summarized.

The problem statement of this study needs to be revisited before closing this literature review: *What are the long term effects among SIRC participants?*

Both the traditional and the new student centered principles for effective staff development can be employed in designing the instrumentation of this study of the successes of the SIRC project on its prior participants. Use of an adult developmental scale can contribute to the study as well.

Particular attention has been paid in summarizing the evaluations of other staff development programs. Some were university based, some were summer institutes only, some were very similar in design to SIRC. There were many interesting evaluation methods and just as many findings. These certainly will contribute to designing instrumentation for this study. But, one very interesting commonality appeared when reviewing the literature and the evaluations of these other science staff development programs--all were conducted on the short term, between the last day of a project and one year after its completion. There is a conspicuous lack of literature that examines the long range effects of a staff development project. Therefore, this research proposal will dare to go where no others found in this search and review of the literature have dared--to documenting changes in belief, attitude, classroom and professional behaviors of its teacher participants three to five years after project completion.

CHAPTER III

METHODOLOGY

Introduction

Research Questions

Using both quantitative and qualitative methods, this study was designed to determine what effects the SIRC project had on its participants in the long term. The study was fashioned to explore:

1. What do incoming SIRC participants believe about science?

2. Did the project **change the belief about science** toward the definition found in AAAS and other reform documents?

3. If teacher confidence is the central issue as to whether science instruction occurs at the elementary level or not, what has SIRC accomplished in **raising participant confidence about teaching science**?

4. What are the teaching practices of incoming SIRC participants?

5. How have these **teaching practices changed** once participants become alumni of the SIRC project?

6. Did required **administrator involvement** and the **team approach** to involvement in the project enhance the development of participants?

7. Did **leadership** and **growth** as professionals occur among participants?

Quantitative research methods were used with both the study group and control group to establish a baseline of comparison. Qualitative methods were used to delve into significant differences between the study group and the control group. Use of both methods allowed for a kind of "bi-angulation" of the results that lends strength to the study.

The quantitative method was employed to conduct descriptive research. Its purpose was "to describe systematically the facts and characteristics of a given population...of interest, factually and accurately" (Isaac, 1981, p.46). An instrument was designed to collect descriptive data and used with both the study group and the control group. The data of the two groups could not be compared in a true "experimental" design. Neither accurate nor extensive pre-project records that would help this research were kept during the participation years of the study group. In order to establish a control group, comparable beginning data of a following current year group were gathered. In comparing the results of the descriptive quantitative data gathered between the two groups, the research had to take a quasi-experimental perspective "to approximate the conditions of the true experiment in a setting which does not allow the control and/or manipulation of all relevant variables. The researcher must clearly understand what compromises exist in the internal and external validity of his design and proceed within these limitations" (Isaac, 1981, p.54).

After the quantitative data was compared, significant differences between the groups called for further research.

Investigating such a human and creative enterprise as teaching calls for methodology beyond numerical comparison. It was more productive to turn to the qualitative research methodology more traditional to a field like anthropology to bring some living flesh to the bones of the numerical data. "Using the techniques of in depth, open-ended interviewing and personal observation," qualitative methods were used in this study as follow up to the quantitative to make "holistic analysis, and detailed description derived from close contact with the targets of study" (Patton, 1980, p. 19).

The methodology of this study is discussed here in terms of sample selection, instrumentation, data collection, and data analysis.

Sample Selection

Two groups comprise the sample selected for this study. The first group, called the study group, consists of approximately 120 active teachers who participated in the SIRC project during school years 1989-90, 1990-91, and 1991-92. The second group, called the control group, includes the 79 active teachers who are actively participating in the SIRC project during school year 1994-95.

Study Group

The study group of this research project consists of approximately 120 classroom teachers who attended all 13 months and 21 days of SIRC training during 1989-92. These years were chosen for two reasons: time and objectivity.

Regarding time, this study has purposefully decided to investigate the long terms effects on participants. The literature review found no similar projects that evaluated participant effects beyond twelve months. For this reason, long term was defined by the researcher as at least two full years from the date of training completion. When data collection was begun with study group participants, 21 to 45 months had elapsed from last project contact.

Secondly, these years were chosen for purposes of objectivity. The project was funded by its first National Science Foundation grant, TPE-8954586, and during this three year period was under different directorship. The researcher had minimal contact and, therefore, influence upon these three project years of the study group.

The SIRC project data base contained 181 names of participants from the three study years chosen. For purposes of internal validity, only data from the active teacher participants were being sought. Each project year of the study group consisted of twelve to thirteen school site teams of two to four teachers each plus a teacher alternate (in case of participant drop out or missed meetings) and the site administrator. This translates into 60-65 names (five times twelve teams) added to the project data base during the three study years, i.e. the 181 names. With most of these dozen teams per year containing an administrator and alternate and since team administrators were not active in the classroom and only attended some training days and team alternates seldom attended if at all, 20-24 names for each of these project years were not actual teacher participants. The size of the actual study group was reduced from 181 to about 120. This elimination of administrator and alternates presented a focus problem for definition of the study group. This problem was resolved by adding a status question of "participant," "alternate," "administrator" to the instrumentation.

Gathering data from the study group about long-term changes continuing since project contact presented two additional problems: accessibility of participants and the design of methods to gather pre-project data from participants after the fact and after so much time.

Regarding accessibility, the SIRC data base was fairly accurate, being updated by "address correction requested" sought once per year with the mailing of the project's bimonthly newsletter. Only two participants of 181 showed no address. Only two other questionnaires were returned for insufficient address. In order to encourage participants to complete the questionnaire several strategies were employed. First, all questionnaires were return addressed and had return postage affixed. Secondly, a letter of need for data was included on the questionnaire and the promise of an alumni coffee mug for its return (see questionnaire, Appendix B, pages 161-166).

Questionnaires were mailed to all 181 names in the study group data base in May of 1994. Forty-eight completed questionnaires were returned. Of these 48 returned, seven were eliminated for being returned by alternates or administrators, leaving 41 valid responses from the study group. Forty-one returns represents 35% of the actual study group (41 of 120) and is deemed a large enough return to be valid for sampling.

Additional internal validity is reflected in the spread of individual project year subjects among the 41 total respondents. From SIRC project year four, 1989-90, thirteen responses were returned, four from males and nine from females. From SIRC project year five, 1990-91, twelve responses were returned, two from males and ten from females. From SIRC project year six, 1991-92, sixteen responses were returned, four from males and twelve from females. The proportion of gender and number of study group subjects from each project year is comparably representative. The demographics of sample groups is found in Table 1.

In addition, the demographic information of these 41 study group respondents resembles the demographics of the control group adding further to validity.

Follow up interviews were conducted with a smaller sampling of the study group in January and February 1995. The institution sponsoring this thesis requires voluntary consent in the interviewing of human subjects. Consent was solicited at the end of the May 1994 questionnaire and was received from 28 of the 41 valid responses.

Eleven follow up interviews at five school sites took place. The researcher sought sites where consent was given by more than one respondent in order to delve into the team support aspect of the project. To be consistent with the gender make up of the group, three of the interviewees were male and eight were female. Three interviewees were from project year four, five from year five and three from year six. Of the eleven interviewed, six were respondents who had given consent on the May questionnaire and five were study group respondents who did not complete a questionnaire but gave consent to be interviewed after telephone contact. These five who were interviewees but not questionnaire respondents increase the number involved in the study group sampling from 41 to 46, increasing to 38% the sampling size of the 120 possible in the entire study group population.

Table 1 Demographics of Sample Groups

Control Group			Study Group		
Sample Number:	79		Sample Number:	41	
Average Age:	36.6		Average Age:	38.5	
Av. Yrs. Teach:	10		Av. Yrs. Teach:	14.7	
Gender:	Females	Males	Gender:	Females	Males
			Year 4	9	4
			Year 5	10	2
Year 9	53	16	Year 5	12	4
Number	53	16	Number	31	10
Percent	80%	20%	Percent	76%	24%

The second problem of gathering pre-project data from the study group was resolved by creating the control group. It could have been assumed that teachers as highly trained professionals ought to have sufficient memory and integrity to reflect and report on their beliefs, attitudes, and teaching behaviors before involvement with the SIRC project, Acting on this assumption would have required this study to use completely qualitative methodology. For logistical reasons of travel, distance, accessibility and time, the result would have been an even smaller sampling of study group subjects due to the intensive interviewing required to gather both the effects from the SIRC project and reflections of self before project involvement.

The SIRC project has continued with the same training model of 21 days during thirteen months and the content of those training days has remained fairly consistent for the last six years. To avoid the accusation of over subjectivity by use of all qualitative techniques, the control group was created. The control group is all the imcoming participants of the current project year nine, 1994-95. Since project configuration and training has remained constant, since participants from the current project year come from schools in the same region, and since the demographic make up of the groups is very similar, it is assumed for the purposes of this study that the pre-project beliefs, attitudes, and teacher behaviors of the current project group are similar to those of the study group at the beginning of their SIRC training two to four years ago. Under these assumptions, utilization of this control group has allowed for use of quantitative techiques.

Control Group

The control group consists of 79 active teachers who are involved in year nine of the SIRC Project. A successor grant, ESI-9154813, was awarded by NSF to continue the work of the previous SIRC project. The configuration of the project calendar, training days, content of training, team make up, administrative involvement were continued in the successor grant. However, NSF insisted that the number of school teams and teacher participants be doubled. Instead of 40 teachers per year from 12-13 sites, the project serves 80 teachers per year from 24-26 sites.

To gather incoming data about beliefs, attitudes, and teaching practices from the control group, an identical questionnaire was given to the 86 attendees of SIRC 9 on the second morning of their first summer institute (consult Appendix C, pages 167-174 for this instrument). There are seven student teachers among the current group and these were eliminated to preserve validity. There were no administrators or alternates involved with the questionnaire. The instrument was given the morning of the second day of the 21 day training schedule. This was done intentionally to gather responses before the effects of project training.

The control group as active participants were a captive audience and, therefore, the accessibility problems of the study group were not encountered. Randomly throwing out half of the 79 questionnaires to get 39 controls to compare with 41 study was contemplated. Random removal of half of the 79 would have had very little mathematical effect on the control group results. Half of any random sample is generally proportional and representative of the other half. Consequently, all control group questionnaires have been used in determining the findings of the control group.

In order to compile qualitative data in addition to the questionnaire given to the control group, journal entries and journal synopsi submitted on a voluntary basis have been reviewed. Project participants are required to keep a reflective journal and turn in an entry or a synopsis of entries beginning with each monthly school year meeting, September through April (training days 7 to 16). Participants give consent for journal use by anonymous citation in reporting to NSF and that consent was utilized in the same way for this study.

It was not logistically possible for the researcher to conduct control subject interviews before the start of the project year. It would not be valid to conduct interviews in the course of the project year as data would be tainted by half a year or more of project involvement. A problem similar to expecting study group participants to report accurately on their pre-project beliefs would result. This is the rationale for use of journal entries. The first journal turn-ins for the period between the summer institute and the September school year meeting were reviewed to gather statements about beginning beliefs, attitudes, and practices about teaching science. The researcher feels this provides a comparable methodology to the qualitative interviews conducted with the study group.

Comparison of Study and Control Groups

A comparison of demographics between the study group and control group reveal many similarities which help establish internal validity (Tables 1, 2, 3). The gender make up of both groups is comparable: the control group is 80% female, study group 76% (Tables 1 & 2).

Table 2 Gender Make-up of Sample Groups

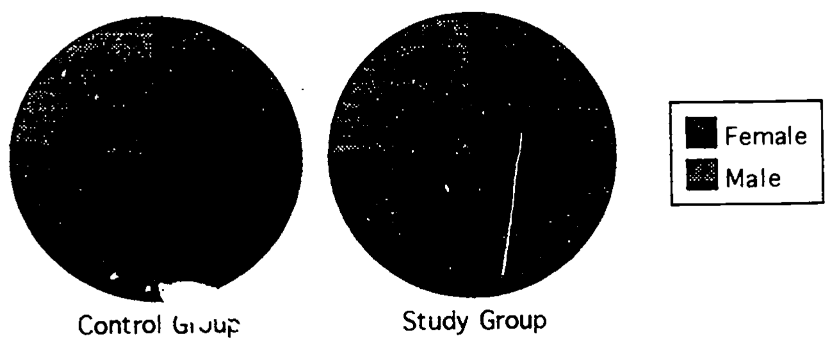
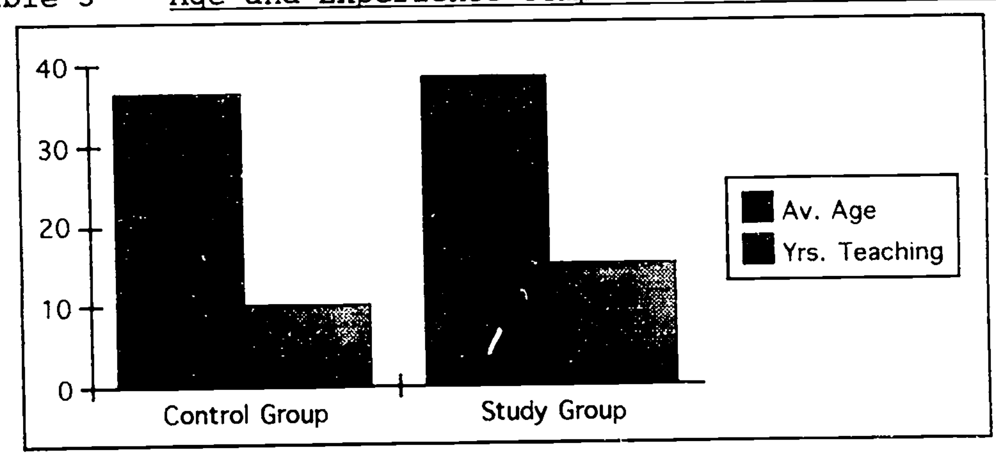


Table 3 Age and Experience Comparison of Sample Groups



The age and number of years of teaching experience of the study group are both slightly greater than the control group (Table 3). The study group averages 38.5 years of age while the control group averages 36.6. The study group averages fourteen years of teaching while the control group averages ten. Since the study group participated in SIRC training between two and four years ago, current age and teaching experience can be factored back to incoming age and experience by an average of three years. The result is surprisingly comparable age and experience between the groups.

Instrumentation

Instrumentation for this study comprised both quantitative and qualitative methodology. A 52 item questionnaire was used with both the study and control groups. There were two demographic questions, 35 five point Likert scale statements concerning beliefs about science, beliefs about the teaching of science, confidence in the teaching of science and teaching practices. Fourteen multiple response items were used to gather data on teaching practices, professional development, importance of project team and administrator involvement. Samples of the questionnaire can be found in Appendices B and C. A blue print of questionnaire items is included in Appendix D.

Use of the questionnaire provided descriptive data for the study and control groups. Building a profile of belief, attitude, and practice from the control group established a baseline for comparison within the study. In those areas where the researcher found significant improvement in the study group, notes were made for follow up interview.

Interview of eleven volunteer study group subjects was used to delve into the significant differences that quantitative comparison indicated. Five site visits were conducted where two or three participants from a study group team still worked together. These interviews were tape recorded. A short visit with the site administrator was conducted to inquire about site science leadership activities among the study subjects interviewed. This visit with the administrator has provided some modest triangulation.

Journal entries submitted voluntarily by subjects in the control group from the period of the first to the seventh day of the project were reviewed to seek the thoughts and reflective language as support to questionnaire results about beginning participant beliefs, attitudes and practices.

The Questionnaire

The 52 item questionnaire was designed to gather a descriptive profile of the study group and the control group regarding this study's seven research questions. An interest survey currently used for annual reporting of the current project to NSF and items found in other instruments during the literature review were extracted and used by the researcher in the questionnaire design. This process led to the selection of teacher beliefs about science, teacher beliefs about the teaching of science, teacher confidence for the teaching of science, teaching methodology used to teach science, and professional growth and peer support as research items.

Among the 52 items, there were 35 Likert statements with a five point response scale: highly disagree (1), disagree (2), neutral (3), agree (4), highly agree(5). The other seventeen questions sought multiple choice response or brief written answers. For purposes of internal validity, Likert statements on this questionnaire were written in pairs with both a positive and negative expression and then randomly distributed throughout the statement section. The positive-negative phrasing was used to get a more consistent response from participants, forcing them to look at statements from both agreement and disagreement. The random mixing was used to eliminate respondents seeing an answer expectation in the sequencing of statements.

Teacher Beliefs about Science

There were six Likert items to identify teacher beliefs about science. Knowing the research base about the fear of most elementary teachers toward the subject area of science, the SIRC project expected participants to enter with a closed definition of science: considering science to be more a body of facts to be learned, content that is hard to grasp, the realm of experts, static. Participants were expected to leave the project with a personal definition closer to the one outlined in the Assumptions section in Chapter I of this study where science is considered as an open process, a way of knowing and a way to know what you know.

The following six statements shown in Figure 6 were purposely distributed in a random fashion in the questionnaire. Participants were asked on a five point scale for their disagreement or agreement with each item.

Figure 6 Likert Questions on Beliefs about Science.

3. *Science is a body of knowledge, facts, theories.*

11. *The process of seeking answers is the real nature of science.*

18. *Science is a way of thinking and asking questions.*

19. *Students must be taught the facts and truths of Science.*

25. *It is important to teach students about what most scientists think and believe.*

31. *Openness is a quality of science.*

Teacher Beliefs about the Teaching of Science

Seven Likert items were used to determine disagreement or agreement about the value of science in the elementary school among teachers as a group. The control group was not expected to value science as highly as the study group. However, the control group was voluntarily enrolled in training to become effective science teachers so high rejection of the value of science was not expected. A relatively higher valuing of science in the school curriculum was to be expected from the study group. Again these statements were purposefully mixed among the 35 statements as shown in the following figure:

Figure 7 Likert Questions on Beliefs about Teaching Science.

7. Science is the most important subject at school.

10. Increased effort in science teaching produces little change in some students' science achievement.

14. Reading and Mathematics are more important than science.

16. Most teachers enjoy teaching science.

22. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.

23. Teachers often put off teaching science.

26. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.

Teacher Confidence for the Teaching of Science

Eleven Likert items were used to determine disagreement or agreement about teacher confidence for teaching science. Many items were both positively and negatively stated. These statements were also randomly mixed among the others and are shown in Figure 8 below. With low teacher confidence being identified in the research as the key contributor to poor or non-existant elementary science programs, this area was expected to show a large difference between the control and study group. Even though the control group was voluntarily

Figure 8 Likert Questions on Confidence for Teaching Science.

5. When teaching science, I usually welcome student questions.

8. I do not know what to do to turn students on to science.

9. I wish I had received more science instruction in college.

13. I understand science concepts well enough to be effective in teaching elementary science.

17. I will not be very effective in monitoring science experiments.

24. I have a strong science background.

29. I wonder if I will have the necessary skills to teach science.

30. I will typically be able to answer students' science questions.

33. Even if I try very hard, I will not teach science as well as I will other subjects.

35. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand better.

37. I will continually find better ways to teach science.

involved in training, their lack of confidence in the teaching of science was expected to be their motivation for enrolling in the project.

Methodologies used in Science Instruction

Four Likert items were used to determine disagreement or agreement about the use of hands-on teaching strategies in science and are shown in Figure 9. Seven Likert items were used to determine disagreement or agreement with the use of developmental theory for appropriate introduction of science concepts to differening ages of students. These developmental questions are shown in Figure 10. More agreement with the use of hands-on and with the use of developmental theory was expected from the study group.

Figure 9 Likert Questions on Use of Hands-on.

4. *Students prefer to learn science from textbooks.*
20. *Children will learn more science by doing hands-on activities.*
26. *Students prefer to learn science by manipulating materials.*
32. *Children learn more science if taught from a good textbook.*

Figure 10 Likert Questions on Developmental Theory.

6. Adults and children learn in identical ways.

12. Students can learn any concept at any grade if they have an effective teacher.

15. Planetary motion can be taught successfully to third and fourth graders.

21. Children as a group think in different ways than adults do.

27. Most second graders (7-8 year olds) are able to understand molecules.

34. Effective teaching matches the cognitive abilities of student to the content of the curriculum.

36. The structure of the cell and the atom are best taught in middle and high school.

In addition to Likert items on use of hands-on and developmental theory, five multiple response items were used to gather description from the study and control groups regarding the amount of time devoted to teaching science per week, the type of student management strategies being used, the number of outdoor study labs conducted per school year, the extent of curriculum integration between science and other subject areas, and the types and extent of various teaching methodologies used in science instruction. The study group was expected to teach more science, give students more involvement in learning, use less direct instruction, integrate more, and do more outdoor labs.

Professional Growth and Peer Support

Eight choice items were used to gather descriptive data about the control and study groups regarding professional growth and peer support. Professional growth was looked at in two ways: the number of leadership qualities each individual possessed and placement on an adult developmental scale. Six professional and leadership growth activities were found in the literature review and used as choices for indication of leadership skills. Barbara Spector's professional development scale with the elimination of stage four, Mid-Life Crisis, was used. Being classroom and teacher derived, Spector's scale was chosen over that of Oja's and Covey's. However, these four of five stages closely resemble the four stages of Oja's scale. Four hypothetical teacher descriptions were drafted, one each for Spector's stage one, two, three, and five. The descriptions were provided out of sequence in the questionnaire and respondents were prompted to select the one most like themselves. Two choice items were designed to gather description between the two groups about peer team collegiality and involvement of the site administrator.

Interviews and Journal Synopsis

Once the descriptive baseline of the control group was established through tabulating the questionnaire, descriptive summaries of the two groups could be compared. The researcher looked for differences of significance. These items became issues to investigate as to "why?" The method of discovering the why of the control group was to review journal entries for explanatory written reflections. A site visit and interview was used with a sampling of the study group (six of 41 respondents. five of the remaining study group sample) to delve into "why?" The site visit consisted of at least one hour of classroom observation, usually of the subject teaching a science lesson and a 30 minute interview. The classroom observation provided a backdrop to judge the authenticity of subject's statements during the interview. The actual interview was a tape recorded private session, conducted after school with students gone and interruptions at a minimum. The interview had some guiding questions about areas to be "delved" (see Appendix E, pages 176-181) but was intended to be as open-ended as possible. The guiding questions were used to gather further information consistently on the "delve" issues from the eleven subjects.

A short visit was conducted with the site administrator of each study group subject interviewed. This principal visit was conducted to determine what site leadership in science was occurring from each subject. The questionnaire, the interview, the principal visit comprise the three pieces necessary to triangulate study group findings. Subject responses in the journals of the control group and in the interviews of the study group are to be used in the report of findings to shed light on "why."

Data Collection

Data collection was done with a 52 item questionnaire from both the control group and the study group. The questionnaire was mailed to the study group in May of 1994 and responses were received between June and November 1994. The questionnaire was completed by the control group on July 26, 1994. A thirty minute follow up interview was conducted with eleven of the study group subjects between January 15 and February 16, 1995. Site principal comments were gathered concurrently with the interviews. Review of journal entries from the control group was conducted as journal entries came in between October 1994 and January 1995.

Data Analysis

Most of the data of this study were generated by the 35 Likert statements on the questionnaire. These statements were accompanied by a five point scale with five being high agreement and one being high disagreement. Item analysis for each Likert statement for the control and study groups was first reported as a total group average as in the example in Table 4. A simple subtraction of the Likert averages between the groups pointed out some gross differences positive and negative, large, small or none at all.

Table 4 Example of Analysis of Likert Average

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.4		3.2		0.2

This revealed some initial findings. Items were further analyzed by scale response, grouping scale four and five responses together as agreement and scale one and two responses together as disagreement.

Table 5 Likert Item by Agreement / Disagreement

Likert Item Response Percentage Comparison:
(1 = disagree to 5 = agree)

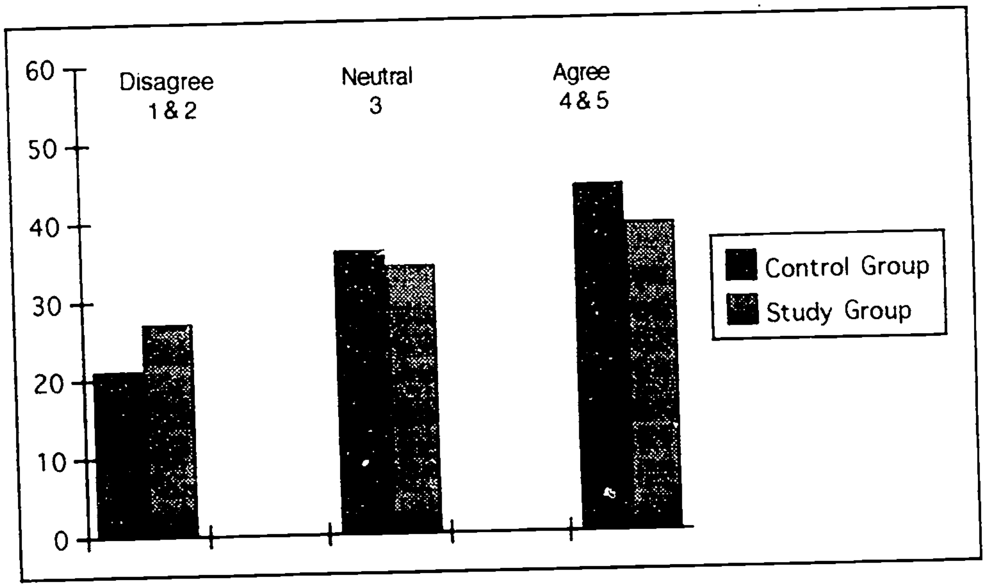
	Control Group			Study Group			Difference
	N	%		N	%		
1	5	7%		4	11%		(6%)
2	10	14%		6	16%		
3	27	36%		13	34%		2%
4	19	26%		10	26%		
5	13	18%		5	13%		4%
	74			38			

This allowed for deeper analysis and difference between the control and study groups as shown in Table 5. In the method used in Table 5, results are tabulated in Likert item response as a percentage of the whole respondent group for each item choice 1-5 in the left two columns. The far right column shows the percentage differences between the two groups when the item responses for agreement and disagreement are first combined and then disagreement, neutrality and agreement are compared between the groups.

This right hand column's results have then been graphically displayed in Table 6. Taking the data from the left hand columns of the response percentage comparison and turning it into a graph allowed for more visual analysis of the differences between the control and study groups.

Complete item analysis of the 52 item questionnaire in these table/graph formats can be found on pages 182-225 in Appendix F. A numerical sequence of response per item and group average comparison tables of the 35 Likert statements can be found on pages 226-237 in the same Appendix F.

Table 6 <u>Graphic Display of Likert Scale Analysis</u>



Before closing the methodology chapter, one issue mentioned briefly in the beginning of this chapter must be discussed again. The general influences of California science reform during the period of this study have effected the analysis of this data, especially among the control group. For the last six years, SIRC has turned out 275 alumni who have gone back into the elementary classrooms of its nine county region to teach science differently. Other science reform projects in California turned out graduates motivated to teach more science. In 1991 California completed and published a new Science Framework for Public Schools. Extensive statewide and local school district efforts to disseminate this framework have also had an influence as well as the official adoption of state approved instructional materials for science in 1992.

An example of this influence is cited: from prior and sketchy project records, teachers entering SIRC in 1989 were teaching approximately 85 minutes of science per week. The average science teaching time of the incoming control group is now reported at 140 minutes per week. This indicates that these regional and statewide influences exist. However, for this study, these regional influences have not been investigated. While being noticed, these influences have been side stepped in the formal report of findings in this study.

Summary

The sole purpose of the analysis of data in this study is to show the long term positive effects of the SIRC project on its participants. A questionnaire was designed to gather descriptive data. The incoming participant data as the "control group" and alumni data from groups of two to four years ago as the "study group" were gathered. Quantitative data from the questionnaire were used for a comparison between the two groups to establish findings. Quantitative questionnaire data were then followed up by qualitative interview and journal analysis to offer explanations for the differences found.

CHAPTER IV

FINDINGS

Introduction

The purpose of this study is to examine the long term changes in teaching beliefs and instructional practices among the teacher participants of the Science in Rural California Project from years 1989-92. This chapter reports the findings from these participants and addresses seven study questions:

1. What do incoming SIRC participants believe about science?

2. Did the project move the belief of its participants about science toward the definitions of science found in AAAS and other reform documents.

3. If teacher confidence is the central issue as to whether science instruction occurs at the elementary level or not, what has SIRC accomplished in raising participant confidence about teaching science?

4. What are the teaching practices of incoming SIRC participants?

5. How have these practices changed once participants become alumni of the SIRC project?

6. Did required administrator involvement and the team approach to participation in the project enhance the development of participants?

7. Did leadership and growth as professionals occur among participants?

These seven study questions can be best reported under four general headings: Findings about Beliefs, Findings about Confidence, Findings about Teaching Practices, Findings about Professional Growth and Collegiality.

Gender & Age Differences

The variable of gender was found during the literature review and reported as significant in the evaluation of two other science staff development projects. Gender differences between male and female participants of both the control group and the study group were examined in the initial analysis of quantitative data in this study. No significant difference was found between males and females in any of the four areas of findings within the study and control groups and offered no explanation for the differences between the two groups. Also, since the study group was more than two years older and had average teaching experience of four more years, the "older and wiser" factor was also explored as a variable. It, too, was found to show little difference and offered no explanation for the results comparison between the control group and study group. For the purposes of examining the findings of this study, no weight was given for the variables of gender or age-experience.

Findings about Beliefs

Beliefs about Science

The control group and study group were expected to show differences in their definitions of beliefs about science. Incoming participants in the control group were expected to view science more traditionally, as a closed content, as a body of facts. Study subjects, after contact with newer ideas about science due to their twenty-one days of training in the project and two to four years practice in the field, were expected to view science as more open, as a process rather than a closed body of facts. Both groups were asked to agree with six statements randomly distributed through the 35 Likert statements in the questionnaire, three of which described science as open and three of which described science as closed as shown in the following Figure 11.

Figure 11 Open and Closed Statements about Science

Open Statements about Science

11. The process of seeking answers is the real nature of science.
18. Science is a way of thinking and asking questions.
31. Openness is a quality of science.

Closed Statements about Science

3. Science is a body of knowledge, facts, theories.
19. Students must be taught the facts and truths of Science.
25. It is important to teach students about what most scientists think and believe.

The findings reveal little difference in beliefs about science between the two groups. The typical response distribution to an open statement is displayed in Table 7 and to a closed statement in Table 8. Tables reporting group

Table 7

Comparison of Openness Beliefs

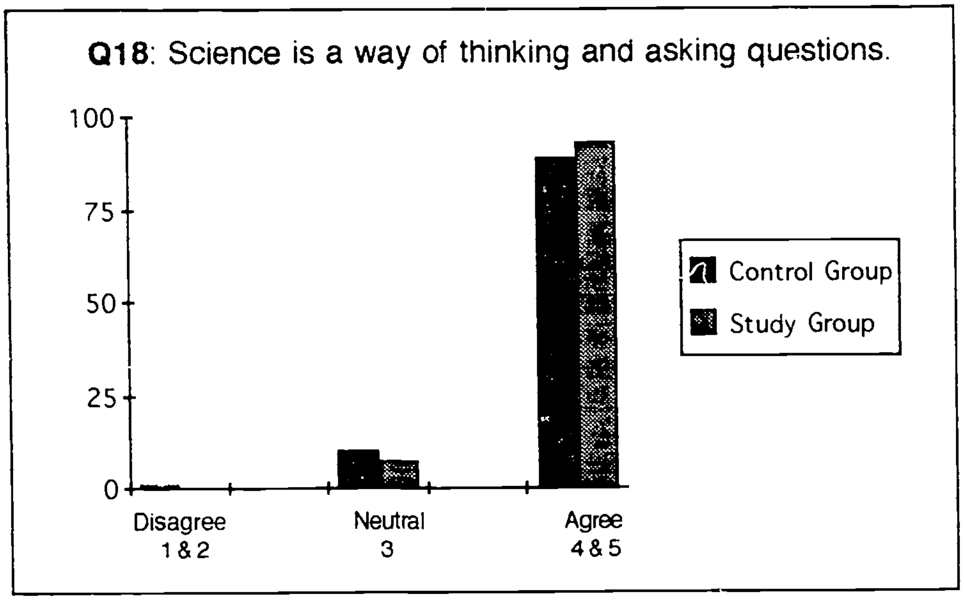
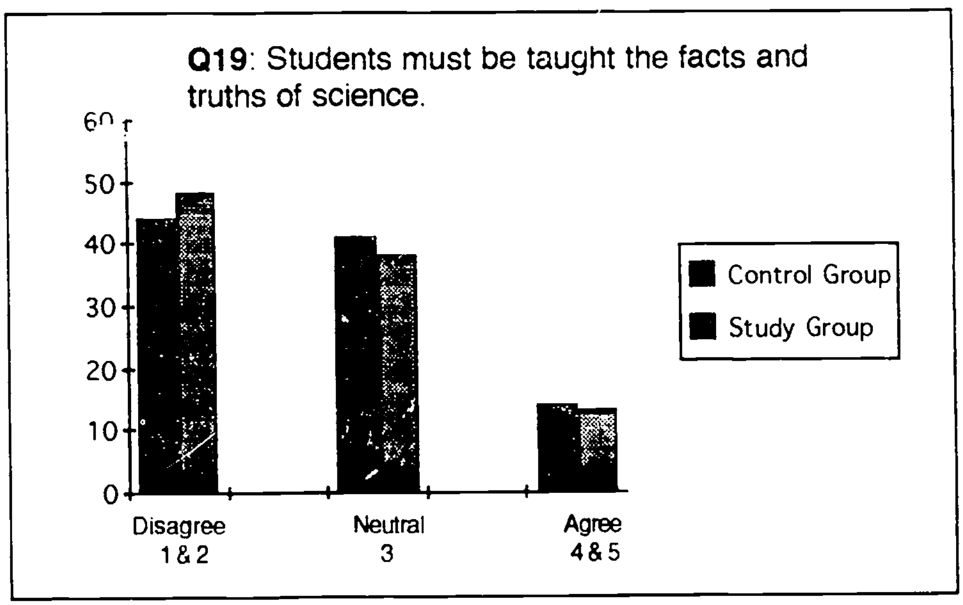


Table 8

Comparison of Cl?sed Beliefs



response in detail to all six items can be found on pages

183-188 of Appendix F. In response to five of the six questions in this cluster, both the control group and the study group shared agreement about a more "open" definition of science and were fairly neutral about the "closed" definition. These findings indicate, contrary to study question expectation, that incoming participants in the control group already had a definition of science congruent with that being framed by the reform documents and to the definition of Science in Chapter I of this thesis.

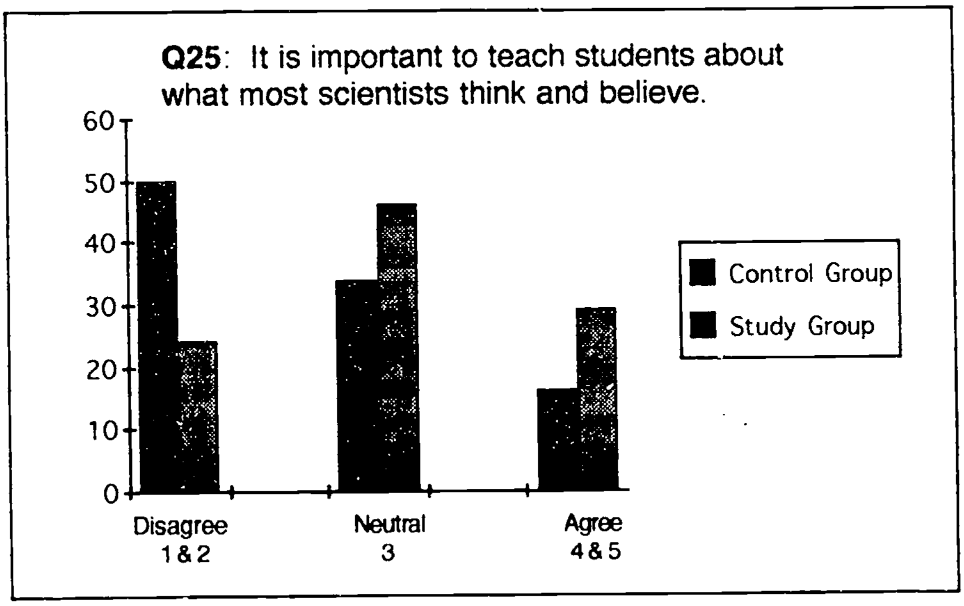
The researcher was surprised at this finding. It was very gratifying to find an open definition of science in both groups which indicates that this may be the current belief of most of the elementary teaching force in northern California. Follow up personal interviews of eleven participants from the study group revealed that eight of the eleven had a closed definition of science before they began their SIRC training, reinforcing the research expectation. All eleven described their current definition of science in very open ended terms. "Science is the way a kid sees the world." "The way we go about learning about our world." "Science is a process of getting at the truth of things."

The only explanation that can be offered for this similarity of belief between the control and study groups is the regional ripple effect of the SIRC project and the general influence of California science reform as mentioned in the closing section of Chapter III, Methodology.

One intriguing discrepant event occurred in studying the results of this six question cluster about a definition of science. Statement 25: *"It is important to teach students about what most scientists think and believe"* was agreed with by more in the study group than the control group. This item had been written with the intention to be a closed definition of science. Not only did this response go in direct opposition to the expected outcome of a more open definition by the study group, but it went against the general pattern of similarity of both groups toward an open definition found in the other five questions on belief. The analysis reported in Table 9 shows twice as many in the control group disagreeing and twice as many in the study group agreeing with this closed definition statement about science.

Table 9

Unexpected Agreement of Study Group on Closed Statements about Science.



This, of course, became an issue for visitation and interview of study group members. All interview subjects were asked to define science. They universally defined science as a process of "investigating the world around you to make sense of why things are the way they are." From probing for an explanation for this unexpected agreement with a closed belief statement, interviewees, contrary to questionnaire response, continued to describe science as a process, but one that contained widely held truths and theories which they felt compelled to share with their students. As one participant put it:

> Students need to be exposed to scientific thought. This de-mystifies science and helps portray scientists as role models. But more important is for students to be taught how scientists arrive at certain beliefs and thoughts. How they come to know-- the process used by scientists-- is much more important than the truths they know.

This discrepancy on statement 25 occurred because study group members were anxious to share their own positive beliefs about science with their students and, as a consequence, the study group viewed the statement as one of mission more than a closed description. The study group interviewees also expressed "what scientists think and believe" as a cumulative process of scientific inquiry, i.e., the answers of science over time.

Better written and indepth statements designed to seek openness of belief about science from a more sophisticated study group may have revealed the desired finding. Better designed statements may have avoided the more positive response from the less informed and much less confident control group.

Beliefs about the Teaching of Science

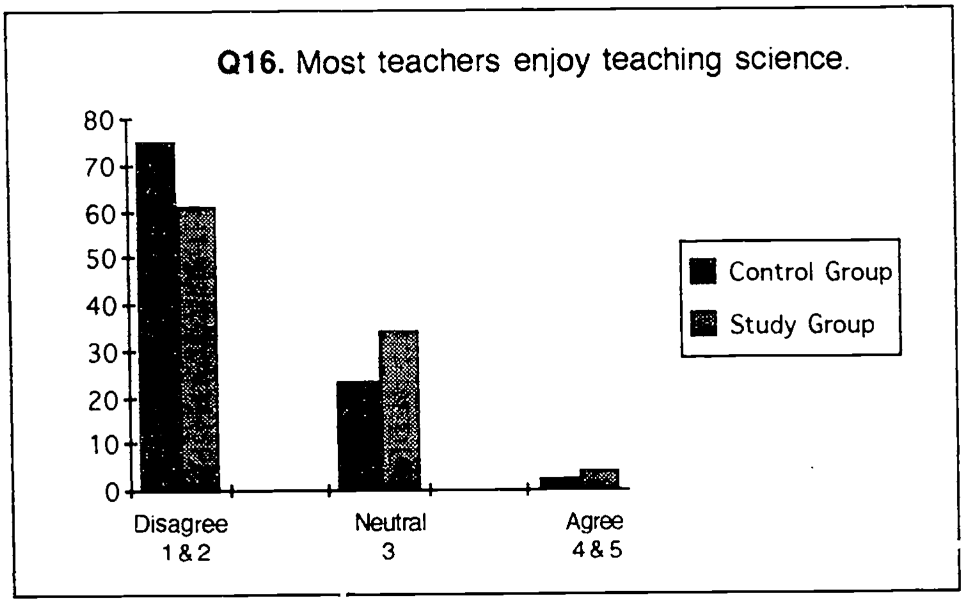
Participants in the study and control groups were asked to respond to seven statements about their beliefs on teaching science. These seven statements can be clustered around three key ideas: teacher attitude about teaching science, the importance of science, and student achievement related to teacher effort. The members of the study group were expected to value science more than the control group. This expected difference was found. Tables of the detailed response to all seven items and of the three not displayed in text in Table 10, 11, 12, can be found on pages 189-195 in Appendix F.

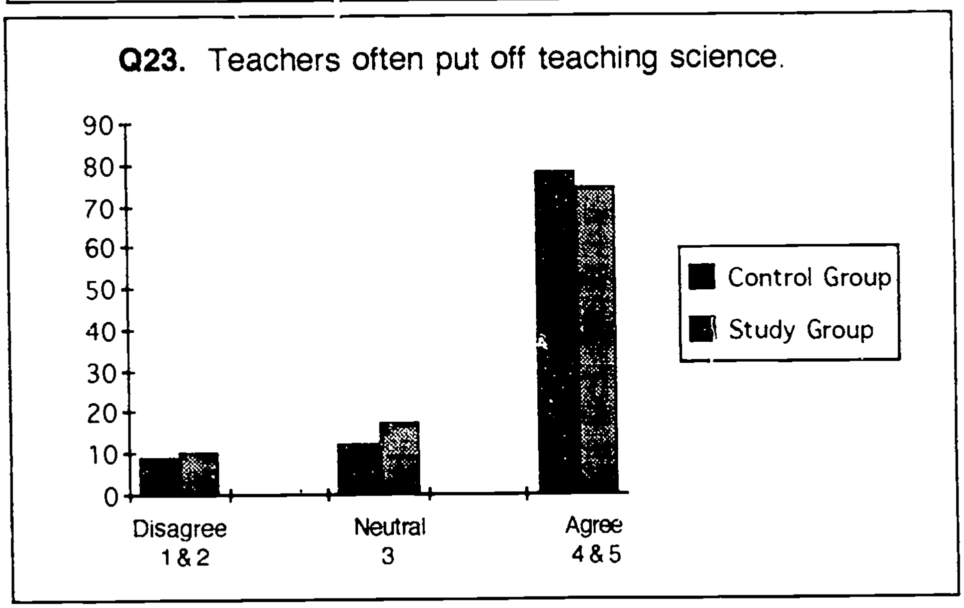
Questionnaire responses to these two items: Item 16, *"Most teachers enjoy teaching science,"* and Item 23, *"Teachers often put off teaching science,"* revealed the two groups feelings about teachers' attitudes toward teaching science. Both the study and control groups agreed in their responses that elementary teachers in general have negative attitudes about teaching science as reported in Table 10.

However, projecting their own group's anticipated feelings about teaching science, the study group felt slightly more positive while the control group felt slightly more negative about teachers enjoying science. As expressed

Table 10

Attitudes about Teaching Science





by one member of the study group: "I used to think science was boring. Now I see science as discovery, finding out about what's happening around you, cause and effect, relationships, whys, everyday things and complicated things." Every one of the eleven study group interviewees, including the three who had science majors or resource agency careers before entering teaching agreed that they felt more at ease with science and sought opportunities to teach it more often because of their SIRC experience. Three were even using an integrated thematic approach to their classroom curriculum and embedded much of their other subject instruction into their daily science instruction.

The next pair of items probed for the importance of science to the school curriculum: Item 7, *"Science is the most important subject at school;"* Item 14, *"Reading and mathematics are more important than science."*

Table 11

The Importance of Science

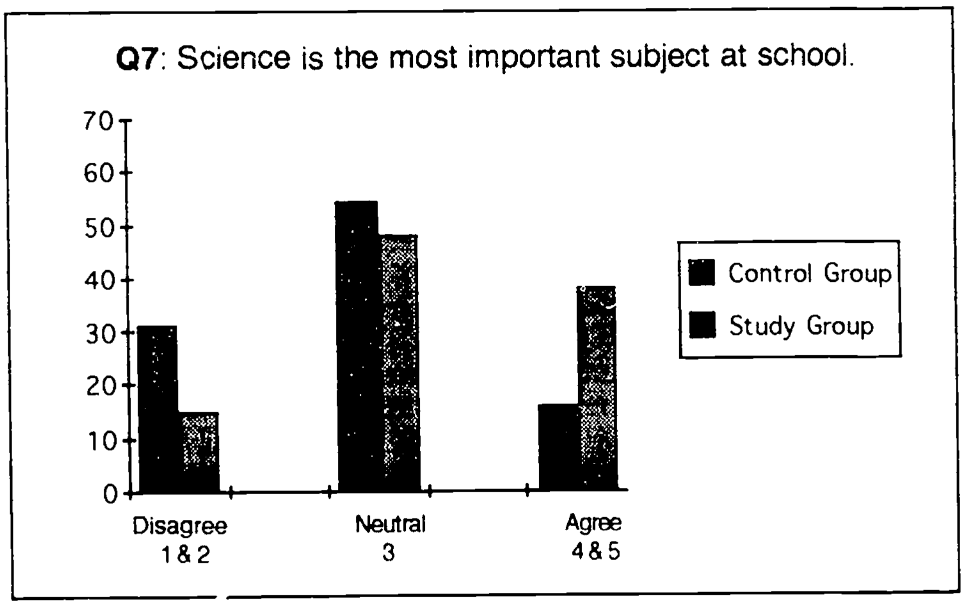


Table 11 displays the findings about the importance of science in the school curriculum in relation to items 7 and 14. Setting aside the neutral portion of each group, the study group viewed science as more important by agreeing or disagreeing by a two to one margin.

When asked to explain the importance of science in the elementary curriculum, one study group respondent stated:

> Science is the most critical. I've tried to look at curriculum from different viewpoints but science is the most crucial. Before SIRC, I used to think reading was the most important. Science offers a team problem solving approach. You use your math and language skills and social science experiences in science. All other subjects can be brought into science. You read to learn; you do not learn to read. Students can do it all through science, everything else is pulled in.

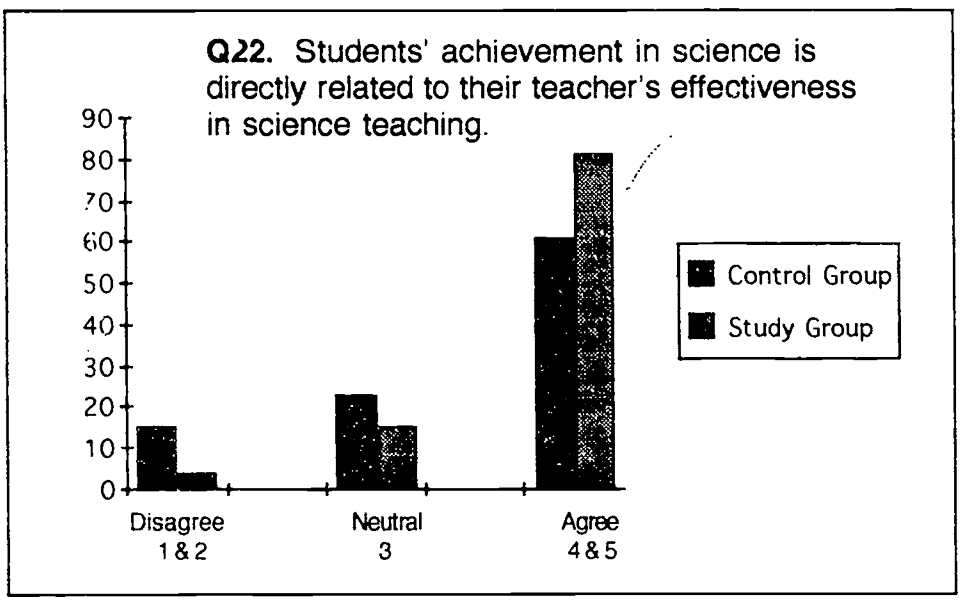
All eleven study group interviewees described science as very important to the elementary school curriculum. Their reasons varied from the curriculum integration just noted to the innate universal interest of students in the operations of the real world, to providing answers for students to everyday questions about how things relate and work, to informed citizenry issues and adult careers.

Completing the seven statements about teachers beliefs about teaching science, three statements about student achievement and teacher effort were responded to: Item 10, *"Increased effort in science teaching produces little change in some students' science achievement;"* Item 22, *"Students' achievement in science is directly related to their teacher's effectiveness in science teaching;"* Item 26, *"When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach."*

A view of Table 12 shows both groups agreeing that student achievement in science is related to teacher

Table 12

Student Achievement-Teacher Effectiveness



effectiveness. Displays of the results of all three teacher effectiveness statements can be found on pages 190, 193, 195, 228, 232, 233 in Appendix F. One interviewed member of the study group stated: "In SIRC I learned a lot of science through direct experience. We did a lot of things. We observed a lot. We went on field trips. This taught me the value of experience. And this made me realize the importance of providing lots of experiences for my students." The study group agreed by a margin of four to three over the control group about the importance of teacher effectiveness and student science achievement.

Summary of Findings about Beliefs

The quantitative side of this study does not show that SIRC participant beliefs about the nature of science have been changed for the long term. Evaluation of questionnaire statements show similar open beliefs about science found among both the study and control groups. However, follow up interviews revealed the study group explaining that their SIRC experience had indeed "opened" up their beliefs about what science is. One study group subject stated it this way: "I used to think science was a bunch of stuff, facts. Now I view it as a process." Another stated: "I used to think that knowing the facts of science was important. Instead of here's the question and here's the answer, now I tell students here is the method of gathering data. You find an acceptable answer. Science is very important because it creates a process that allows higher level thinking to take place and that is important in all of the subjects."

While the data does show that the majority of participants in both groups do hold an open definition of science, based on the efficacy study cited in the literature review above, positive beliefs are not enough to change behavior. This has implications for the finding of the next general heading: teacher confidence.

The beliefs that study group participants hold about the teaching of science and about teacher effectiveness on the results of their teaching were found more positive than those of the control group and can be reported as a long term effect of the project. Even after four years since contact with the SIRC project, study group subjects were able to make these reflective statements:

> Science is most important in the curriculum because it develops process thinking, higher thinking skills.
>
> Science has a bum rap: students are very interested in science. They can identify with it and write out what they observe.
>
> It is so easy to fit all school subjects into science.
>
> Science is most important because it is at the center of life. Science is what students are most interested in; it is what motivates students.

Findings about Confidence

From the onset of this research, a significant and lasting increase in the confidence to teach science was expected to be found in the study group when compared to the control group. After all, Enochs and Riggs found "teacher's preconceptions concerning their qualifications for teaching science were consistent with the amount of time they spent doing it"(1989, p.16). This was the research base upon which the SIRC project was conceived and formed.

Both groups were asked to agree or disagree with eleven statements about teacher confidence. The statements can be clustered into three categories: two of these statements concerned the teacher's ability to answer students' science

Figure 12 Statements About Teacher Confidence

Statements about Answering Student Questions

5. *When teaching science, I usually welcome student questions.*
30. *I will typically be able to answer students' science questions.*

Statements about Competence in Science

8. *I do not know what to do to turn students on to science.*
17. *I will not be very effective in monitoring science experiments.*
33. *Even if I try very hard, I will not teach science as well as I will other subjects.*
35. *When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand better.*
37. *I will continually find better ways to teach science.*

Statements about Personal Science Background

9. *I wish I had received more science instruction in college.*
13. *I understand science concepts well enough to be effective in teaching elementary science.*
24. *I have a strong science background.*
29. *I wonder if I will have the necessary skills to teach science.*

questions, five had to do with competence in science, four had to do with personal science background. All eleven statements are displayed in <u>Figure 12</u>.

Excepting statements numbered 9 and 35 among the eleven which show little difference, a comparison of the Likert response averages between the study and control groups on the remaining nine statements shows significant lasting confidence among the study group. A summary of these items and their average differences by the three categories is displayed in Table 13. Average differences between the groups ranges from 0.2 to 1.2 on these nine items. All averages indicate higher confidence among the study group with four items having an difference of 1.0 or greater.

Several excerpts from the control group journals reveal the thinking of participants about their self confidence at the beginning of their training:

> In elementary and high school, I hated science. Most of these classes were boring / lecture style. I thought science had to be taught that way.

> I'm frustrated! I don't seem to have time to squeeze everything in! Our day is so fast and we have so many interruptions.

> There are so many things to cover in the normal school year, now I also have 21 days of SIRC activities, and I have to move in and out of my

Table 13 Likert Average Comparisons on Confidence

Statements about Answering Student Questions

5.When teaching science I usually welcome student questions.

Control Group		Study Group		Difference
4.6		4.9		(0.3)

30.I will typically be able to answer students' science questions.

Control Group		Study Group		Difference
3.0		3.8		(0.8)

Statements about Competence in Science

8. I do not know what to do to turn students on to science.

Control Group		Study Group		Difference
2.3		1.3		1.0

17. I will not be very effective in monitoring science experiments.

Control Group		Study Group		Difference
2.0		1.6		0.4

33. Even if I try very hard, I will not teach science as well as I will other subjects.

Control Group		Study Group		Difference
1.7		1.5		0.2

35. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand better.

Control Group		Study Group		Difference
2.1		1.7		0.4

Statements about Personal Science Background

13. I understand science concepts well enough to be effective in teaching elementary science.

Control Group		Study Group		Difference
3.1		4.3		(1.2)

24. I have a strong science background.

Control Group		Study Group		Difference
2.1		3.1		(1.0)

29. I wonder if I will have the necessary skills to teach science.

Control Group		Study Group		Difference
3.1		2.0		1.1

room 3 times due to year round school.

I was a science major, but I could not relate my love for science to my students. Instead of planning for science, I let a textbook lead me. So whenever we had a spare 20 minutes, we did science as a reading activity. I did not know any other way to teach it.

I had a class in field biology in college. Most teachers aren't too afraid of life science. But when it comes to earth and physical science, I avoided them. No one feels comfortable teaching about something you know nothing about.

We made it through the activity. We had our hands on, but wow, do I have a bunch of non-listeners! I feel like I have gone through WWII. Many group readers didn't finish reading instructions and dumped their solutions. Many dawdled and didn't finish. Others argued they didn't want to be recorder any more, and some starters became dictators! With all the conflict, I'm not sure how valuable the experience was for the students.

The following study group interview citations reveal a startling contrast:

I feel so fortunate to be a SIRC member and I feel so comfortable teaching science which used to be a subject I feared all of my life.

I have learned that Science is something "I" can teach. My concept of teaching science was that it was a difficult subject to teach, as well as abstract. SIRC has taught me not to be afraid to integrate science into the curriculum. It is real, meaningful, and fun!

Since attending SIRC, my enthusiasm for science has not died. It's great because I have never enjoyed teaching science. Those minutes of the day loomed large and avoidable. But now I have moved it to first thing in the morning so I have time to teach it.

I have a whole new attitude toward science. I am not apprehensive about teaching science like I was using just a textbook. I teach science much more now. Around my school, I'm becoming known as the "science lady."

After 12 years of being a presenter at several national and international symposiums and 10 years of teaching experience, I was finally able to stop relying on a text book and start having "science fun."

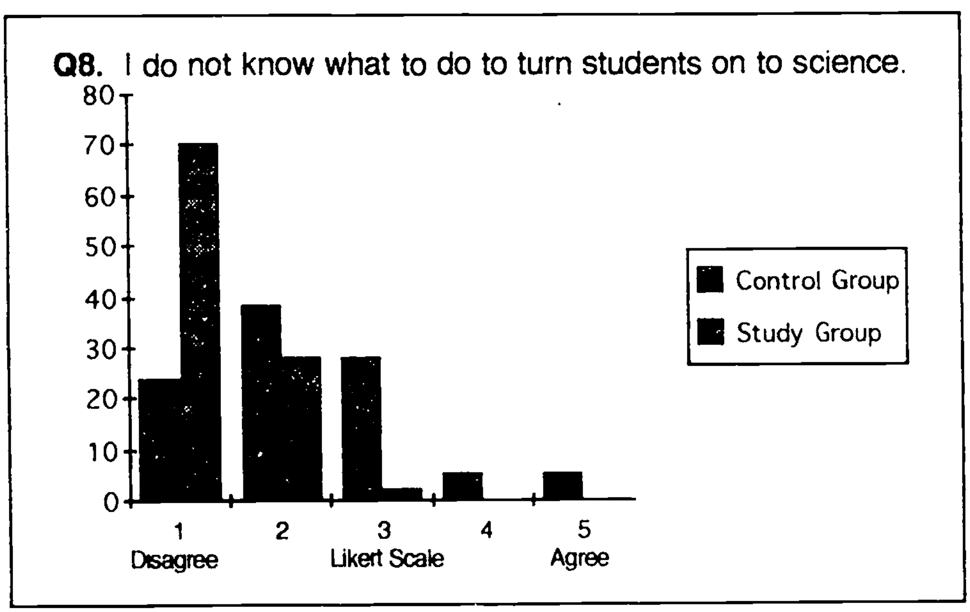
Data gathered both qualitatively and quantitatively in this study indicate a long term effect in teacher confidence among the study group. The following pages will detail the four items among the eleven with the highest difference between the two subject groups, those where the Likert response averages are a whole item (1.0) or higher. A entire point difference on the five point scale used in this study was deemed high significance by the researcher, being 20% or one fifth of the entire point range.

Confidence to Motivate

First, a significant part of being confident in the teaching of science is being able to motivate students about

Table 14

Motivation of Students



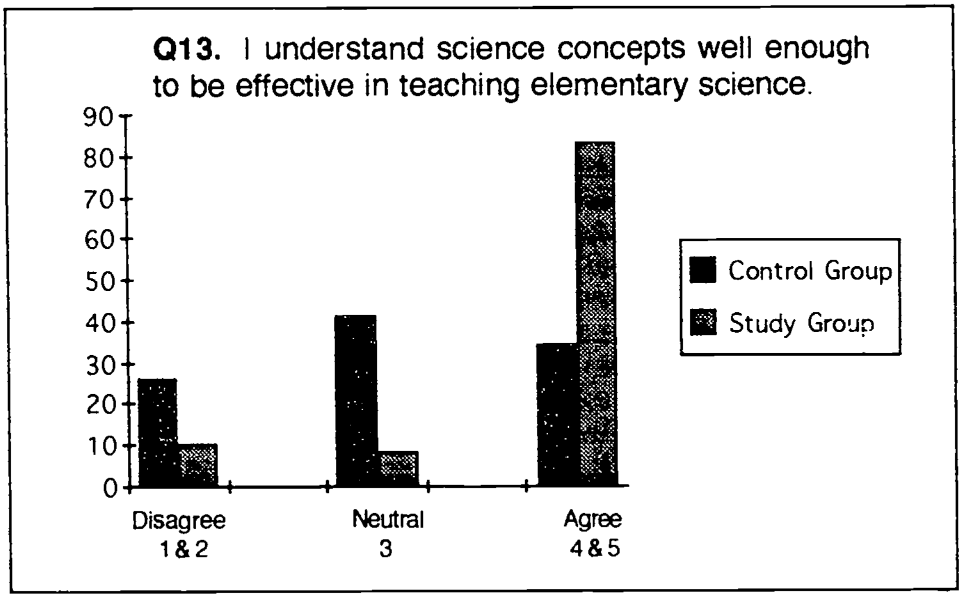
the subject. As one study member said: "The students enjoy the lessons and I enjoy leading them. I enjoyed learning along with the students. Hands-on learning with such frequency is both fun and rewarding. Students ask when we're going to do it again, even though two to three lessons a week have been devoted." Table 14 shows the study group's almost double disagreement with statement 8: *"I do not know what to do to turn students on to science"*. One long term effect of the SIRC project is the continued sense of confidence in the ability to motivate student interest in science. The difference is glaringly positive.

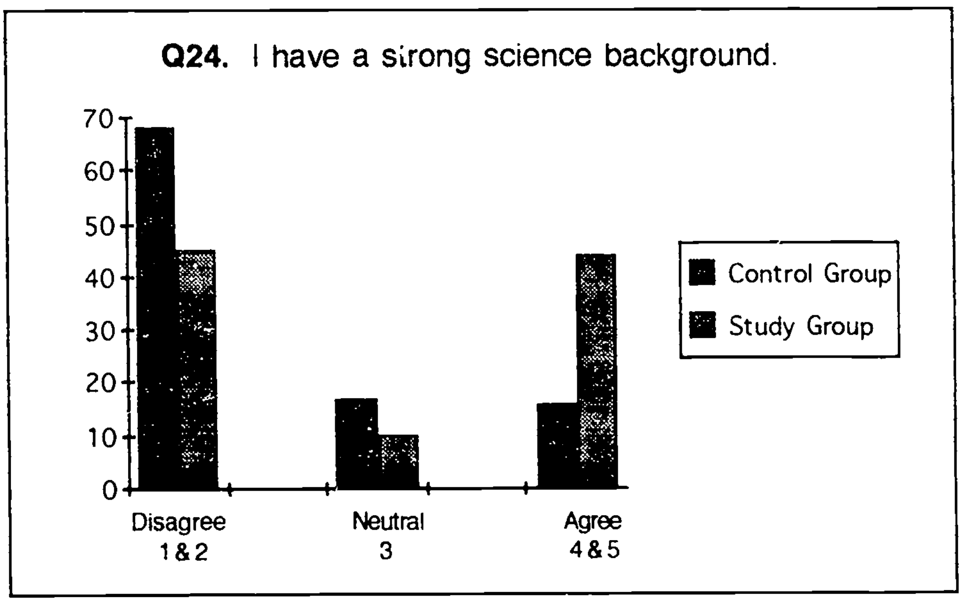
Confidence to Teach

Secondly, a teacher does not have confidence unless there is some factual reason for it. In science staff development this is generally considered to be a matter of providing teachers with content training in science. With more knowledge, there can be more self confidence. Looking at the three statements, 13, 24, 29, an extremely high attitude of science understanding is found among the study group. Their results are shown by the summary of two positive statements in Table 15 and one negative statement in Table 16. The SIRC project was not intended when it was designed to be a science content project. Its main purpose was to raise teacher confidence by modeling experience based learning. Participants were provided with training in curriculum developed by the Lawrence Hall of Science and interacted with materials in the role of student in these

Table 15

Agreement about Strong Background

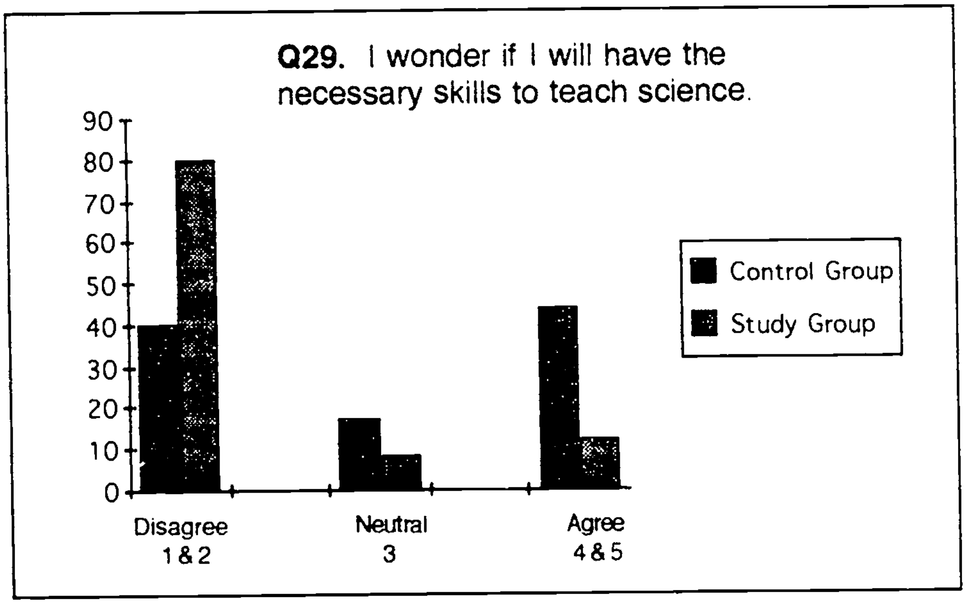




trainings. Apparently this modeling of experiential learning during these curriculum trainings, along with confidence growth in learning new teaching methods, contributed to a lot of science knowledge among study group subjects. With SIRC's heavy emphasis on training teachers to improve their science and teaching process skills, it also improved their science content knowledge. As one interviewed study group member stated: "I realize that the more I learn the less I know, and SIRC has kindled a greater curiosity in me that I haven't felt for all my adult life."

Table 16

Disagreement about Weak Background



Summary about Teacher Confidence

These findings about lasting high confidence levels among the study group are the most significant long term effect found in this research project. Nine of the eleven items show lasting effect in high confidence about teaching, with four of the nine having very significant numerical differences. The qualitative follow up interview gathered highly positive statements about confidence in teaching science from all study subjects. These findings demonstrate that the SIRC project met its primary goal in science staff development: making elementary teachers confident in teaching science. Tables and graphs for the eleven items on teacher confidence can be found in Appendix F on pages 196-206, 226-230, 233-235.

However, high confidence does not necessarily mean that behavior is changed. Returning to Bandura's work on self efficacy in the literature review, high confidence results in a high self efficacy factor, i.e. teachers have high assurance or high frustration (review Figure 1). The will to act on this confidence or high outcome expectancy is also required. The next section of findings will show that the study group did change their teaching behaviors in using developmental theory and hands-on methods, in the amount of time devoted to teaching science and the move to student centered instruction. Therefore, high outcome expectancy was found as well as high self efficacy.

One study subject gave an eloquent analogy that describes this change found in teacher confidence. "Being in SIRC was like learning to swim. At first you are terrified of the water. Little by little you get used to it until you learn how to swim. Once you learn how to swim, you can do it no matter how deep the water is. Because I learned to swim in science, I can approach any science topic and teach it."

Findings about Teaching Practices

There were three major expectations about changed teaching practices in the study group. First, the study group was expected to have a greater understanding of developmental learning theory. Second, study group subjects were expected to be teaching more hours of science. Finally, the study group was expected to be using less direct instruction and, instead, using more hands-on teaching and more collaborative student groupings.

Both the study and control groups were asked to agree or disagree with seven Likert statements regarding developmental learning theory as shown in Figure 13. Subjects were also asked to record how many minutes of their weekly teaching was devoted to science, Figure 14. Finally, there were four Likert statements presented about hands-on learning, one multiple response item about use of different types of pedagogy and one multiple response item about use of various student groupings.

Figure 13 Statements about Developmental Theory

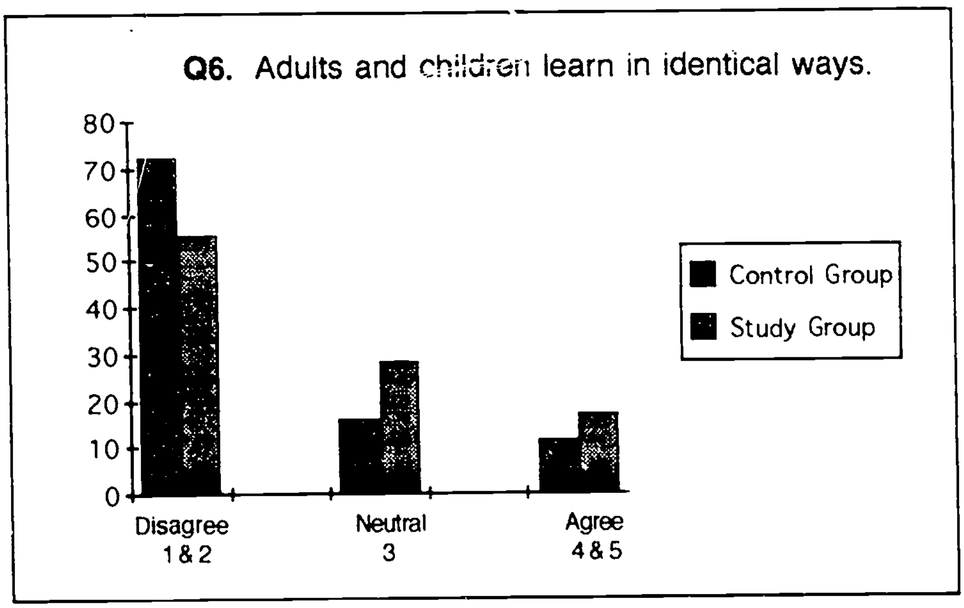
6. Adults and children learn in identical ways.
12. Students can learn any concept at any grade if they have an effective teacher.
15. Planetary motion can be taught successfully to third and fourth graders.
21. Children as a group think in different ways than adults do.
27. Most second graders (7-8 year olds) are able to understand molecules.
34. Effective teaching matches the cognitive abilities of student to the content of the curriculum.
36. The structure of the cell and the atom are best taught in middle and high school.

Developmental Theory

Only minimal differences were found between the study and the control groups. In fact, the control group seemed to have a slightly higher understanding of the theory as indicated by greater disagreement as shown in Table 17. However, when it came to applying the theory's implications to age groupings of students, response from both groups was equally poor as displayed in Table 18. Response from two of the seven statements on developmental theory have been displayed in the text by Tables 17 & 18. Detailed comparative responses and graphs on all seven developmental Likert items can be found on pages 213-219 in Appendix F.

Table 17

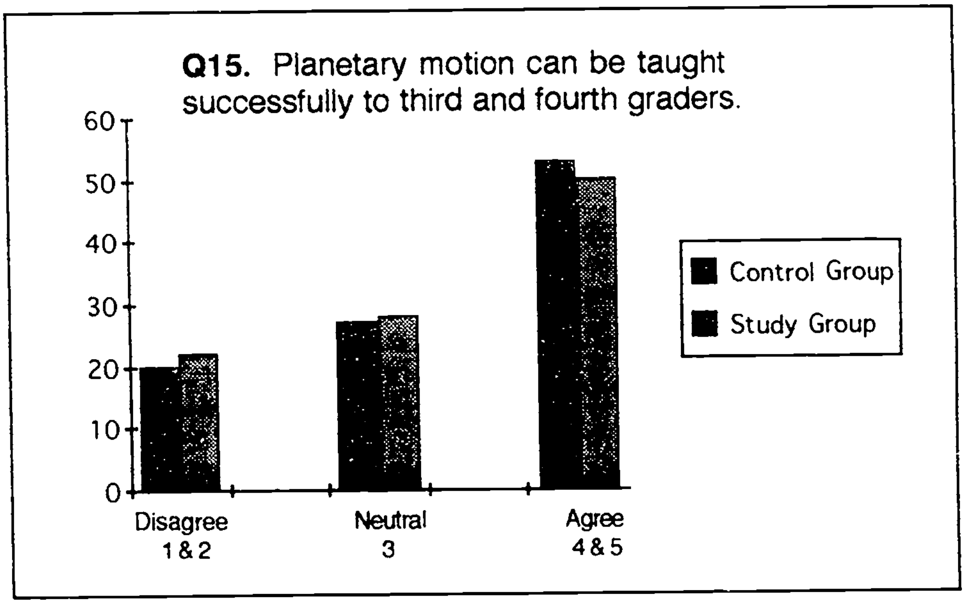
Knowledge of Developmental Theory



In comparing responses about developmental theory to all seven questionnaire statements, response to statements 6 and 21 are very similar from both groups. The control group has obviously been exposed to the theory elsewhere, and even

Table 18:

Application of Developmental Theory



understands it better than the study group as indicated by its response to statements 6 and 21. On statements 12 and 34, the study group's response indicates better understanding. Regarding the application of the theory to different ages of students in questionnaire statements 15 and 27, both groups responded contrary to the theory. Only on statement 36 did the study group show proper application of theory to the age group in question.

How can this discrepancy of better developmental theory understanding by the control group be explained? Regional ripple effects from California science reform are most likely at work. An entire chapter in the 1991 Science Framework was devoted to this theory.

The SIRC project may have failed to help participants make the connection between developmental theory and classroom teaching practice. Study group subjects were trained with curriculum materials developed by the Lawrence Hall of Science. Teachers did not have to use their knowledge of developmental theory to adjust materials up or down for their grade and stage of student. Proper thinking stages were already embedded in the grade level units authored by Lawrence Hall.

Interviews with the follow up portion of the study group received comments about use of developmental theory:

> The developmental levels of children and the science process skills that go with each have made an impact on me. I've realized that in the past I was placing more emphasis on content and not enough on process. I'm emphasizing the appropriate science process thinking skills much more. I'd heard it before--I guess I need to hear it again.

This study subject may have fallen prey to reverting back to teaching as she was taught, what she did herself, as a young learner, instead of applying sound theory.

Time for Science

The amount of time devoted to teaching science and the number of outdoor study labs conducted was investigated. The questions asked are reported in Figure 14.

Outdoor labs and field studies were reported similarly by both groups, about 10 per year. School budgets being tight and campuses very crowded, a systems constraint was found that limited both groups to about one activity on the playground or one off campus field trip per month. While the study group expressed interest in more, site constraints held them at the same level as the control group. The control group's response was actually a surprise as much less outdoor work was expected.

Figure 14. Time Devoted to Science

38. How many minutes are devoted to teaching science in your program, per week?.

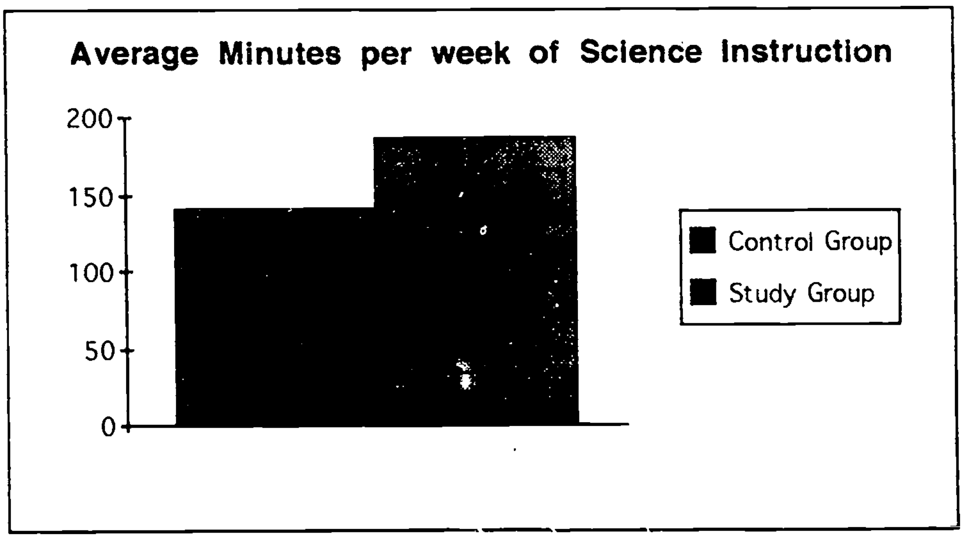
41. How often do students in your science program do science outdoors and field studies?

Subjects in both groups were asked to report how many minutes they devoted to science each week. The results are reported in Table 19. This finding revealed another positive long term effect of the SIRC project. Two to four years after contact with the project, study group member were teaching 45 minutes more per week than the control :roup. While the control group reported teaching science slightly more than two hours per week, i.e. two days of 70 minutes or three days of 45 minutes each day, the study group added one more science period per week: three days of 60 minutes or four days of 45 minutes. Not only is this long term effect amazing, but the whole regional effect as reported in the methodology chapter has increased that weekly average up 55 minutes from 85 to 140. Discounting the regional effect and comparing to the initial data gathered by the project in 1988, the study group is devoting more than twice as much time to science than its peers did six years ago.

Table 19

Minutes of Science Instruction per week

Control Group		Study Group		Difference
141		186		(45)



Interviewed subjects from the study group spoke about time invested in science:

The students enjoy the lessons and I enjoy leading them. I enjoyed learning along with the students. Hands on learning with such frequency is both fun and rewarding. Students ask when we're going to do it again, even though 2-3 lessons a week have been devoted.

I am teaching science every day--almost--at least three times per week. I find it is getting easier and I find it relates to other subjects and content areas.

Since SIRC my enthusiasm for science has not died. Those minutes of the day used to loom large and avoidable. But I have moved science to first thing in the morning so I have time to teach it.

Use of Hands-on and Student Groupings

Participants in both groups were given four Likert statements for agreement or disagreement about hands-on science teaching, statements 4, 20, 28, 32. They were also asked in questions 39 and 42 for multiple responses about the types of teaching methods and the kinds of student groupings they used in their classrooms . Detailed results of the four statements and two questions can be found on pages 207-210, 212 and 220 in Appendix F. Both groups showed universal choice of the hands-on style as reported in Table 20.

Figure 15 Statements re: Pedagogy and Student Management

4. Students prefer to learn science from textbooks.

20. Children will learn more science by doing hands-on activities.

28. Students prefer to learn science by manipulating materials.

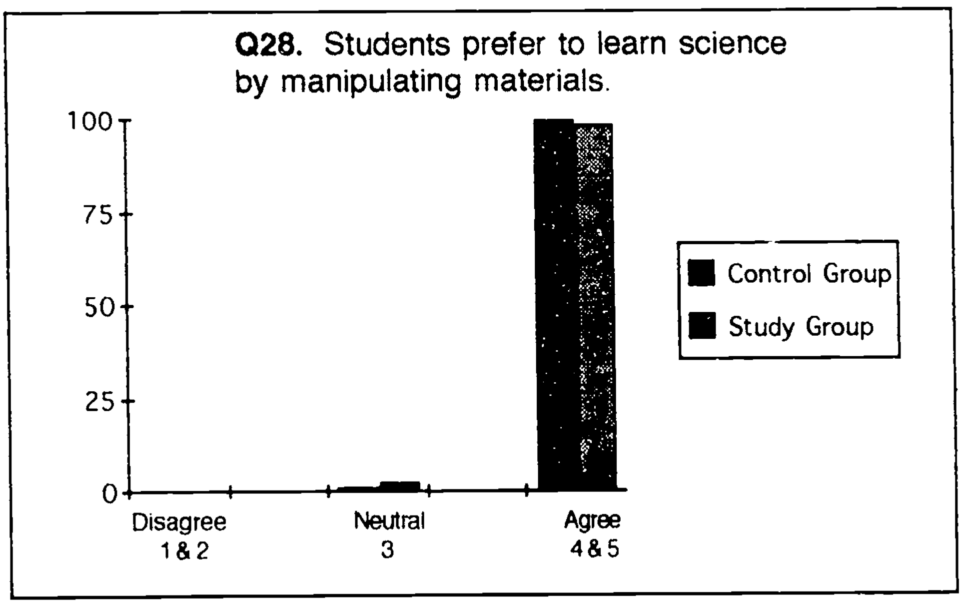
32. Children learn more science if taught from a good textbook.

39. What methods of teaching are used in your science program: "hands-on","teacher demonstration","direct instruction?"

42. What method of student management is predominant in your science program?

Table 20

Attitudes about Hands-on Teaching

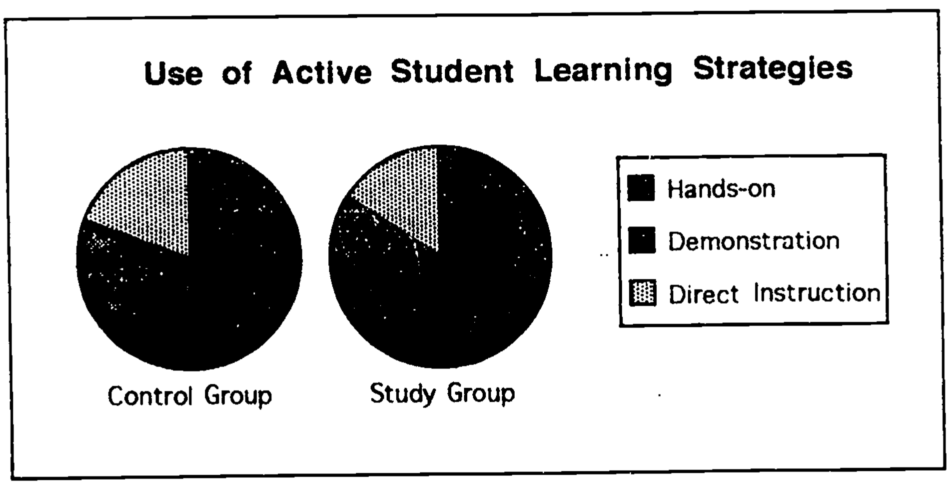


Regarding the desire to use hands-on teaching methods, again regional influences can be detected. Direct instruction and teaching science as a language arts activity from a textbook was the dominant method seven years ago when the project was started.

However, while both groups showed similar attitude about the use of hands-on teaching methods, when actual percentage of use of this strategy are compared, the study group used it more. Table 21 shows the combined use of hands-on learning by students, teacher demonstration to students and direct instruction by the teacher. The study group actually used hands-on methods 20% more often than the control group. The study group also used teacher demonstration 20% less and direct instruction more than 30% less often than the control group. Control group teachers would be twice as likely to show or tell their students about something. Study group

Table 21

Teaching Methods Used



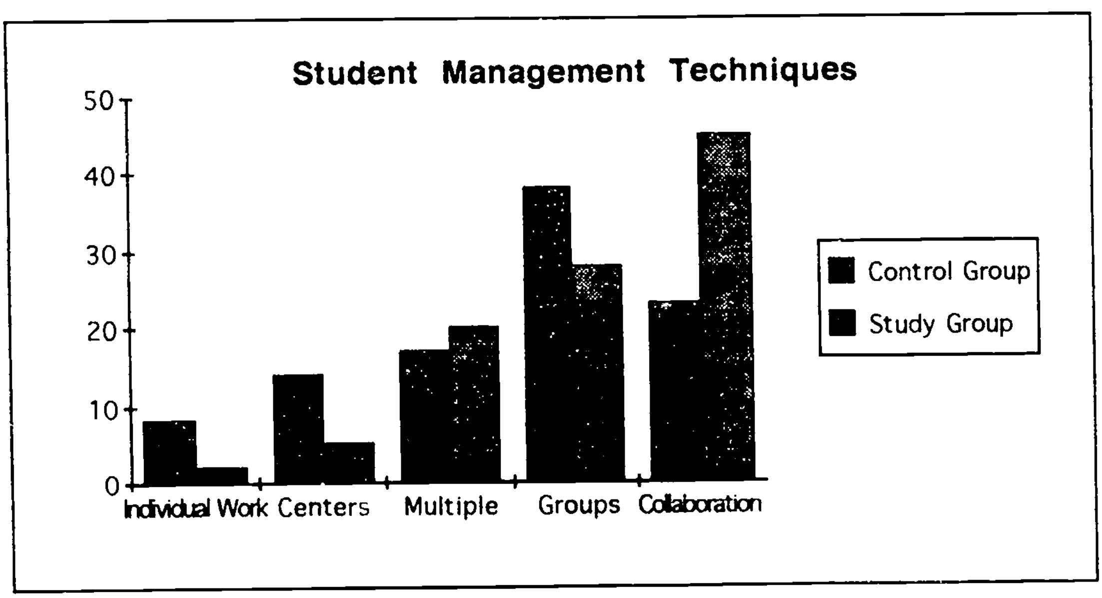
teachers would be twice as likely to let their students discover it for themselves.

Student Management

Subjects in both the control and study groups selected student groupings as their dominant student management method. The study group used formal collaborative groupings twice as often as the control group and as half of all their choices. The control group used informal, undefined student groupings as its dominant choice and only as a third of all choices. A comparison of the five most popular student management choices are displayed in Table 22 while complete response and data of the management choices can be found on page 220 of Appendix F.

Table 22

Student Management Techniques



This finding shows the sophistication of the study group over the control group. Realizing that definitive roles within the groups give more focus and direction to student work, the study group routinely chose it as its dominant teaching strategy in science and other subject areas as well.

In follow up interviews with study group subjects, these thoughts about collaborative groups were shared:

> SIRC helped me grow in my teaching methodology. What SIRC gave me was a model to use for student work groups, where each student had a specific role in the group. This greatly improved my limited success with cooperative groups. This has become my major teaching strategy. Even when I use direct instruction now, my students are in groups and are given opportunities to re-discuss or investigate solutions within their groups during my direct instruction. This strategy has been so successful that I use it with my other subject area, mathematics.

> Oh...and the collaborative groups! So much better than "cooperative." Maybe its just in the name, but what a difference!

> I find collaborative learning groups using hands-on science a very rewarding method of teaching. At first it took me a while to get used to the extra

noise, but then I realized that the noise was the joy of discovery." It was then when I realized that I was part of a new way of teaching.

The collaborative group process gives students who are normally quiet self confidence when it is their turn to be their group's "reporter." The same esteem building is seen with the recorders writing their groups' results on the board. Students must listen to their groupmates, and they learn to depend on each other rather than on the teacher.

Summary about Teaching Practices

In Chapter II a case study by Martens was reviewed (refer page 44). The female elementary teacher in this case study was trying to change her science teaching practices. Jane was not able to overcome three internal factors and change her behaviors. The first was a closed belief system about science with right answers; the second, dependence on the use of direct instruction; and the third, rigid student management. If Jane were in this study group, she would have changed her closed beliefs about science. Jane would also have learned to use other teaching strategies and to let go of tight student control. If Martens had done a case study on Jane as a member of the SIRC study group, she would have found all three of these internal factors overcome.

It is disappointing that study group members were found not applying developmental learning theory very successfully.

It is significant that both the study and control groups have been exposed to and have good knowledge of the theory. Perhaps, it is too much to expect a thorough enough understanding in twenty-one days of training for teachers to be using developmental theory in the design of their own curriculum. Since study group members are aware of and heavy users of the commercially developed materials of the Lawrence Hall of Science that have developmental theory embedded, use of student appropriate materials is occurring in the classrooms of the study group. Still, further work with participants on application of the theory to classroom practice needs to be pursued by the project.

The amount of time that study group subjects continue to devote to science is a very significant long term effect. When time is coupled with the other highly significant finding of lasting confidence in science teaching, a picture of actual behavioral change among teachers is revealed. This picture is reflected by the dominance of hands-on over teacher controlled teaching strategies as vocalized by three study group interviewees:

> Through SIRC training and experiences I've come to expect more from science than reading about things in a textbook, taking notes and testing. I'm very dissatisfied if I can't find a way to have my students experimenting and experiencing science rather than just reading about it.

> Its a new love for science that the children have

and their feelings of success that has led me to focus on other subject areas and let them experience hands-on there too.

If science is really questioning and leaves more unanswered than answered, then lets make sure kids know this and give them the freedom to experiment, try different ways of solving problems and come up with more than one "right" answer.

Findings about Professional Issues

The final report of findings responds to the last two of the seven study questions. Did teachers grow as professionals because of their involvement in the project? and acquire leadership skills? Did the team structure and administrator involvement improve collegiality and what are collegial relations like at the school site now? These issues were first examined by the questionnaire and then, with the study group, by interview.

Leadership

Concerning leadership, subjects were asked six yes/no questions to build a profile of active leadership behaviors. Similar questions to determine leadership levels had been used in the evaluation of other science staff development projects discussed in the literature review. These six behaviors or attributes are displayed in Figure 16.

Study group subjects had an average of two out of six behaviors while control group subjects averaged only half of one behavior as reported in Table 23.

<u>Figure 16</u> Leadership Behaviors

44. *I keep a journal of my classroom practices and other professional activities.*

45. *I belong to the California Science Teachers Association.*

46. *I belong to the National Science Teachers Association.*

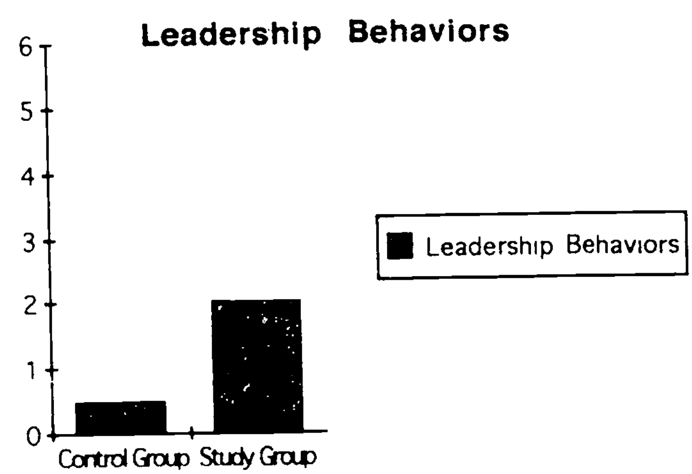
47. *I belong to another science related Association.*

48. *I have been a science mentor for my school & district.*

49. *I have made science inservice presentations to other teachers.*

Table 23

<u>Leadership Behaviors</u>



The principals of the eleven interview members of the study group were asked to address the site leadership activities of these members. Principals reported high leadership activity about six of these individuals. Activities noted included mentor projects on site and in the home district, local inservice to colleagues, participation in county science curriculum committees, staff developer roles in other regional science curriculum projects, and general and continuous lobbying for more and better science instruction.

One principal commented about two of his three past SIRC participants:

> L... has taken a strong leadership role. Her SIRC training combined with a mentorship in science gave her the resources to work with colleagues in their classrooms, help us with materials adoption, and generally "mother hen" science throughout the middle grades at our school.

> T... has revised our seventh & eighth grade science curriculum. He has been a staffwide advocate for science and has aided in all classrooms with science. He also continues to serve on the county science committee.

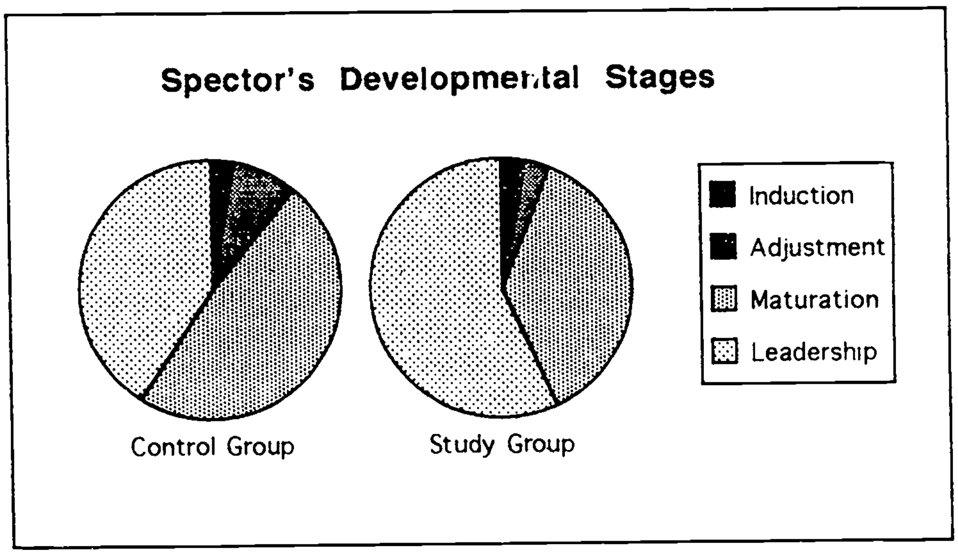
Another principal showed the researcher the professional growth logs of his entire teaching staff. Each teacher had listed all the professional growth activities that had been completed during the previous school year. This principal had a highly active staff with most teachers showing an entire page of staff development activities, except for two. These two ladies were the former SIRC participants. They both had over two full pages each and most of their activity was more science staff development.

Teacher Growth

In evaluation of the professional growth of teachers, Barbara Spector's developmental scale was used with the elimination of stage 4, mid-career crisis. Table 24 displays these findings. Complete analysis of the item responses can

Table 24

Professional Growth Levels of Subjects



be found on page 223 of Appendix F and the actual hypothetical teacher descriptions to which respondents were asked to match themselves to can be found on page 165 of Appendix B.

Half of the control group rated themselves as being in stage 3, maturation, while one third rated themselves as being in stage 5, leadership. On the other hand, nearly two thirds of the study group placed themselves in stage 5, leadership. This finding is supported by a correlating number of the interview study subjects who were identified by their site principals as leaders. If approximately one third of the teaching force is naturally comprised of leaders, then the project has been effective at nearly doubling this number.

> If any one would have told me a few years ago that I would be: 1) comfortable teaching science, especially physical science, 2) presenting to other teachers at meetings, 3) teaching colleagues at a workshop, I would have thought they were crazy....It's so nice to be doing something that makes me feel so good about my teaching ability and potential.

Administrative Support

Findings about the importance of the role of the site administrator were inconclusive. Both the control group and the study group valued the presence of the site administrator and verified its importance during their project involvement.

In trying to determine if continued involvement of the administrator was necessary for study subjects to continue or maintain their growth, the over 50% turn over in site administration made this impossible to investigate.

All interviewed study subjects spoke of the need for this support during the project to allow changes to be made. They also reported the need for the current administrator's support to keep a high quality hands-on program going. All felt that the minimal meeting attendance of their site administrator during the project was necessary for his/her visualization of the program and of teaching changes needed and required. All were also universal about the necessity of their current administrator's support in time and materials. Analysis of questionnaire response on administrative support can be found on page 225 of Appendix F.

One study group principal commented on what he had learned through his involvement in the project:

> SIRC definitely introduced me to the current level of science teaching at the elementary schools. It has given me great insight into the demands placed on elementary schools and has guided me in assisting our elementary school teachers. SIRC has been invaluable in propelling our district into science reform that is reachable.

Collaboration

Professional collaboration was investigated by one item on the questionnaire and through interviewing. Both groups were asked to complete the statement. "There is a group of teachers at my site that I collaborate with..." There were five possible completions and respondents were allowed to check all those that applied as shown in Figure 17.

In graphing the findings of this response, responses "b" and "c" were lumped together as being forms of sharing;

Figure 17 Choice of Collaboration

a)...we socialize outside of school and support each other at school

b)...we share science ideas and materials regularly

c)...we plan science lessons together regularly

d)...we trade students, teach each other's students regularly

e)...we observe each other teaching regularly.

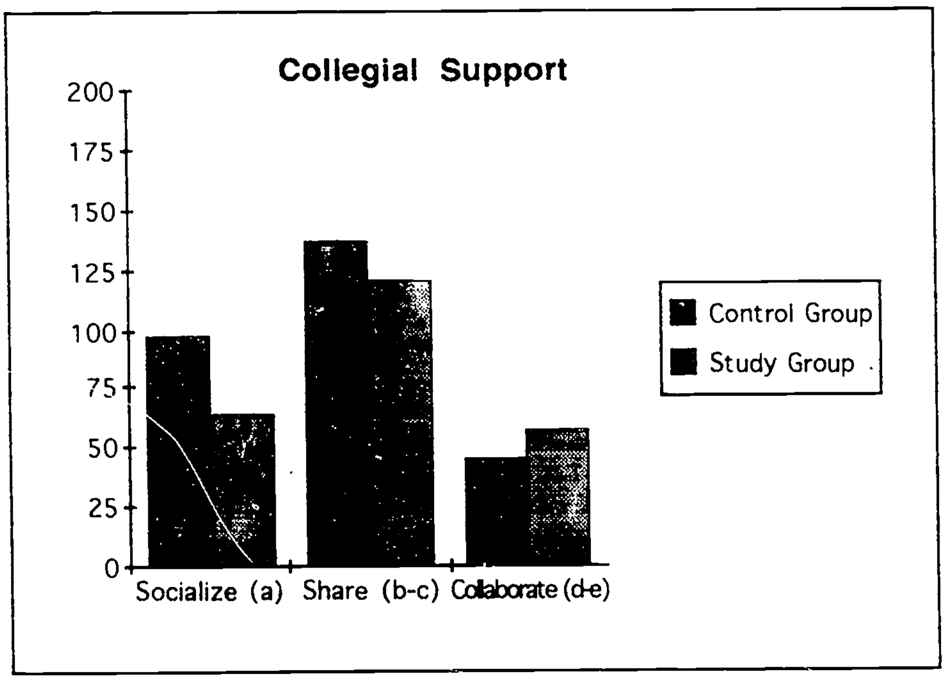
responses "d" and "e" were lumped together as indicative of collaboration. The three ratings of interactions between colleagues at the site became: socializing, sharing, collaborating as displayed on Table 25.

Table 25 shows socializing and sharing as the dominant collegial interaction among the control group. A higher level of collaboration is shown among the study group. This finding is significant in light of Wave III of the reform movement. Members of the control group are centered around human pleasantries and sharing outside of the setting of the classroom. Members of the study group have moved from the teacher centeredness of the Wave II era and into interactions over and around students and learning.

Site team participation in the SIRC project was one of its operating principles. A built-in support network was necessary for teachers to return to their sites after trainings and struggle through implementing change. The project also wished to model the collaborative nature of the scientific enterprise, another rationale for team work.

Table 25

Teacher Collaboration



One study group interviewee expressed her feeling about the value of the team approach:

> Being in a team was good modeling for student group work. I saw the importance and value and support

from working with others.

Besides being part of a collegial site team, participants soon came to view the entire project membership as part of their personal support network in a risking trusting learning community:

> Not only do I get food for thought and exposure to teachable ideas, I get to reconnect with my fellow teachers who are becoming friends as we support one another as we try out new teaching practices this year. This, I believe, is one of the greatest bonuses of being a part of this project.

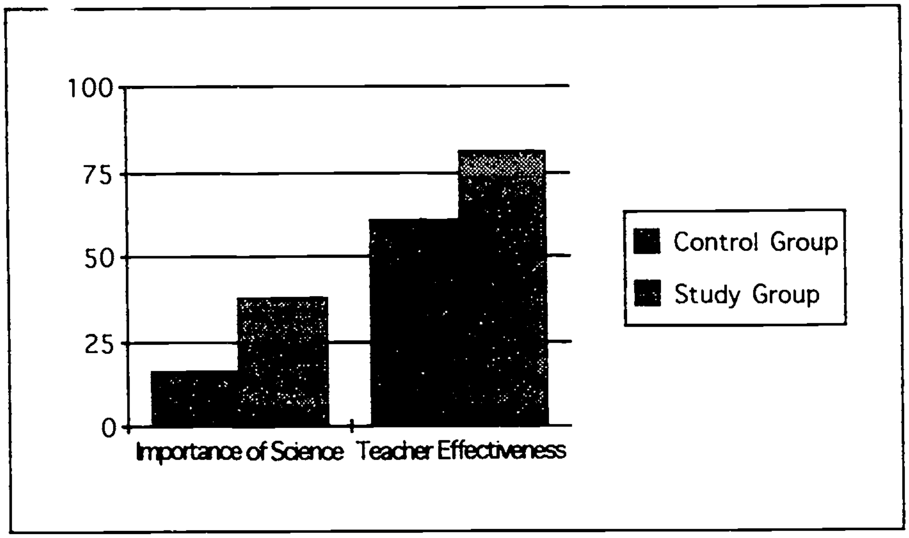
Summary of Findings

This study was conducted to determine the long term effects of the SIRC project upon its participants, two to four years after contact with the project. It at[illegible]pted to pursue answers for seven study question listed at the beginning of this chapter. These questions can be grouped into four areas as the primary elements of this study: teacher beliefs about science, teacher confidence in science, teaching pedagogy, and professional growth.

Significant long term effects were found in each area of the study: belief, confidence, pedagogy, and growth. Alumni of the SIRC project from years 1989-90, 1990-91, and 1991-92 as subjects in the study group believed that science was most important in the elementary school curriculum twice as often as the control group. They also believed 20% more often

Table 26

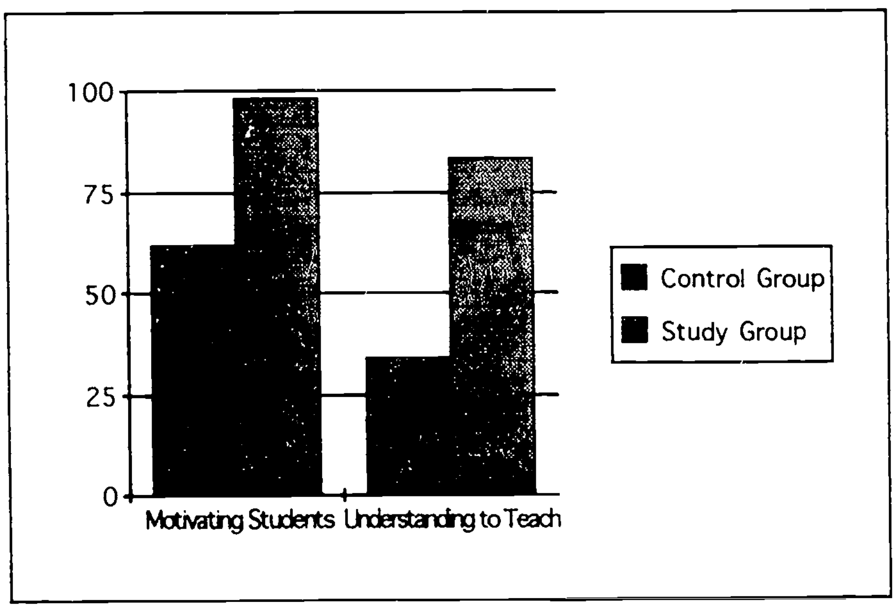
Belief Findings



that students could succeed in science if they had an effective science teacher.

Table 27

Confidence Findings

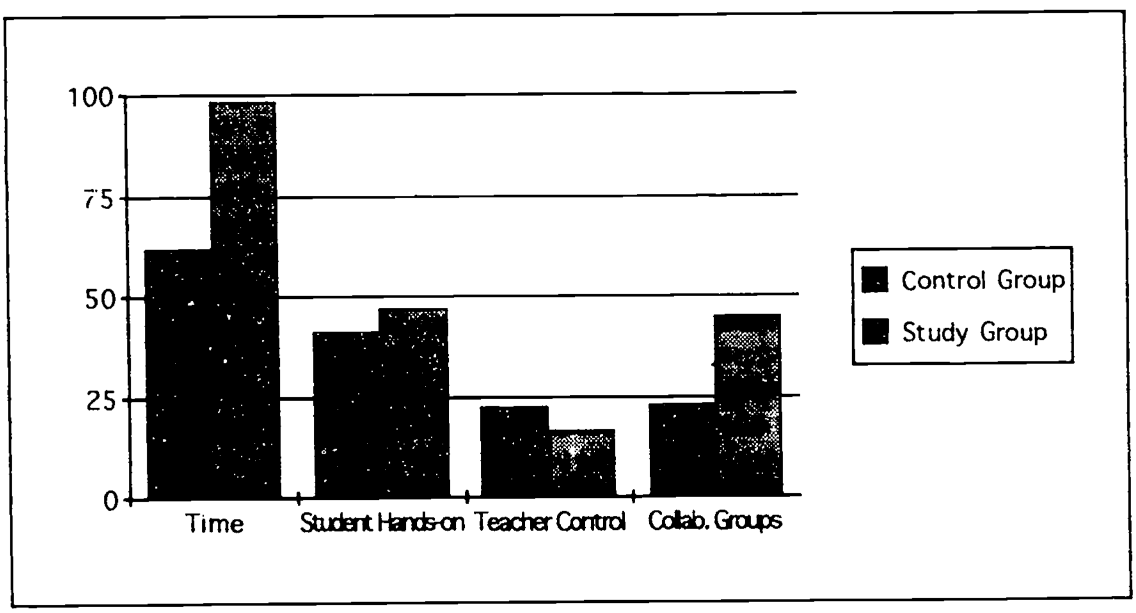


Members of the study group showed one third more confidence in motivating students in science over their colleagues in the control group. The study group was also more than twice as confident about their background in science.

Teachers in the study group were found to be teaching an additional period of science per week for a total of 185 minutes per week, 45 minutes more per week than the control group. They also used hands on strategies 20% more often and teacher controlled pedagogy 20% less often. Study group

Table 28

<u>Pedagogy Findings</u>



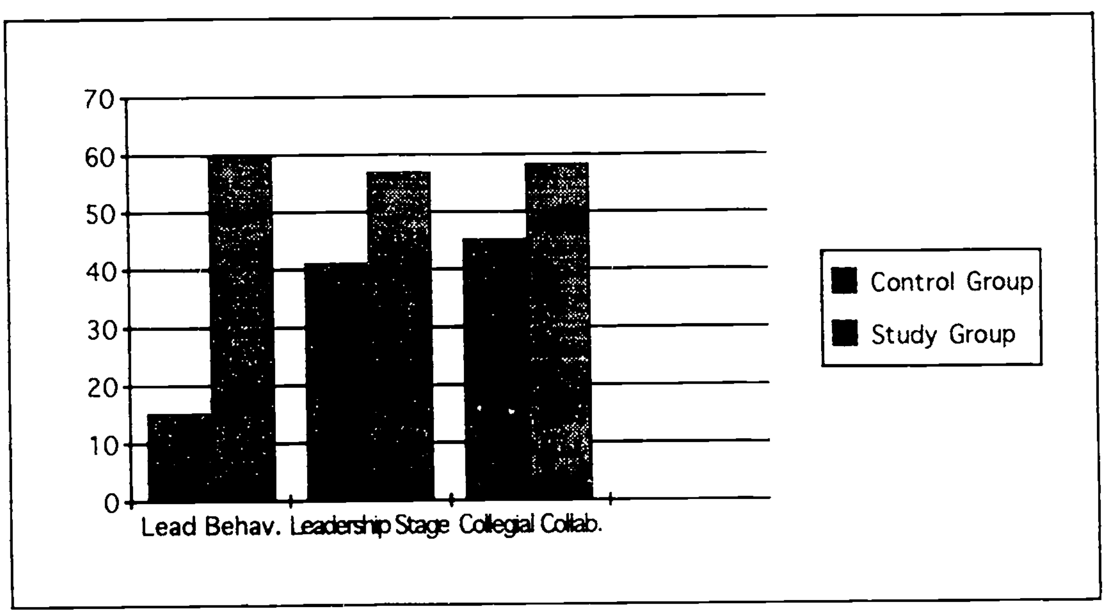
teachers expected more of their students in group work and were twice as likely to use formal collaborative groupings with defined roles than the informal groupings of the control group.

Leadership behaviors were four times more likely among members of the study group. Nearly a third more identified themselves as leaders on a four stage professional developmental scale. Site principals identified half of their SIRC participants as current site leaders reinforcing this leadership level. Study subjects spent less time socializing and sharing and 25% more time collaborating over instruction and students than the control group.

These long term findings about belief, confidence, pedagogy, and growth are displayed graphically on Tables 26, 27, 28, 29.

Table 29

<u>Professional Growth Findings</u>



These eight participants and study group members speak very eloquently of their SIRC project experience:

> SIRC is one of the most worthwhile inservices I have involved in in my 30 years as a classroom teacher and 15 years as a site administrator. It "actually changes" thinking and teaching behaviors and, therefore, student thinking, behaviors, and learning.
>
> It has been four plus years since I was involved with SIRC, but the effects have been long-lasting. I am a more confident teacher as a result of this training and hopefully a more effective one!
>
> SIRC was the beginning of my plunge into hands-on science instruction. I thoroughly enjoyed that two-year experience and have seen a big change in my own knowledge and teaching science since.
>
> I know without a doubt that my involvement in SIRC (having a very weak science background) has dramatically altered my teaching.
>
> SIRC was a wonderful experience! I do not have a strong science background, but after SIRC, I am able to choose any science topic and teach it! The networking, methods and resources have been

invaluable to me.

My SIRC training is the most valuable in-service I have received. It definitely improved and changed my approach to teaching science.

I don't feel I need to know answers to provide my students science instruction. I feel my job is to provide opportunities for them to observe, compare, collaborate, experiment, research and form their own opinions.

SIRC was a real experience for me since my science background was not strong. Every new unit I taught I learned more. SIRC was wonderful!

Discussion

What caused this SIRC project to be successful with these resulting long term effects? During the literature review in Chapter II a new, Wave III, learning centered model of teacher staff development by Thomas Guskey and Dennis Sparks was summarized. Guskey and Sparks propose three essential elements or factors for successful staff development that will improve student learning. These factors are quality, content and context.

Briefly, quality is comprised of instrumentality, congruence and cost. Teacher participants must understand the instrument or goal of the staff development. They must find that the changes posed fit with the practices they use every day in their classrooms. Participants must be able to accept the cost of effort and time to make the proposed changes. The content of staff development needs to be research based and have a track record of successful implementation. Finally, the context of the culture and climate of the school organization must be realized and confronted in order to institute change.

The SIRC project was successful in creating long term effects in past participants because it used quality, content, and context effectively.

The major goal of the project was to improve the almost universal poor attitude of elementary teachers about science. This vision (instrumentality) was communicated to each participant and modeled meeting after meeting. Participants took on the role of learner and by doing hands-on activities themselves were able to build a strong base of confidence. As hands-on science became possible, direct instruction was no longer needed. "I really benefited from the doing."

The project had several support mechanisms that helped in this area of quality. First the project was thirteen months in length. A residential summer institute of intense learning for six days was followed by eight school year meetings four to six weeks apart, a two day field study, and a final five day residential institute in the thirteenth month. This intensity followed by regular follow up meetings allowed for incremental learning. Use of reflective journals made participants think about the implications of using the training in their own classrooms. Monthly journal submissions allowed project staff to be aware of the issues of congruence and cost on the minds of participants. Time was allowed for group discussion and problem solving of classroom implementation problems. The site team configuration created a ready made support system that went back to school with participants and was there until the next training.

Other project practices contributed to the quality and assisted participants with the instrumentality, congruence and cost of the changes they were being asked to make. The project director routinely visited the school sites and assisted participants in their classrooms. The summer institutes offered full day childcare during these two residential weeks making it possible for many female teachers to attend who otherwise would not have. The printed teacher guides for each instructional unit from the Lawrence Hall of Science were provided to participants. No trying to find where to get it in order to do it. Decent lunches served with a full 45 minutes to relax in networking discussion also helped.

Research regarding brain compatible learning, constructivism, questioning strategies and the developmental stages of student learning were all presented to staff participants by Dr. Lawrence Lowery of the Lawrence Hall of Science. Not only has this research been widely accepted but it has been validated by the work of others during the last decade and a half. This research was already embedded in the instructional materials that were used with participants. And the instructional materials like Lawrence Hall of Science's SAVI-SELPH and OBIS programs had all undergone local and national field testing by teachers. New materials under development were also presented to SIRC participants and they were allowed to serve as a national trials center. Participants enjoyed the invitation to try new materials, to see if materials and activity sequences fit appropriately with the learning levels of their students, and to provide feedback to curriculum developers at Lawrence Hall. In these ways, participants received good content instruction.

The best way to teach collaborative groupings as the most effective method of hands-on learning was modeling. In each curriculum training, participants became "getters," "readers," "recorders" and "starters." They learned the effectiveness of hands-on collaboration by doing it themselves. This contributed to effective staff development procedures as well. The unplanned side effect was the amount of science knowledge participants gained through being students themselves.

Great attention was paid to context issues by the SIRC project. Guskey and Sparks cite examples of culture barrier in the school organization: administrative support, climate for collegiality, allowance for experimentation, an environment of trust and shared decision making. By making training days fun, allowing time for networking, providing family support through childcare, providing teacher print materials, creating a collegial atmosphere through the residential institute and field study, SIRC modeled a learning environment where risks could be taken, where failure could be discussed and evaluated, and where confidence was built.

By its structure, SIRC required teachers to come in teams and for administrators to attend at least the five days of the summer institute. This in itself resolved many issues regarding administrator support and collegiality. More school science planning and collegial networking happened than can be counted in the carpools coming in the early morning hours and going in the late afternoon before and after school year meetings. More collegiality occurred in the bigger network of the whole project during these school year meetings, during lunches, and in dormitory rooms, recreation rooms and motel rooms at night during the project year.

Playful experimentation during curriculum trainings often became hard to manage as participants became so engaged in their hands-on teamwork. Formal experimentation was required also at each site and with administrative involvement. Each site team had to draft a simple goal for improving its school's science plan in some way. Each teacher had to commit to spend at least three days helping non-project colleagues in some way. Principals had to provide the materials and release time resources to support these three days per participant and the school goal that they had helped draft. So shared decision making was also modeled through the project.

Science in Rural California has been a powerful project because it has used effective learning centered principles. Its practices reflect the three elements of quality, content and context as offered by Guskey and Sparks. SIRC has had long term impact on its participants in their beliefs about teaching science, in the competence and confidence to teach science, in their leadership behaviors, and in their professional growth.

In addition to fitting well the new model for effective staff development programs posed by Guskey and Sparks, the SIRC project's effectiveness can be compared to the research based standards found in the 1994 National Research Council's draft National Standards for Science.

The standards for teaching science and professional development were reviewed in Chapter II of this study. To briefly revisit them, there are six standards for the teaching of science and four for professional development.

National Standards for the Teaching of Science: (a) teachers must plan year long inquiry based programs; (b) teachers must guide and facilitate learning instead of control it; (c) teachers must engage in ongoing assessment of their own learning; (d) teachers with student involvement manage the learning environment; (e) teachers develop communities of science learners; and (f) teachers are involved in the ongoing creation and improvement of their school science program.

The national standards for Professional Development of teachers in science are: (a) professional development must model learning science through inquiry; (b) integration of science knowledge, learning theory, good pedagogy, and the intellectual development of students must be embedded in professional development; (c) professional development must create life long learning among teachers and allow them to reflect individually and with peers; and (d) professional development plans must be ongoing and coherent.

The SIRC project believes that it has been successful in obtaining these long term effects among past participants because it addressed these standards years before their publication. Regarding teaching standards, the project put Lawrence Hall of Sciences year long inquiry based science program, Full Option Science System (FOSS), into participants' hands. Many even shared a role in field testing it. This program, by embedding hands-on collaborative student groupings as the required pedagogical method, forced the development of student communities of science learners and of teachers who would guide and direct learning. In addition the project modeled these two standards during training by allowing participants to become communities of science learners themselves under the guidance of project trainers.

Teachers as they started to implement this inquiry program were also forced to change their learning environments. Individual desks supported neither collaboration nor hands-on materials. Teachers tried to keep charge of the learning environment at first, but soon learned that the many materials of inquiry and the individual direction that student groups would take required sharing decisions about designing the learning environment. Many discussions in project meetings centered on this issue.

By requiring participants to keep a reflective journal during the project, teachers again modeled one of the behaviors of ongoing assessment for their own learning. Moving away from pencil, paper and textbook science led to the use of process assessments and portfolios for students. To many participants this was difficult, but it also brought them to the first stages of allowing student involvement in self reflection and assessment of learning. Finally, by requiring a simple school site goal, the project got participants started in schoolwide science program planning and schoolwide articulation of the program. SIRC gave participants the opportunity to see that a schoolwide plan was a good idea and that they could have a voice and influence it. Involvement of the site administrator made this possible. Many SIRC alumni have gone to participation in the California Science Project (CSP) or the California Science Implementation Network (CSIN), learning the process and the facilitation skills to create a schoolwide science program and implement it. The SIRC project, in its second grant cycle, obtained additional augmentation funds from NSF to collaborate with CSP in providing additional site leader training and site based assistance in implementation of a schoolwide science plan.

The National Research Council's draft standards prescribe that professional development programs use and model inquiry based methods in the training of teachers in science. Use of inquiry based hands-on training with participants instead of traditional collegiate direct lecture instruction has probably been the single practice that most contributes to the long term effects found in this research.

The SIRC project was coherent in its training. It told its participants from the start that research indicated that they were afraid of science, probably taught it 17 minutes per day from a textbook as a language skill (if they could not find an excuse to avoid it). Participants knew that the project was going to pump the love of science into them. In the theoretical segments of its training and embedded in the teaching materials given to participants was full integration of science knowledge, learning theory, good pedagogy, and development of students. Participants were exposed to the developmental theory and, apparently, are not good at applying it on their own, but the FOSS curriculum, with which they were trained, contained it already. Participants learned science knowledge through doing and good pedagogy through trial and error in their own classrooms. This study has demonstrated that.

Finally, the project modeled that learning is a time intensive enterprise with its 21 days over thirteen months. The project would never change its calendar configuration to become a series of unrelated episodic training days. The project provided both self reflection and peer reflection opportunities for participants through journaling, team structure, peer discussion, administrative involvement and project director visitation. "I can honestly say that SIRC has resulted in nothing but positive feelings about my own growth and development."

The long term effects of the SIRC project can be attributed to its foresight in providing quality, content and context and to its delivery methods that modeled for teachers good science teaching practices and provided the support necessary for effective professional development.

> SIRC inservice has been the best inservice that I have received in my teaching career. The information, materials, exchange of information, methods used, presenters were excellent. The classroom implementation of materials and student management strategies were successful partly because you always had a "support group" that you could call on. "Doing" helped me.

CHAPTER V

SUMMARY

Problem

Millions of dollars have been spent nationally during the last three quarters of a decade in the effort to reform elementary science education through staff development. What have these efforts accomplished? What are the changes in science teaching that are taking place? Will they be lasting changes? Who has studied or documented the intended and unintended changes of staff development in the science education reform effort? No long term effect studies of similar staff development projects beyond twelve months were found in the review of current literature.

The SIRC project believes that significant changes have occurred among its project participants and that these changes continue beyond the project contact time. What are the long term effects among SIRC project participants?

Purpose

The purpose of this study was to examine the long term changes in teaching beliefs and instructional practices among the teacher participants of the Science in Rural California Project from the project years 1989-92. This study is interested in documenting the changes in beliefs about science and the teaching of science, teacher confidence about science, and the continuing, lasting changes in teaching methodology among the 120 teacher participants of these three project years.

The study sought to answer the following seven questions:

1. What do incoming SIRC participants believe about science?

2. Did the project change its participants' beliefs about science toward the definitions of science found in AAAS and other reform documents.

3. If teacher co..fidence is the central issue as to whether science instruction occurs at the elementary level or not, what has SIRC accomplished in raising participant confidence about teaching science?

4. What are the teaching practices of incoming SIRC participants?

5. How have these practices changed once participants become alumni of the SIRC project?

6. Did required administrator involvement and the team approach to participation in the project enhance the development of participants?

7. Did leadership and growth as professionals occur among participants?

Methodology

Both quantitative and qualitative methods were used in this research. One of the biggest problems confronted in designing the research was to establish a base of pre-project data for the study years. Few records of participant entry beliefs or practices were kept during those years of the project.

The problem was solved by using the pre-project data of the current year of participants. Since demographic data between the teacher groups were similar and project training has remained fairly similar, using the current year pre-project data became the solution of choice.

The study group consisted of 180 persons, 120 of whom were actual full time teacher participants from project years 1989-1992. From this 120, a sampling of 41 valid questionnaire respondents was used to gather quantitative data about long term effects two to four years after contact with the project. Six from the 41 questionnaire respondents and five more from among the 120 were used to gather qualitative data through interview.

The control group consisted of 79 persons, the full time participants of the current project year. All 79 responded to the research questionnaire and many voluntarily submitted journal entries from the first month of the current project to be used.

The demographics of the two groups were very similar in percentages of gen er, age groupings and years of teaching experience.

The research design was descriptive. The questionnaire responses were used to build a before and after profile concerning beliefs about science, beliefs about the teaching of science, confidence levels to teach science, the amount of time, learning theory and methods of teaching science, and the professional growth of individual participants. The descriptive results of the control group were matched against the study group.

After comparison of the groups, follow up interviewing was done with 11 members of the study group. This created a human voice for the differences arising from the comparison. Two discrepant responses in the study group in beliefs about science and developmental learning theory were probed. First month journal entries from the control group were used to create a similar voice for entry beliefs and practices.

Besides being descriptive, the methodology was also quasi-experimental. Direct cause and effect on study group members could not be conducted, so a control group of current participants had to be created. The influence of regional changes in the teaching of science over the five years between the first year of the study group and the current project year (control group) have been detected and cannot be overlooked. The study group members themselves were probable influences on higher positive entry data in the control group than would have been found five years ago with true experimental methodology.

Instrumentation

Instrumentation for this study comprised both the quantitative and qualitative. A 52 item questionnaire was used with both the study and control groups. There were two demographic questions, 35 five point Likert scale statements concerning beliefs about science, beliefs about the teaching of science, confidence in the teaching of science and teaching practices. Fourteen multiple choice items were used to gather data on teaching practices, professional development, importance of the project team and administrator involvement. Use of the questionnaire provided descriptive data for the study and control groups. Building a profile of belief, attitude, and practice from the control group established a baseline for comparison with the study group. In those areas where the researcher found what was felt as significant improvement in the study group, notes were made and follow up interviews conducted.

Interviewing of eleven volunteer study subjects was used to delve into the significant differences that quantitative comparison indicated. Five site visits were conducted where two or three participants from a study group team still worked together. These interviews were tape recorded. A short visit with the site administrator was conducted to inquire about site science leadership activities among the study subjects interviewed. This visit with the administrator provided modest triangulation.

Journal entries voluntarily submitted by subjects in the control group from the period of the first to the seventh day of the current project were reviewed to seek the thoughts and reflective language about beginning participant beliefs, attitudes and practices.

Findings

Significant long term effects were found in each area of the study: belief, confidence, pedagogy, and growth. Alumni of the SIRC project from years 1989-90, 1990-91, and 1991-92 as subjects in the study group believed that science was the most important subject in the elementary school curriculum twice as often as the control group. They also believed 20% more often that students could succeed in science if they had an effective science teacher.

Members of the study group showed one third more confidence in motivating students in science over their colleagues in the control group. The study group had more than double the confidence level. The study group also indicated that they now possessed a strong background in science.

Teachers in the study group were found to be teaching an additional period of science more than the control group with a per week average of 186 minutes, 45 more minutes than the control. They also used hands on strategies 20% more often and teacher controlled pedagogy 20% less often. Study group teachers expected more of their students in group work and were twice as likely to use formal collaborative groupings with defined roles than the informal groupings used by the control group.

Leadership behaviors were four times more likely among members of the study group. Nearly a third more identified themselves as leaders on a four stage professional developmental scale. Site principals identified half of their SIRC participants as current site leaders reinforcing this high level of leadership. Study subjects spent less time socializing and sharing and 25% more time collaborating with their peers over instruction and students than the control group.

These results were dramatic. If the regional influences and changes of the last five years could be discounted, these results would be even more dramatic.

Conclusions

The SIRC project made significant long term effects on the participants who were involved in its project and who had no participation in the last two to four years. These long term effects can be attributed to the structure and methods of this staff development project.

The practices of the project have been compared to the three new elements of effective staff development that influence learning and improve student achievement as researched by Guskey and Sparks in 1991. The practices of the project have also been compared to the new draft National Science Standards (NRC, 1994). The SIRC project addresses each of the six national standards for the Teaching of Science as well as the four standards for Professional Development.

The SIRC project has always been learning centered and, thus, was a Wave III reform project during the Wave II era. While not every teacher participant in SIRC became a superstar, a leader, an exemplary science teacher, more became these things because of the project and each participant was influenced in a positive way. Professional development should be viewed as moving individuals along a developmental scale. This project gave many big pushes.

The SIRC project has been an exemplary staff development project for elementary science teachers.

Recommendations

There are two audiences for the recommendations of this research: first, the SIRC project staff itself; and, second, others in the United States who are striving for effective learning centered staff development no matter what subject area.

The SIRC project needs to continue its work in strengthening teacher confidence and knowledge in science teaching. Working on these strengths, the project should investigate the apparent lack of application of acquired learning theory among participants. The SIRC project staff believes that its participants understand many aspects of this theory, that they believe in the theory's validity but are not at the competent level of understanding where they can verbalize it well or generalize it in their everyday teaching practice. After determining the causes for theory knowledge without application, project staff should take steps to improve participant application of developmental learning theory.

The SIRC project has been successful at both developing and increasing the number of teacher leaders in the field of science. Not every teacher will have the luxury of materials with developmental theory already embedded. A higher competence of understanding of developmental theory in leaders among elementary classroom practitioners is needed.

Leaders are needed who not only know developmental learning theory very well but who can practically apply the theory. Their assistance in the local drafting of schoolwide science plans, their creation of teacher made curricula and their correction of existing curricula that does not have sound developmental underpinnings will assist in the attainment of the highest standards of teaching science as cited in the National Science Standards.

Groups in the United States who are conducting staff development in elementary science or who are planning to do so should investigate the structure and practices of the SIRC project. Climate, culture, and regional conditions differ but the practices that create motivated science learners out of elementary teachers are possible to replicate. The incremental learning calendar, the many methods of participant support, the creation of a participant learning community, the methods of training participants in inquiry learning and collaborative groupwork, and the use of developmental learning theory in the SIRC project should be examined by other staff development practitioners.

Other science staff development projects in the U.S. should also engage in long term effect studies of their project participants. The literature was dominated by projects which conducted evaluations during the last contact day with their participants or some short follow-up interval no more that twelve months later. The National Science Foundation should require its teacher enhancement projects to hold back funds to conduct long term effect studies two to four years after participant contact time.

This type of last day evaluation is too embedded in the tradition of Wave II reform focusing on the immediate feeling responses of participants instead of the changed behaviors that continue to benefit students year after year because of the project's goals. The science education community does not need more project evaluations that tell us what pleased the participanting teachers. It needs a broad national research base that illuminates the effective practices employed by staff development projects used to improve teacher practices which, in turn, will improve instruction for students. It needs this research base of long term effects to be greatly broadened so that providers of professional development will have proven effective practices to employ. A large base of long term effect studies is essential to achieving our national goals in science.

Every elementary student has nine or more classroom teachers in their K-8 experience. Ten years ago, a student would be lucky to get one teacher who devoted time to science and who made science a real learning experience. Now a student is likely to get one or two. It should be a national goal to guarantee that each student has nine competent, confident, and inquiry based teachers. To do so would force the reform of secondary and post secondary science education and create the critical mass needed to develop a scientifically literate society.

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Science in Rural California
Project Description

Science In Rural California, an elementary teacher staff development project in science, is a collaborative partner with Carter House Natural Science Museum in Redding, Shasta and surrounding counties, California SIRC began collaborating with Carter House in 1989 when Carter House staff attended SIRC training. In early 1992, SIRC became a vehicle for training elementary teachers in the local natural science biology units that Carter House is developing through the HHMI grant.

SIRC began in 1986 with local and state regional funding. In 1989 it received three years funding from the National Science Foundation. In 1992 it was awarded a continuing four year grant from NSF, entitled: "Collaborative Partnerships in Establishing Permanent Change in Science Education in Northern California, (SIRC) TPE 91-54813. In its ninth year of teacher staff development, SIRC has had participating teams from 144 of 188 possible elementary school sites and has involved 539 teacher participants, about 25% of the entire elementary teaching force in the region.

SIRC serves the 9 northeastern counties of California, an area the size of Ohio and, with three major mountain ranges, with a geography much like Austria. The statistical average elementary school in this region is a K-8, nine classroom, single district school. The spectrum of schools is spread between schools that are multi-graded, one to three classroom sites (15-60 students) and schools that are on year round schedule with three to four teachers at each grade level K-5 (400-600 students) feeding a 6-8 middle school. The typical SIRC participant is a female elementary teacher in her late 30's who has taught at least 5 years, feels she is a good language arts teacher and has had negative personal school experiences with science and/or has no confidence in teaching science.

The research base that prompted the birth of the SIRC project described elementary science teaching as: out of a textbook twice a week for a total of 30 minutes. SIRC envisioned elementary science teaching where a teacher facilitated the group hands on work of students for 60-120 minutes per week. Evaluation of the SIRC project has demonstrated that this vision is being realized.

SIRC has two primary goals: to increase the amount of time elementary teachers spend on science and to transform their teaching from textbook to active student, "hands on" methodology. SIRC believes that to be successful in changing teaching practices, sufficient training time and ample teacher support are required.

SIRC staff development involves 21 training days over 13 months. The project begins with a six day intense summer residential institute. There are 6 monthly school year meetings, a four day field study, and a second five day summer residential institute the second summer. Participants must attend all 21 days. The 13 month time period allows teachers to institute and test classroom changes incrementally. Teachers cannot apply independently to SIRC. School teams of two, three, or four teachers attend together. The site administrator is part of the team and must attend five of the 21 days. School year meeting days allow time for grade level meetings among teacher peers. The team approach and time for participants to collaborate is a must: allowing for metacognition, risk taking, confidence building, and peer support. Administrative involvement is a must: educating administrators who can unintentionally may become an obstacle to change.

Other unique support teacher mechanisms are available at SIRC. Full daycare is provided at the two summer institutes. Motel lodging the night before meetings is provide for those over 100 miles from the training site and mileage reimbursement for those traveling more than 75 miles one way. The project charges a team fee of $500 with which it purchases start uo hands-on materials for the school team to get started with. A $500 materials management grant is also provided to teams who develop a written plan to manage and supply a hands-on science program. Teacher participants are paid a stipend of $50 for own day attendance and their schools districts are reimbursed substitute costs when attendance is on contract days. Teachers are always given a copy of the teacher's guide to any unit they are trained in. Two teams of fifth year student teachers are part of the project, attend all training, and conduct their student teaching with SIRC alumni.

Curriculum training models the hands-on method: teacher participants spend 60% of their 21 training days being students and learning science through hands-on, conceptually organized units. This builds science content and replaces fear of science with confidence. Teachers generally think they must possess the body of knowledge known as "science" before they can teach it adequately. SIRC participants soon adopt the attitude that science is the process of inquiry and that each question leads to other questions and that answers are found in the process of investigation. The issue of how to make science the integrating core of all school subjects is addressed during the project. New, real time, embedded methods of assessing student growth are also addressed Graduates of SIRC have continuing support through a regular project newsletter and through no cost SIRC alumni events.

Teacher participants are required to keep a reflective journal and to turn in a monthly synopsis of their journal. School teams are required to develop and implement a simple change plan for science with their whole school staff back at the site. School teams are entitled to on-site assistance from SIRC Mentors and from the SIRC project director in these site plans.

Quality hands on and developmentally appropriate commercial science curriculum from the Lawrence Hall of Science is presented to participants: Full Option Science System (FOSS), Great Experiences in Math and Science (GEMS), and Outdoor Biological Instructional Strategies (OBIS). Carter House Natural Science Curriculum units: Ornithology, Volcanoes, Fabulous Filaree, Ants, Autumn Oaks, Primarily Ponds, Energy Flow through Spring Ponds are also presented. Trinity County's Adopt a Watershed Curriculum is shared. The outdoors as a classroom is also modeled.

SIRC BASIC PRINCIPLES

Background

The SIRC project has trained elementary teachers to become better teachers in science for 9 years In its first three years, it struggled to form its identity and the core principles that the project now embeds in its training. Over the last 6 years, these eight core principles have been employed in training teachers:

1 Research shows that only 15% of elementary teachers have the **confidence** to teach science adequately Most teachers who teach science do so as a reading activity. Many avoid teaching it altogether. Building confidence to teach science is primary.

2. Science is a **process of learning** and acquiring knowledge, not a body of facts. People **construct** their own knowledge based on preconceived notions of how things work, changed by personal experience and reflection on experience. Science is a way of knowing that is characterized by specific features, such as empirical criteria, logical agrument, and skeptical review It **not dogmatic**. Ideas and theories are always subject to scrutiny and further testing.

3. Science is an active process involving investigation of objects and interactions. Therefore, instruction cannot be individual. Instructional methods in science must involve active student learning and inquiry strategies, **hands-on** lessons employing **collaborative** learning styles

4. Teachers need to learn that science is a process and to learn through hands-on and collaborative methods. The project must model these strategies and involve teacher **participants as learners**. **Enough time**, alternating between training and response, spread over a school year, is critical to changing teacher practice. A networking community of learners is developed and nutured among project participants. The SIRC project involves 21 days of contact over 13 months: two separate week long summer institutes with 10 days spread over the school year in between .

5. Students in the elementary grades do not think as adults do but are acquiring thinking skills in **development stages**. Science needs to be taught at the operational stage of that group of students' development. Teachers need to use developmentally appropriate instruction and use materials that are designed for a group of students' current developmental stage.

6. In order for teachers to change their teaching practices, peer and administrative **support** are necessary. Participation in the SIRC project must be by team This approach includes two, three, or four teachers from the same site/district and membership of the site administrator.

7 In order for teacher participants to change their teaching practices they must **reflect** on their SIRC experience This was done in three ways: By requiring participants to keep reflective journals. By requiring participants to devote three days in formal or informal training of non-participating colleagues And with ongoing grade level sharing sessions.

8 Science happens in the real world, not just the classroom **Outdoor** long term projects at a regular study site are highly promoted

Questionaire #:_____

NATIONAL SCIENCE FOUNDATION

Science In Rural California

Steve Essig, Project Director

Teacher Questionnaire

Dear Respondent:

The Science in Rural California Project is conducting a research study of its long term effects. The purpose of this study is to determine if the desired changes in teacher belief and practices continue. We hope toseek funding for a new project, just for SIRC alumni based on this research. As an alumni of SIRC 4, SIRC 5, or SIRC 6, you are among the select group for this study.

Please complete this questionnaire and help SIRC gather this data. A space for (optional) comments has been provided at the end. If you wouldn't mind a possible personal interview in the future please complete that section at the end of the questionaire. If you were a team alternate or the team administrator, please so indicate and answer what questions do apply. If you complete and return this questionaire by May 30, we'll mail you the famous SIRC alumni coffee mug as a "thank you." There is a stamped return envelope and mug label stapled to the questionaire. Complete the label to receive your SIRC mug. Use the envelope to return your completed questionaire and label.

All information collected by this questionnaire will be confidential. The questionaires are numbered and only SIRC knows the identity of respondents. The comments and volunatry interview page will be removed from the questionaire by SIRC to protect confidentiality. Only general trends and anonymous comments will be published in the report. Thank you in advance for your assistance in this important study.

1. Participant Data

Current Age: ___20's ___30's ___40's ____50's ____60's

Sex. ____Male ____Female

Years of Classroom Teaching: _______ Year retired or left teaching: 19_____

Current School Site:_______________________________Years at Site_________

Administrator at Current Site:_______________________________________

____ I was a team administrator or alternate and only attended _____ of the 21 days of the project.

2. Historical Data:

Year of SIRC participation:
___1989-90 SIRC 4
___1990-91 SIRC 5
___1991-92 SIRC 6

School Site of SIRC Involvement _______________________________

Team members when in SIRC. _______________ _______________

_______________ _______________ _______________

(star those SIRC team members who are still site colleagues)

Administrator of SIRC Team when involved.___________________________

3629 Canterbury Drive • Redding, CA 96002 • (916) 222-5[illegible]

For each statement, please **circle** the number that best describes your view Read each item completely before answering.

	disagree				agree
3 Science is a body of knowledge, facts, and theories.	1	2	3	4	5
4. Students prefer to learn science from textbooks.	1	2	3	4	5
5. When teaching science, I usually welcome student questions	1	2	3	4	5
6. Adults and children learn in identical ways.	1	2	3	4	5
7. Science is the most important subject at school.	1	2	3	4	5
8. I do not know what to do to turn students on to science	1	2	3	4	5
9. I wish I had received more science instruction in college.	1	2	3	4	5
10. Increased effort in science teaching produces little change in some students' science achievement.	1	2	3	4	5
11. The process of seeking answers is the real nature of science.	1	2	3	4	5
12. Students can learn any concept at any grade if they have an effective teacher.	1	2	3	4	5
13. I understand science concepts well enough to be effective in teaching elementary science.	1	2	3	4	5
14. Reading and mathematics are more important subjects than science.	1	2	3	4	5
15. Planetary motion can be taught successfully to third and fourth graders.	1	2	3	4	5
16. Most teachers enjoy teaching science.	1	2	3	4	5
17. I will not be very effective in monitoring science experiments	1	2	3	4	5
18. Science is a way of thinking and asking questions.	1	2	3	4	5
19. Students must be taught the facts and truths of science.	1	2	3	4	5
20. Children will learn more science by doing hands-on activities.	1	2	3	4	5
21. Children as a group think in different ways than adults do.	1	2	3	4	5
22. Students' achievement in science is directly related to their teacher's effectiveness in science teaching	1	2	3	4	5
23. Teachers often put off teaching science	1	2	3	4	5
24. I have a strong science background.	1	2	3	4	5
25. It is important to teach students about what most scientists think and believe	1	2	3	4	5
26. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach	1	2	3	4	5

	disagree				agree
27. Most second graders (7-8 year olds) are able to understand molecules.	1	2	3	4	5
28. Students prefer to learn science by manipulating materials.	1	2	3	4	5
29. I wonder if I will have the necessary skills to teach science.	1	2	3	4	5
30. I will typically be able to answer students' science questions.	1	2	3	4	5
31. Openness is a quality of science.	1	2	3	4	5
32. Children learn more science if taught from a good textbook.	1	2	3	4	5
33. Even if I try very hard, I will not teach science as well as I will other subjects.	1	2	3	4	5
34. Effective teaching matches the cognitive abilities of student to the content of the curriculum.	1	2	3	4	5
35. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand better.	1	2	3	4	5
36. The structure of the atom and cell are best taught in middle and high school.	1	2	3	4	5
37. I will continually find better ways to teach science.	1	2	3	4	5

38. **How may minutes** are devoted to teaching science in your program?

____ minutes per day, ____days per week. **/or/** _______minutes per week.

39. **What method(s) of teaching** is/are used in your science program?

Method(s)	Portion of Program (100%)
____lecture	_______%
____demonstration	_______%
____textbook, read & discuss	_______%
____literature based	_______%
____hands on, labs	_______%
____field trips, field work (outdoor)	_______%
____video and multi-media	_______%
____computer programs	_______%
____other	______% explain:______________ ____________
Total	**100%**

40. **What curriculum resources are available** for you to teach science?

Please list	Portion of Use (100%)
textbooks:_______________________________	______%
materials / program 1.______________________	______%
materials / program 2.______________________	______%
materials / program 3 ______________________	______%
other:_________________________________	______%

41. **How often** do students in your program do science **activities outdoors** and field studies? (Record number)

______month or ______year

42. **What method of student management** is predominant in your science program?

(Check only one):
____individual student work (each student does own separate work after teacher direction)
____student centers (part of class with teacher for lesson, class rotates to two three centers)
____informal groups, cooperative groups (groups formed quickly and change often with task)
____formal groups, collaborative groups (jobs within group defined, group lasts with task)

43. **How much integration** of science with other subjects is taking place in your program?

____little ____some ____a lot

(Check all the comments that apply):

____It is difficult to integrate other subjects into science.
____It is easier to teach reading, math, science, PE, etc. in separate time blocks
____I am successful with integrating math and language arts.
____I am successful at the integration of math with science.
____I am successful at the integration of social studies with science.
____I am successful at the integration of literature with science.
____I am successful at the integration of reading and writing with science.

44. **I keep a journal** of my classroom practices and other professional activities. _____yes _____no

45. **I belong** to the California Science Teachers Association. _____yes _____no

46. **I belong** to the National Science Teachers Association. _____yes _____no

47. **I belong to another** science related Association, named______________________

48. **I have been a science mentor** for my school & district. _____yes _____no

Years of mentorship:______to_______, _______to_______, _______to_______

49. **I have made science inservice** presentations to other teachers. _____yes _____no

How may presentations per year or in this past year.__________

50. Which teacher description below best illustrates your classroom situation?

Check only one

a _____This teacher is very concerned about the individual needs of students and is very saddened and depressed when unable to solve a student's problem. This teacher has a vision for what he/she wants to be doing in education five years from now and is self-reflective and self critical Strong at recognizing many possible solutions, this teacher feels free to take independent action and uses time wisely. This teacher is very idealistic, has high personal goals, and feels very responsible for personal and student success at school.

b _____This teacher wants to be liked by all students. It is frustrating for this teacher to accept unkindness and anger from students especially from students this teacher cares about. This teacher wants to be liked by colleagues and will do his/her part at the school. It is important for this teacher to follow the rules of the school, district, contract. This teacher will do a excellent job of completing what is expected.

c _____This teacher has a picture of the school's place in the community and has political and business ties outside of the school. Balancing home life with professional duties and school demands this teacher seems to be self-fulfilled. This teacher likes to work in collaboration with other teachers and is considered a leader who shares, has creative ideas, able to handle complexity. This teacher is able to develop viable contingencies and exceptions for students with individual special needs.

d _____This teacher is very nervous when the principal or another comes into the classroom. It is hard for this teacher to manage student anger and aggression. This teacher talks about vacations frequently. This teacher depends on colleagues for advice. It is very important for this teacher to have control of the classroom.

51. There is a group of teachers at my site that I collaborate with: _____yes _____no

Check all that apply to your collaborative group at school:

____we socialize outside of school and support each other at school
____we share science ideas and materials regularly
____we plan science lessons together regularly
____we trade students, teach each other's students regularly
____we observe each other teaching regularly
____this group was my SIRC team

52. My site administrator is:

Check all that apply:

____a member of my planning and collaboration group (refer to 51)
____takes time to listen to what the group is doing in science
____understands what we are doing in science
____supports what we are doing with time and materials
____works with us and students in school science events
____visits our classrooms a lot
____was a member of our SIRC team

53 **Comments** (optional).

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54 I am willing to be **interviewed** for this study (if follow up needed). _____yes _____no

If yes, please complete.

Name:____

Home Address.______________________________City ____________________

Zip ____________________ Home Phone _(___)______________________

School Phone _(____)______________________

Questionaire #:_____

NATIONAL SCIENCE FOUNDATION

Science In Rural California

Steve Essig, Project Director

Teacher Questionnaire
SIRC 9 - First Institute

Dear Respondent:

The Science in Rural Califomia Project is conducting a research study of its long term effects. The purpose of this study is to determine if the desired changes in teacher belief and practices occurred. The data from your group, as the incoming group, will be used as a base line to compare with previous SIRC alumni. You will also be given this questionnaire again in the second summer, July 95. Gathering this data in 12 months will help us examine one year effects. The data will also be used in our final report to the National Science Foundation at the conclusion of your project year, SIRC year 9.

Please complete this questionnaire and help SIRC gather this data. A space for (optional) comments has been provided at the end. If you wouldn't mind a possible personal interview in the future please complete that section at the end of the questionaire.

All information collected by this questionnaire will be regarded as confidential. The questionaires are numbered. Your name at the bottom of the first page and the comments and volunatry interview section on the last page will be removed to protect confidentiality. Only the SIRC director will know the numbers to identify respondents. Only general trends and anonymous comments will be reviewed by outsiders and published in the report. Thank you in advance for your assistance in this important study.

1. Participant Data

Current Age: ___20's ___30's ___40's ___50's ___60's

Sex: ___Male ___Female

Years of Classroom Teaching: _______

Current School Site:_______________________________ Years at Site__________

___ I am full participant will attend all 21 days of the project.

___ I am a team administrator and will only attend 5 of the 21 days of the project.

___ I am a team alternate and expect to attend ____ of the 21 days of the project.

2. Historical Data:

Year of SIRC participation:

___1989-90	SIRC 4	___1992-93	SIRC 7
___1990-91	SIRC 5	___1993-94	SIRC 8
___1991-92	SIRC 6	_x_1994-95	SIRC 9

- -

Participant Name:_______________________________ Ques #: ________

Will be removed to protect confidentiality

3629 Canterbury Drive • Redding, CA 96002 - (91· ; 222-58'

For each statement, please **circle** the number that best describes your view Read each item completely before answering

	disagree				agree
3. Science is a body of knowledge, facts, and theories.	1	2	3	4	5
4. Students prefer to learn science from textbooks.	1	2	3	4	5
5. When teaching science, I usually welcome student questions	1	2	3	4	5
6. Adults and children learn in identical ways.	1	2	3	4	5
7. Science is the most important subject at school.	1	2	3	4	5
8. I do not know what to do to turn students on to science.	1	2	3	4	5
9. I wish I had received more science instruction in college.	1	2	3	4	5
10. Increased effort in science teaching produces little change in some students' science achievement.	1	2	3	4	5
11. The process of seeking answers is the real nature of science.	1	2	3	4	5
12. Students can learn any concept at any grade if they have an effective teacher.	1	2	3	4	5
13. I understand science concepts well enough to be effective in teaching elementary science.	1	2	3	4	5
14. Reading and mathematics are more important subjects than science.	1	2	3	4	5
15. Planetary motion can be taught successfully to third and fourth graders.	1	2	3	4	5
16. Most teachers enjoy teaching science.	1	2	3	4	5
17. I will not be very effective in monitoring science experiments.	1	2	3	4	5
18. Science is a way of thinking and asking questions.	1	2	3	4	5
19. Students must be taught the facts and truths of science.	1	2	3	4	5
20. Children will learn more science by doing hands-on activities.	1	2	3	4	5
21. Children as a group think in different ways than adults do.	1	2	3	4	5
22. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	1	2	3	4	5
23. Teachers often put off teaching science.	1	2	3	4	5
24. I have a strong science background.	1	2	3	4	5
25. It is important to teach students about what most scientists think and believe.	1	2	3	4	5
26. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	1	2	3	4	5

	disagree				agree
27. Most second graders (7-8 year olds) are able to understand molecules.	1	2	3	4	5
28. Students prefer to learn science by manipulating materials.	1	2	3	4	5
29. I wonder if I will have the necessary skills to teach science.	1	2	3	4	5
30. I will typically be able to answer students' science questions.	1	2	3	4	5
31. Openness is a quality of science.	1	2	3	4	5
32. Children learn more science if taught from a good textbook.	1	2	3	4	5
33. Even if I try very hard, I will not teach science as well as I will other subjects.	1	2	3	4	5
34. Effective teaching matches the cognitive abilities of student to the content of the curriculum.	1	2	3	4	5
35. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand better.	1	2	3	4	5
36. The structure of the atom and cell are best taught in middle and high school.	1	2	3	4	5
37. I will continually find better ways to teach science.	1	2	3	4	5

38. **How may minutes** are devoted to teaching science in your program?

____ minutes per day, ____days per week. **/or/** _______minutes per week.

39. **What method(s) of teaching** is/are used in your science program?

Method(s)	Portion of Program (100%)
____lecture	______%
____demonstration	______%
____textbook, read & discuss	______%
____literature based	______%
____hands on, labs	______%
____field trips, field work (outdoor)	______%
____video and multi-media	______%
____computer programs	______%
____other	______% explain:______________________
Total	**100%**

40. **What curriculum resources are available** for you to teach science?

Please list — Portion of Use (100%)

textbooks:______________________ ______%

materials / program 1:______________________ ______%

materials / program 2:______________________ ______%

materials / program 3:______________________ ______%

other:______________________ ______%

41. **How often** do students in your program do science **activities outdoors** and field studies? (Record number)

______month or ______year

42. **What method of student management** is predominant in your science program?

(Check only one):
____individual student work (each student does own separate work after teacher direction)
____student centers (part of class with teacher for lesson, class rotates to two three centers)
____informal groups, cooperative groups (groups formed quickly and change often with task)
____formal groups, collaborative groups (jobs within group defined, group lasts with task)

43. **How much integration** of science with other subjects is taking place in your program?

____little ____some ____a lot

(Check all the comments that apply):

____It is difficult to integrate other subjects into science.
____It is easier to teach reading, math, science, PE, etc. in separate time blocks
____I am successful with integrating math and language arts.
____I am successful at the integration of math with science.
____I am successful at the integration of social studies with science.
____I am successful at the integration of literature with science.
____I am successful at the integration of reading and writing with science.

44. **I keep a journal** of my classroom practices and other professional activities. _____yes _____no

45. **I belong** to the California Science Teachers Association. _____yes _____no

46. **I belong** to the National Science Teachers Association. _____yes _____no

47. **I belong to another** science related Association, named______________________

48. **I have been a science mentor** for my school & district. _____yes _____no

Years of mentorship:_____to_______, _______to_______, _______to_______

49. **I have made science inservice** presentations to other teachers. _____yes _____no

How may presentations per year or in this past year:_________

50. Which teacher description below best illustrates your classroom situation?

Check <u>only one</u>

a. _____This teacher is very concerned about the individual needs of students and is very saddened and depressed when unable to solve a student's problem. This teacher has a vision for what he/she wants to be doing in education five years from now and is self-reflective and self critical. Strong at recognizing many possible solutions, this teacher feels free to take independent action and uses time wisely. This teacher is very idealistic, has high personal goals, and feels very responsible for personal and student success at school.

b._____This teacher wants to be liked by all students. It is frustrating for this teacher to accept unkindness and anger from students especially from students this teacher cares about. This teacher wants to be liked by colleagues and will do his/her part at the school. It is important for this teacher to follow the rules of the school, district, contract. This teacher will do a excellent job of completing what is expected.

c._____This teacher has a picture of the school's place in the community and has political and business ties outside of the school. Balancing home life with professional duties and school demands this teacher seems to be self-fulfilled. This teacher likes to work in collaboration with other teachers and is considered a leader who shares, has creative ideas, able to handle complexity. This teacher is able to develop viable contingencies and exceptions for students with individual special needs.

d._____This teacher is very nervous when the principal or another comes into the classroom. It is hard for this teacher to manage student anger and aggression. This teacher talks about vacations frequently. This teacher depends on colleagues for advice. It is very important for this teacher to have control of the classroom.

51. There is a group of teachers at my site that I collaborate with: _____yes _____no

Check <u>all that apply</u> to your collaborative group at school:

____we socialize outside of school and support each other at school
____we share science ideas and materials regularly
____we plan science lessons together regularly
____we trade students, teach each other's students regularly
____we observe each other teaching regularly
____this group was my SIRC team

52. My site administrator is:

Check <u>all that apply</u>:

____a member of my planning and collaboration group (refer to 51)
____takes time to listen to what the group is doing in science
____understands what we are doing in science
____supports what we are doing with time and materials
____works with us and students in school science events
____visits our classrooms a lot
____was a member of our SIRC team

Please check those that apply and add needed explanation:

53. Textbook

____At my site we use a science textbook

Publisher is: ____________________

Copyright date is: ____________________

____I would like to have a textbook.

____I prefer not to use a textbook.

54. Science Framework

____I have a copy of the 1991 California Science Framework.

____I use my copy of the Science Framework in planning my science units and curricula

____I do not have a Framework,but there is one available to me at my school.

____I would like to know more about 1991 California Science Framework.

____My school site has developed a schoolwide Content Matrix in science.

____I would like my school to have a schoolwide science plan.

55. Personal Science Background:

____I have formal training in a life science, i.e.: ____________________

____I have formal training in a physical science, i.e.: ____________________

____I have formal training in a earth science, i.e.: ____________________

____I feel most comfortable creating and teaching units of science about:

____________________ ____________________

____________________ ____________________

____________________ ____________________

56. My School has adopted the following approved (instructional materials) science programs:

____Britannica Science System (FOSS)

____Insights, EDC, Optical Data

____Scholastic Science Place

____McMillan/McGrall Hill Science

____Discover the Wonder, Scott Foresman

____Prentice Hall Science Learning System

____Science 2000, Decision Development

____Science Plus, Holt-Rhinehart

The specific units I use from this adopted program are:

____________________ ____________________

____________________ ____________________

____________________ ____________________

*Please star those units that you feel competent enough to present as inservice to colleagues.

57. **Other Science Programs**

Please check and name the units of other science programs that you regularly use:

_____a. **GEMS**, Great Experiences in Math and Science, Lawrence Hall of Science
I use the following units:
_____________________ _____________________

_____b **SAVI-SELPH**, Science Activities for Visually Impared, Lawrence Hall of Science
I use the following units:
_____________________ _____________________

_____c. **OBIS**, Outdoor Biological Instructional Strategies, Lawrence Hall of Science
I use the following units:
_____________________ _____________________

_____d. **AIMS**, Activties in Math and Science, Fresno Pacific
I use the following units:
_____________________ _____________________

_____e. **Project Wild**, California Department of Fish and Game
I use the following units:
_____________________ _____________________

_____f. **Project Wild Aquatic**, California Department of Fish and Game
I use the following units:
_____________________ _____________________

_____h. **Project Learning Tree**, California Division of Forestry
I use the following units:
_____________________ _____________________

_____i. **ESS, Elementary Science Study**
I use the following units:
_____________________ _____________________

_____j. **SCIS, Science Curriculum Improvement Study**
I use the following units:
_____________________ _____________________

_____k. **Other Program, Please Name:**_____________________
I use the following units:
_____________________ _____________________

_____l **Other Program, Please Name:**_____________________
I use the following units:
_____________________ _____________________

This page will be removed to protect confidentiality

58 Comments (optional)

59. I am willing to be **interviewed** for this study (if follow up needed) _____yes _____no

If yes, please complete:

Name:

Home Phone: _(____)

School Phone:_(____)

Blueprint Questionnaire 2/4/95

Item Types	Content			
	Teacher Belief	**Teacher Confidence**	**Teaching Practices**	**Professional Growth**
Data Collection: 28%	Personal Comments *53* Demographic Data. *1, 2* items: 3	Personal Comments *53* items: 1	Time for Science *38* Time for Outdoor Labs *41* Curriculum Resources *40* Instructional Methods *39* items: 4	Peer Support *51, 52* Refection *44* Leadership Behaviors *45, 46, 47, 48, 49* Professional Maturity *50* items: 9
Personal Response: 72%	Beliefs about Science 3, 11, 18, 19, 25, 31 Beliefs about Teaching Science 7, 10, 14, 16, 22, 23, 26 items 13	Teacher Confidence 5, 8, 9, 13, 16, 17, 24, 29, 30, 33, 37 items 11	Student Management *42* Curriculum Integration *43* Developmental Appro 6, 12, 15, 21, 27, 34, 36 Hands on Value 4, 20, 28, 32, *38*, *39* items 15	Personal Comments *53* items 1
No of Items	16	12	19	10

Time for Questionnaire 45 minutes *Italics* for non-Likkert items **Appendix**

Study Group Follow Up Questionnaire:

Participant Name________________________Yr4 (5 out) Yr5 (4 out) Yr6 (3 out)

Interview Date________________Time____________________

Open Ended:

What was(were) the most important learning(s) that you received from SIRC?

1. ____
2. ____
3. ____
4. ____

(Constructivism, Hand-on, Developmental)

Why? (Probe)

If a teaching colleague at another school was asking you about whether to apply for SIRC or not, what would you tell them?

Is there anything else about your SIRC experience that you would like to share for this study?

About Science:

How would you define science?

Is this your current definition? What was your definition of science before SIRC?

Has it changed SIRC? Is it still changing?

About the Teaching of Science:

How important is science in the school curriculum? Why?

Did you always feel that way?

About the Teaching of Science (Cont.):

Statement "It is important to teach students about what most scientists think and believe "
What does this statement mean to you?

Describe your current science teaching?

Program

Student Management

Time

Methods of teaching

About the Teaching of Science (Cont.):

What was your science teaching like before SIRC?

Program
Student Management
Time
Methods of teaching

About Science Teaching Confidence:

Most respondents agreed with this statement: "I wish I had received more science instruction in college."

Do you agree or disagree?

What was your confidence level or attitude about teaching science before SIRC?

Did SIRC help change your attitude? How?

About Professional Growth and Collegiality:

How did SIRC help in improving your science background and understanding?

Have you engaged in any other learning activities since SIRC to improve your science knowledge and understanding? (Did the SIRC experience motivate this?)

In what ways, outside of science, has SIRC helped you grow as a teaching professional?

About Professional Growth and Collegiality (Cont.):

How important was your team during SIRC?

Do you still have this same team? Do you use it?

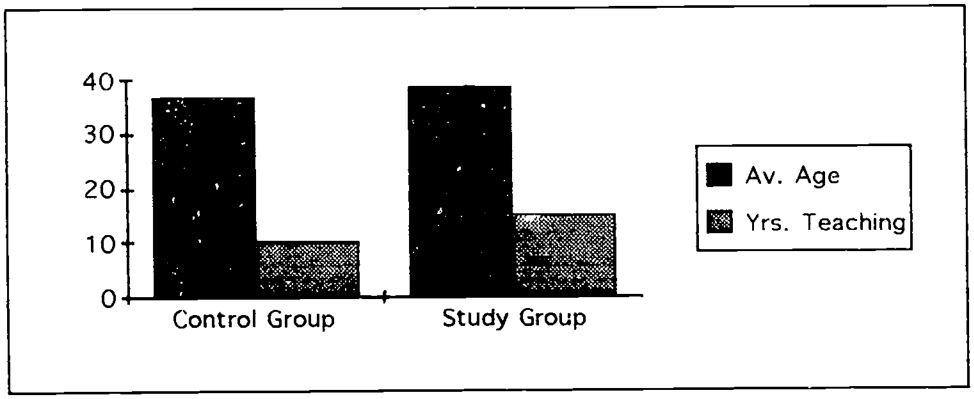
Do you still use this team concept in your current teaching assignment?

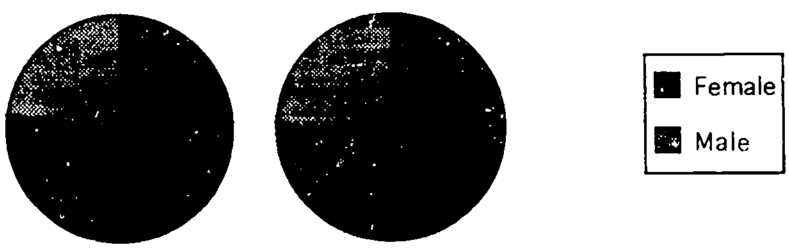
How important was the involvement of your site administrator during SIRC?

Appendix F
Teacher Questionnaire
Item Analysis

Demographics

Control Group			Study Group		
Sample Number:	79		Sample Number:	41	
Average Age:	36.6		Average Age:	38.5	
Av. Yrs. Teach:	10		Av. Yrs. Teach:	14.7	
Gender:	Females	Males	Gender:	Females	Males
			Year 4	8	4
			Year 5	10	2
Year 9	53	16	Year 5	13	4
Number	53	16	Number	31	10
Percent	80%	20%	Percent	76%	24%





Control Group Study Group

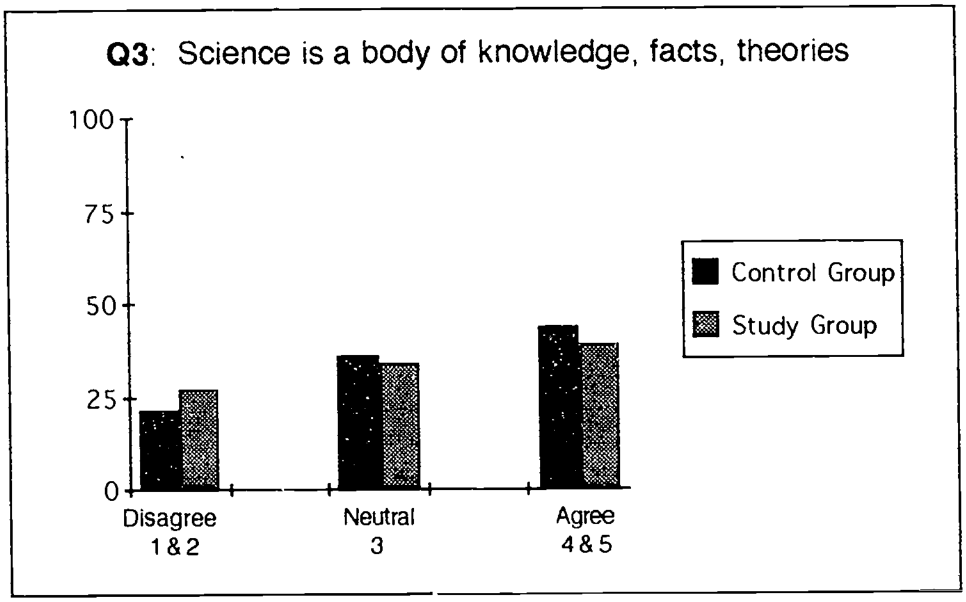
Teacher Beliefs about Science:
(5 point Likert questions):

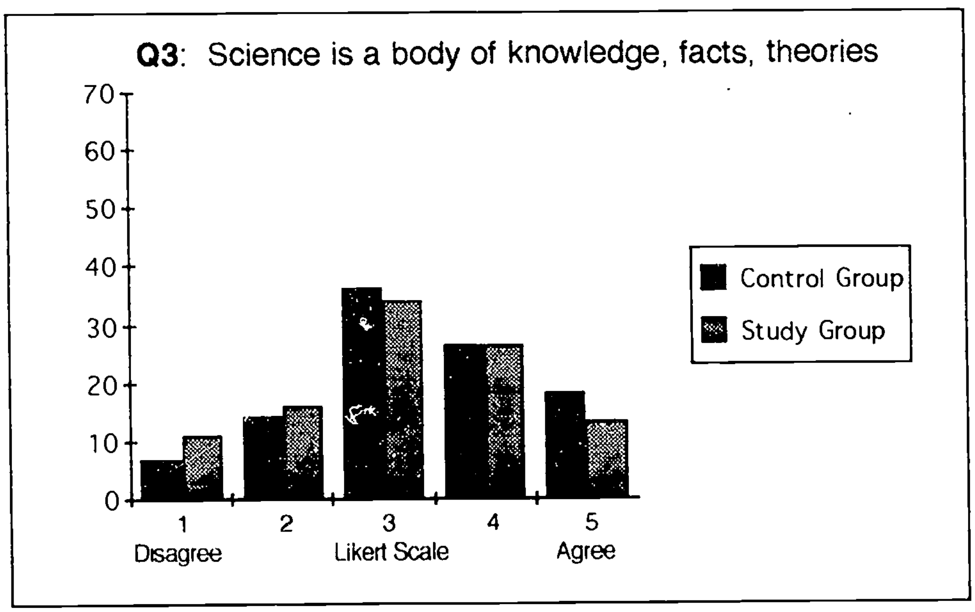
3. Science is a body of knowledge, facts, theories.
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
3.4		3.2		0.2

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





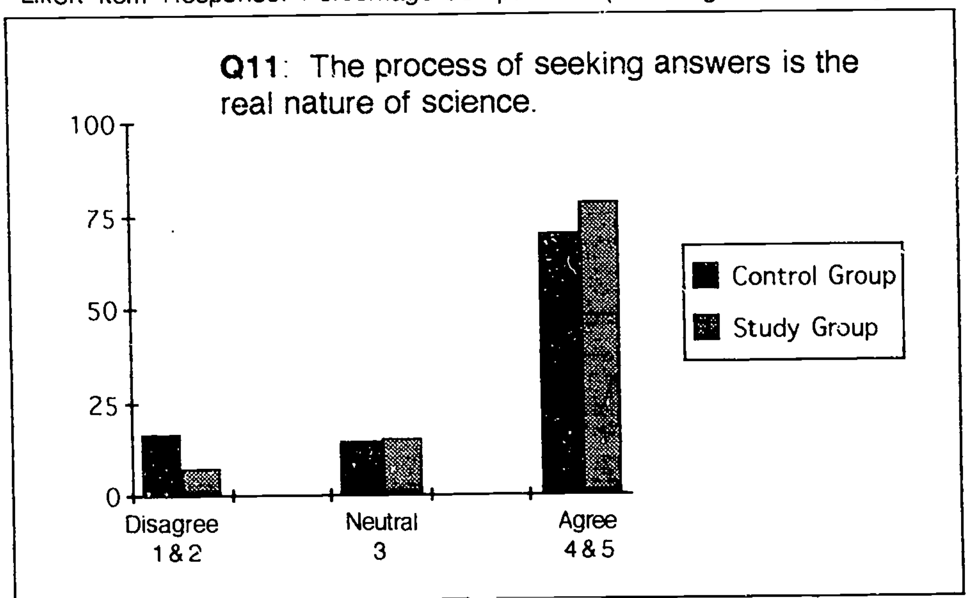
Teacher Beliefs about Science:
(Continued)

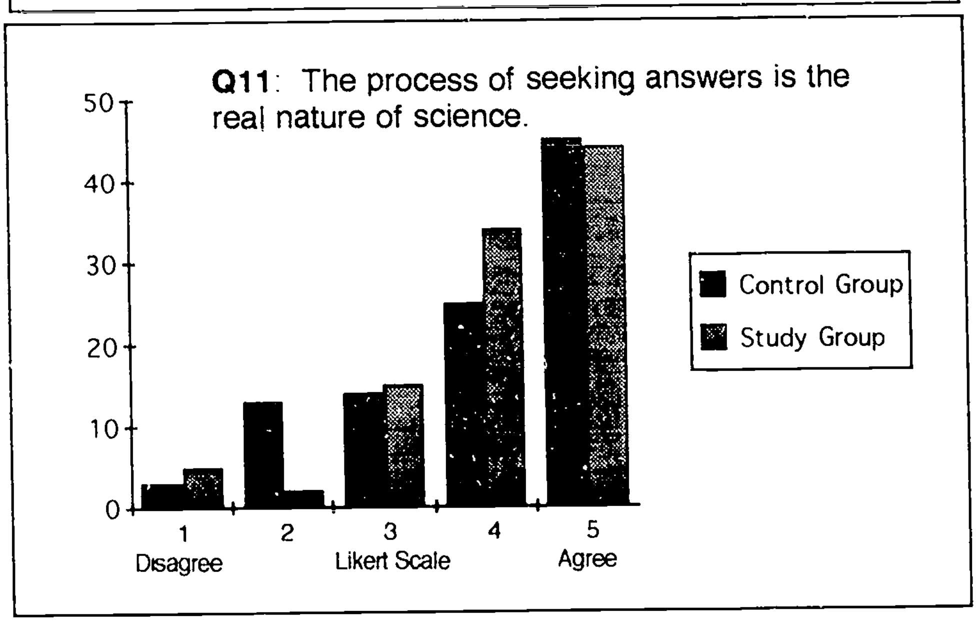
11. The process of seeking answers is the real nature of science.
(Expected Study group agreement)

Likert Total Response Average Comparison

Control Group	Study Group	Difference
4.0	4.1	(0.1)

Likert Item Response: Percentage Comparison: (1 = disagree to 5 = agree)





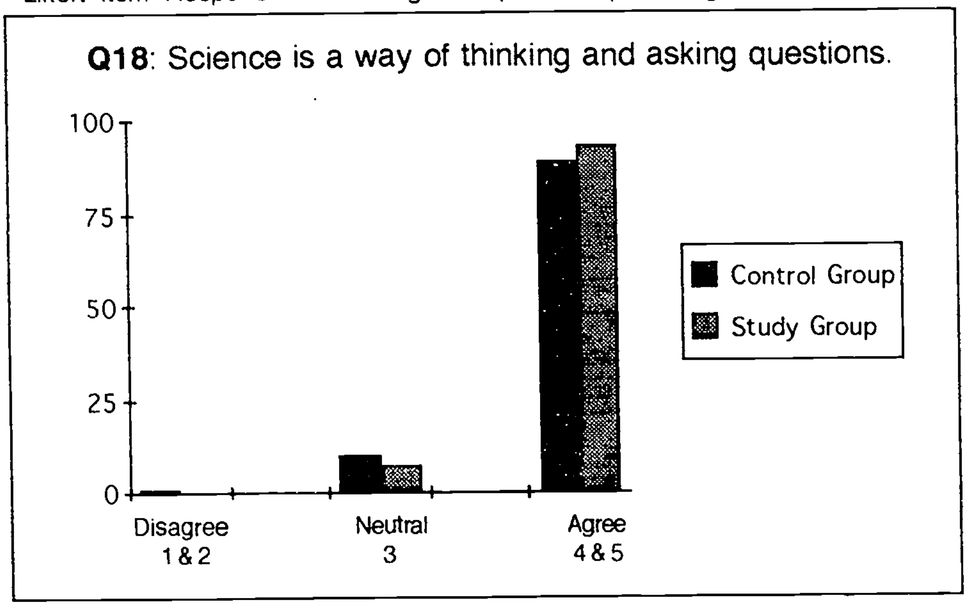
Teacher Beliefs about Science:
(Continued)

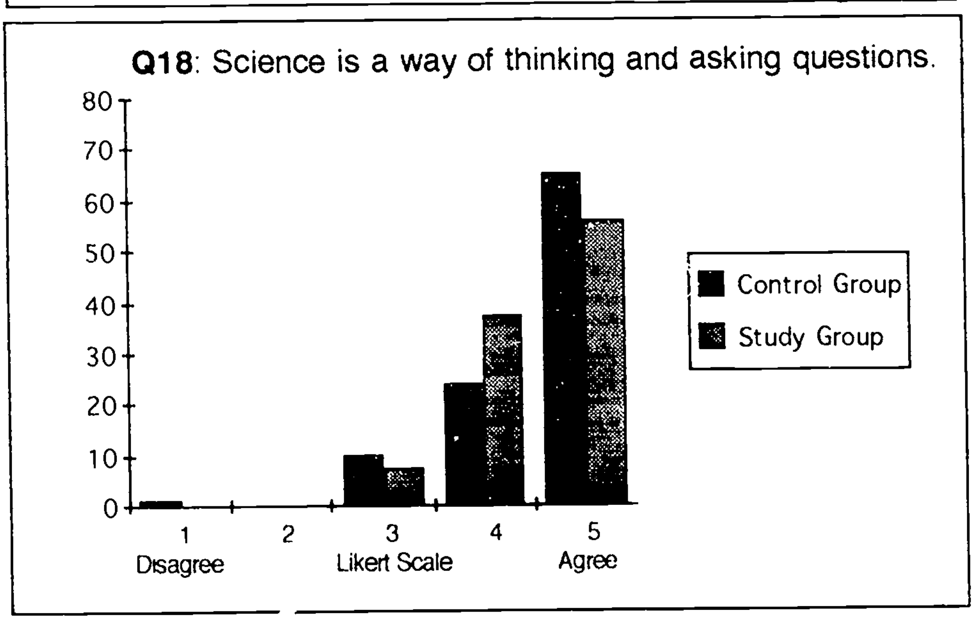
18. Science is a way of thinking and asking questions.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group	Study Group	Difference
4.5	4.5	0

Likert Item Response: Percentage Comparison. (1 = disagree to 5 = agree)





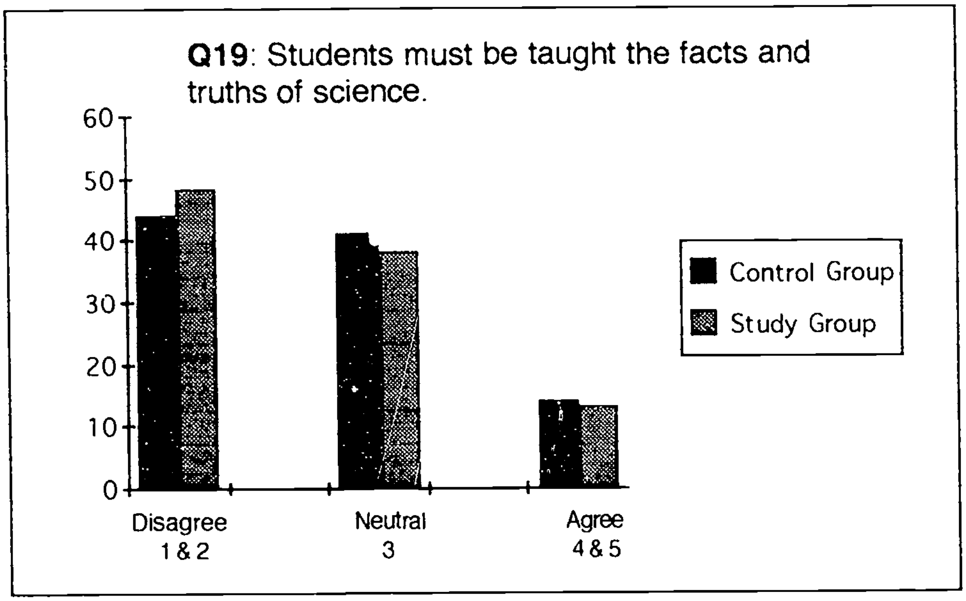
Teacher Beliefs about Science:
(Continued)

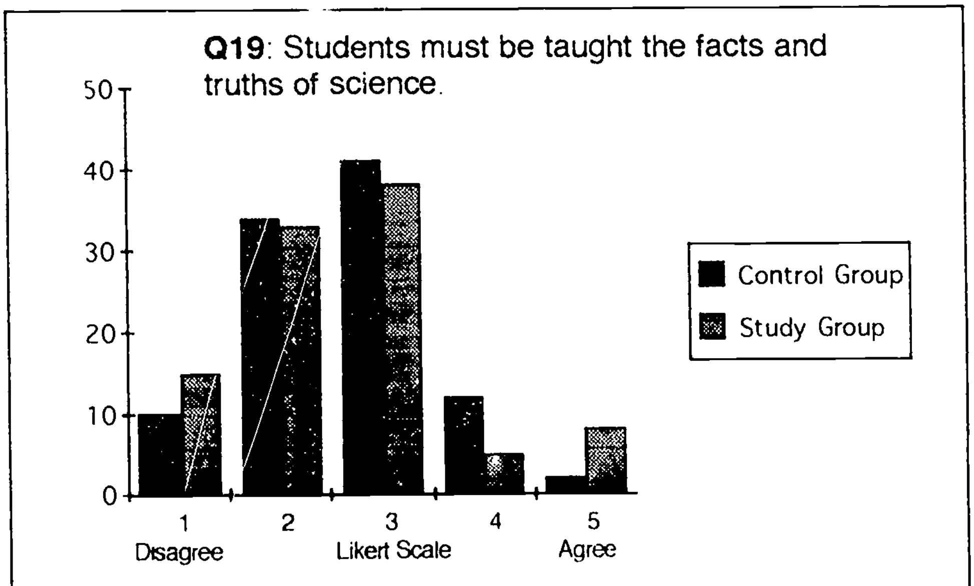
19. Students must be taught the facts and truths of science.
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
2.6		2.6		0

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





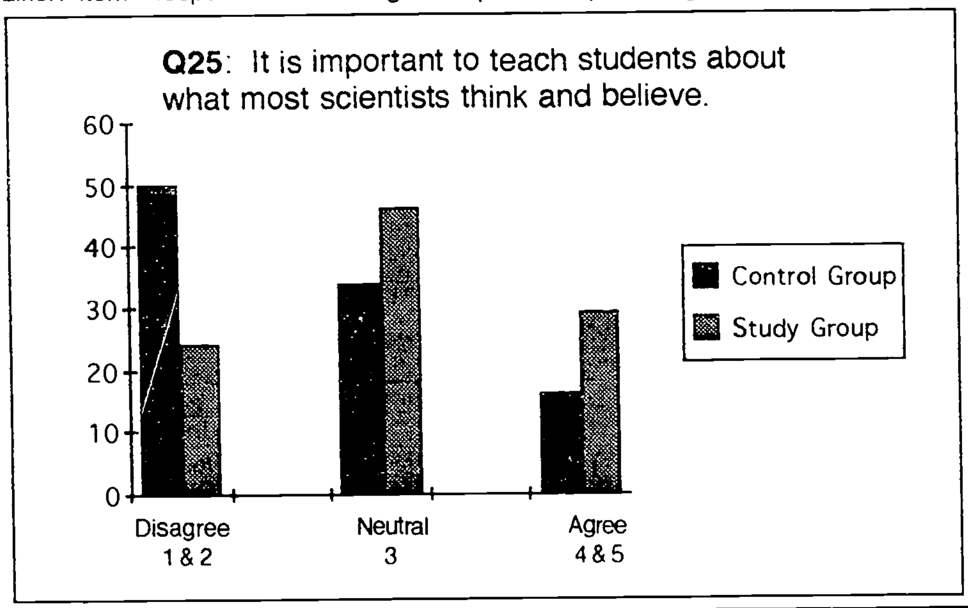
Teacher Beliefs about Science:
(Continued)

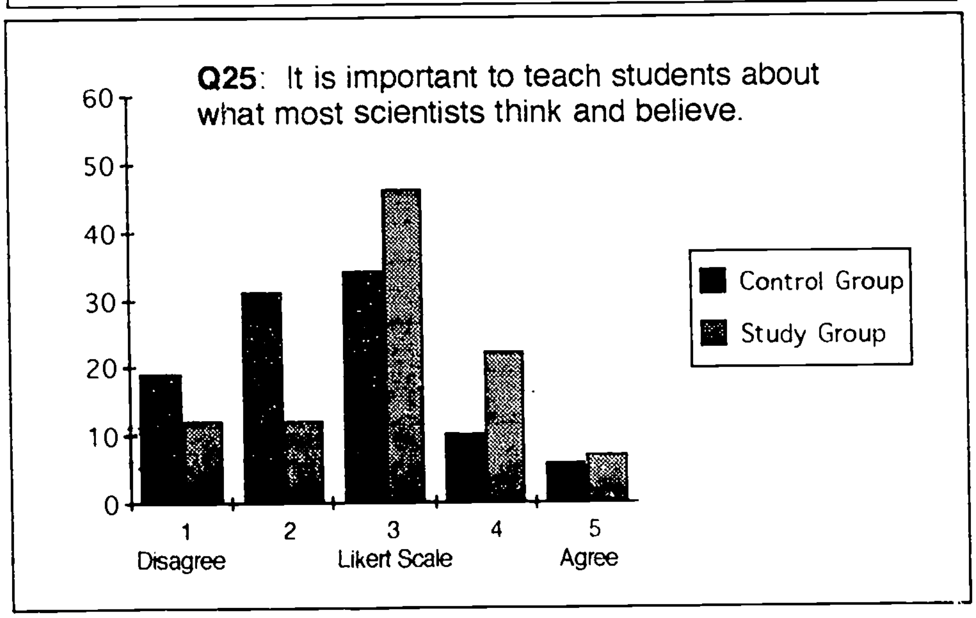
25. It is important to teach students about what most scientists think and believe.
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
2.6		3.0		(0.4)

Likert Item Response: Percentage Comparison. (1 = disagree to 5 = agree)





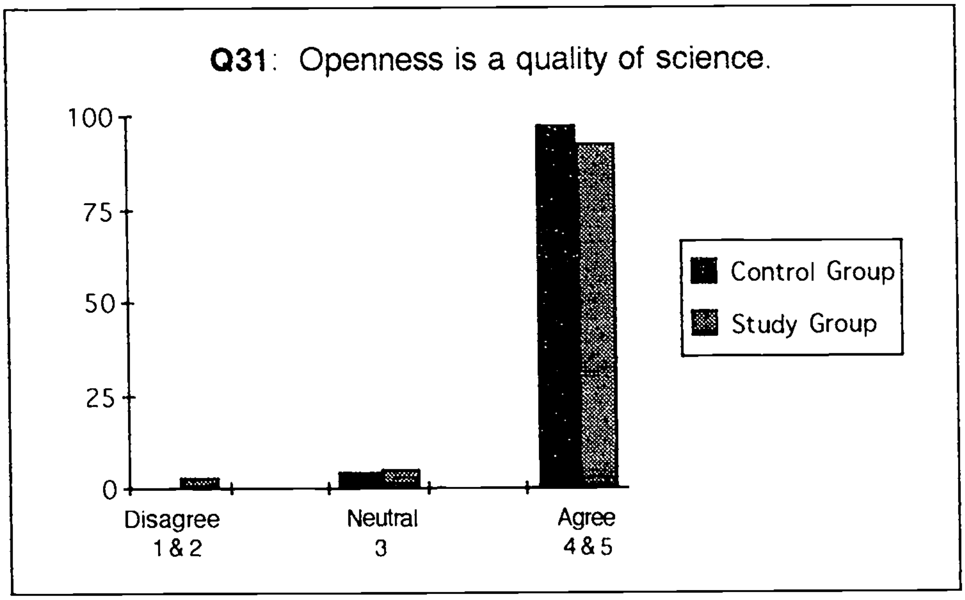
Teacher Beliefs about Science:
(Continued)

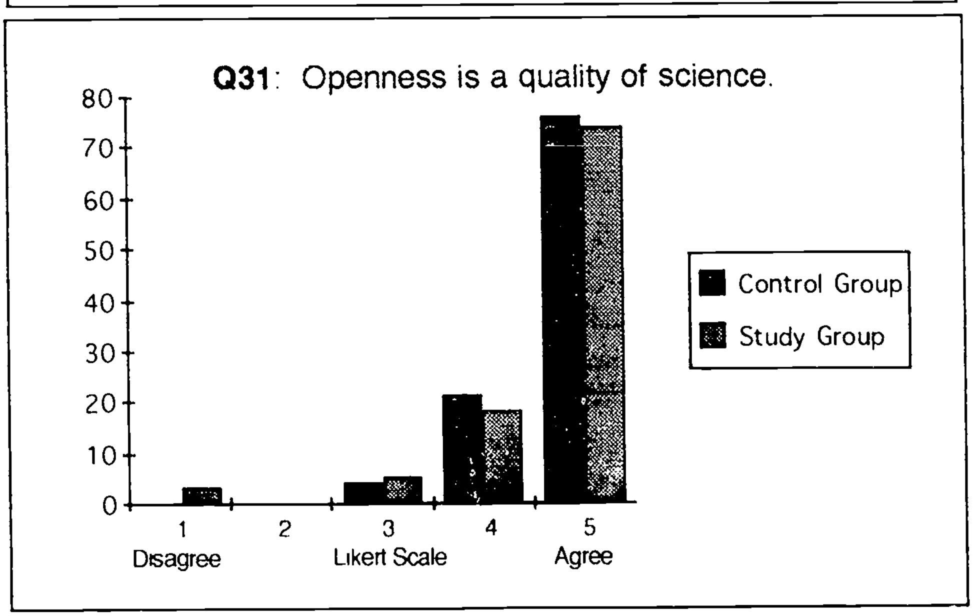
31. Openness is a quality of science.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
4.7		4.6		0.1

Likert Item Response: Percentage Comparison: (1 = disagree to 5 = agree)





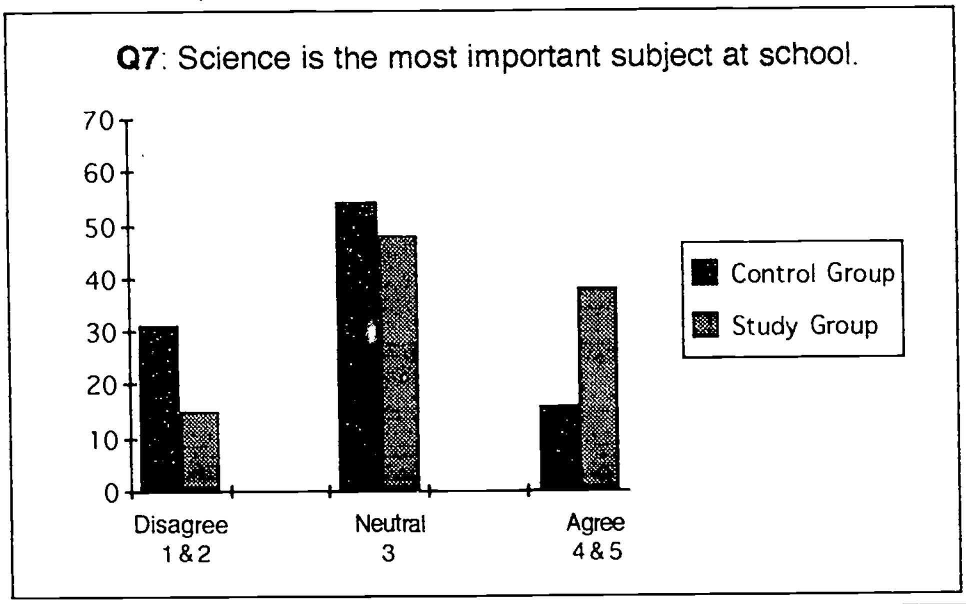
Beliefs about Teaching Science:
(5 point Likert questions):

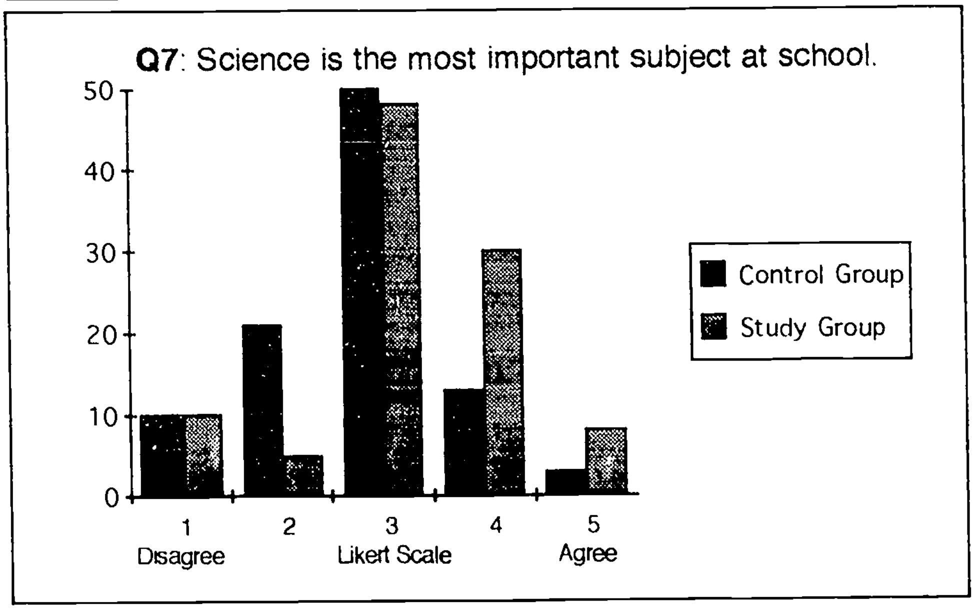
7. Science is the most important subject at school.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group	Study Group	Difference
3.4	3.2	0.2

Likert Item Response: Percentage Comparison: (1 = disagree to 5 = agree)





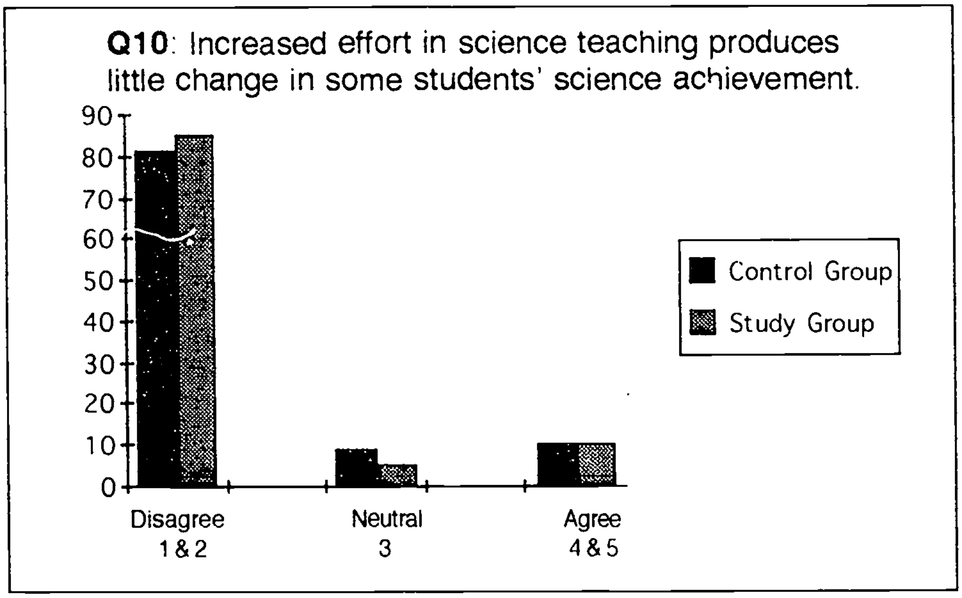
Beliefs about Teaching Science:
(continued):

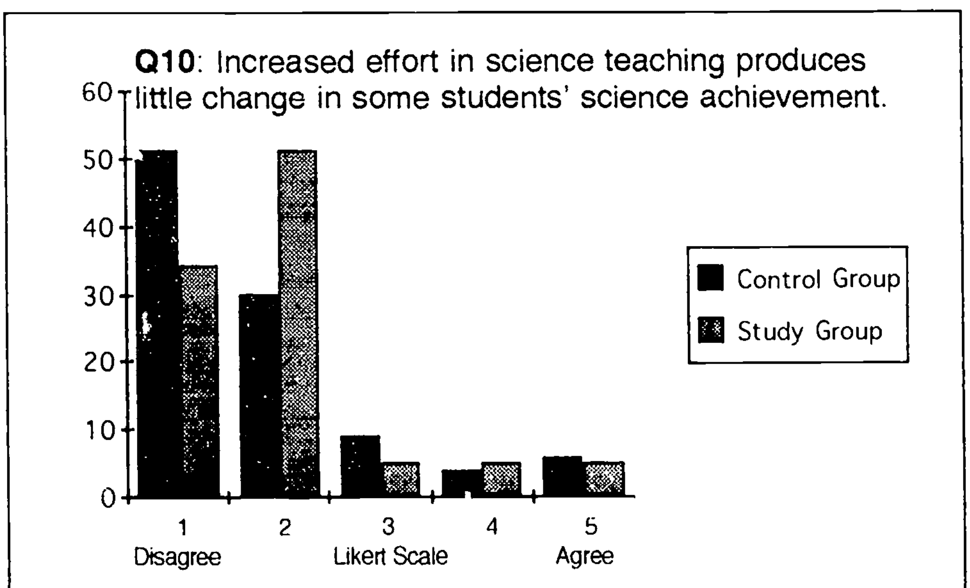
10. Increased effort in science teaching produces little change in some students' science achievement.
(Expected Study group disagreement)

Likert Total Response· Average Comparison

Control Group		Study Group		Difference
1.9		2.0		(0.1)

Likert Item Response. Percentage Comparison: (1 = disagree to 5 = agree)





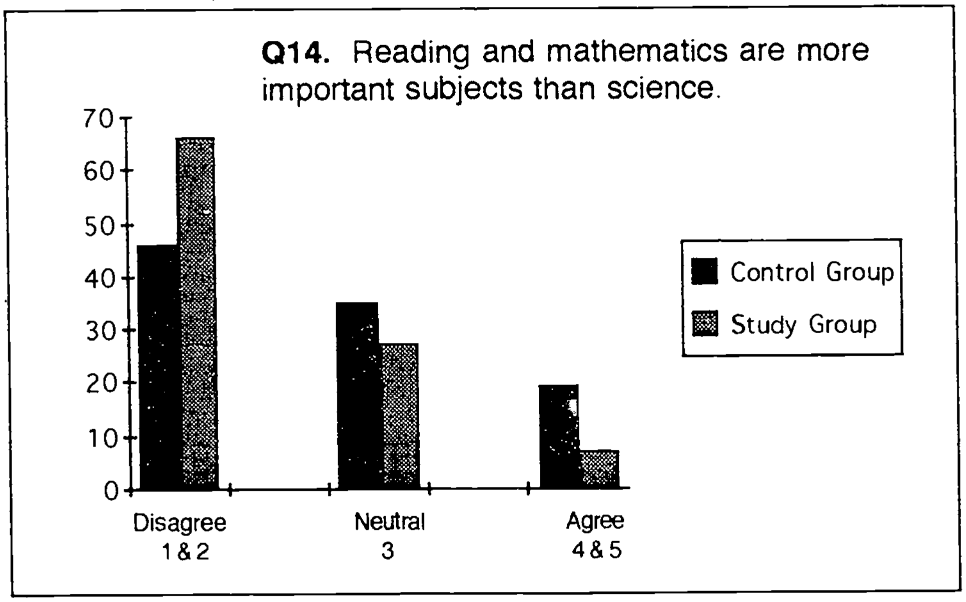
Beliefs about Teaching Science:
(continued):

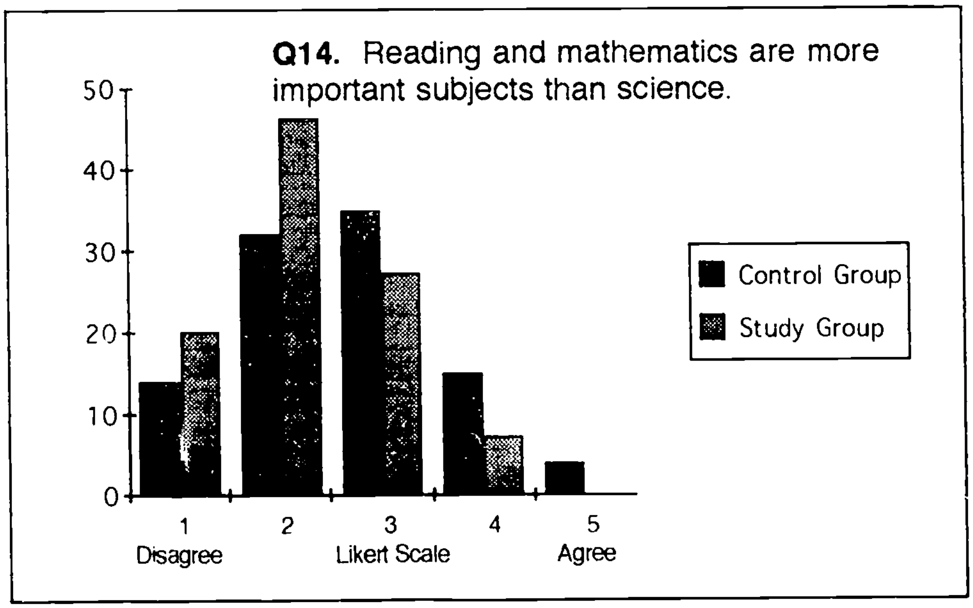
14. **Reading and ma ıematics are more important subjects than science.**
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
2.6		2.2		0.4

Likert Item Response. Percentage Comparison: (1 = disagree to 5 = agree)





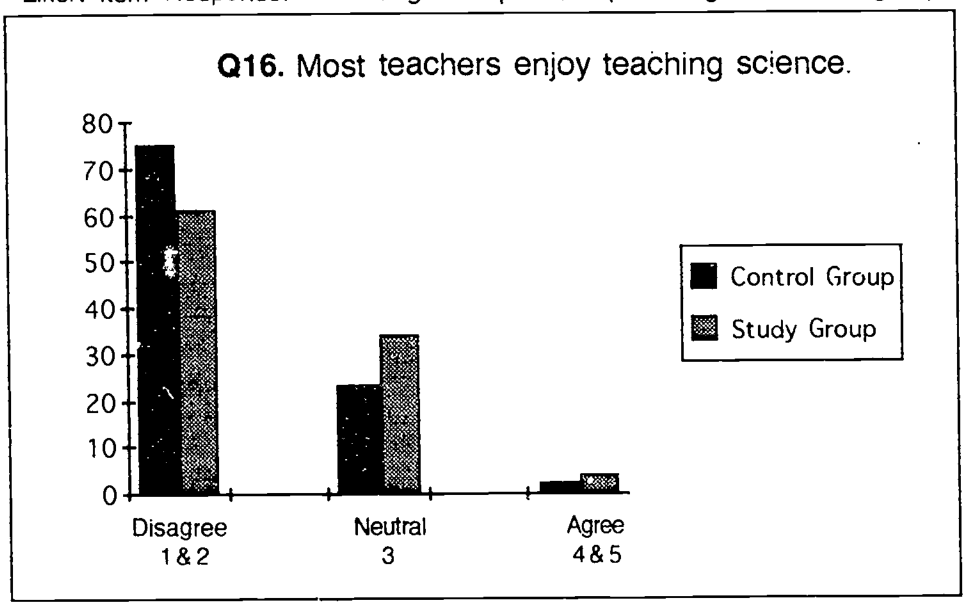
Beliefs about Teaching Science:
(continued):

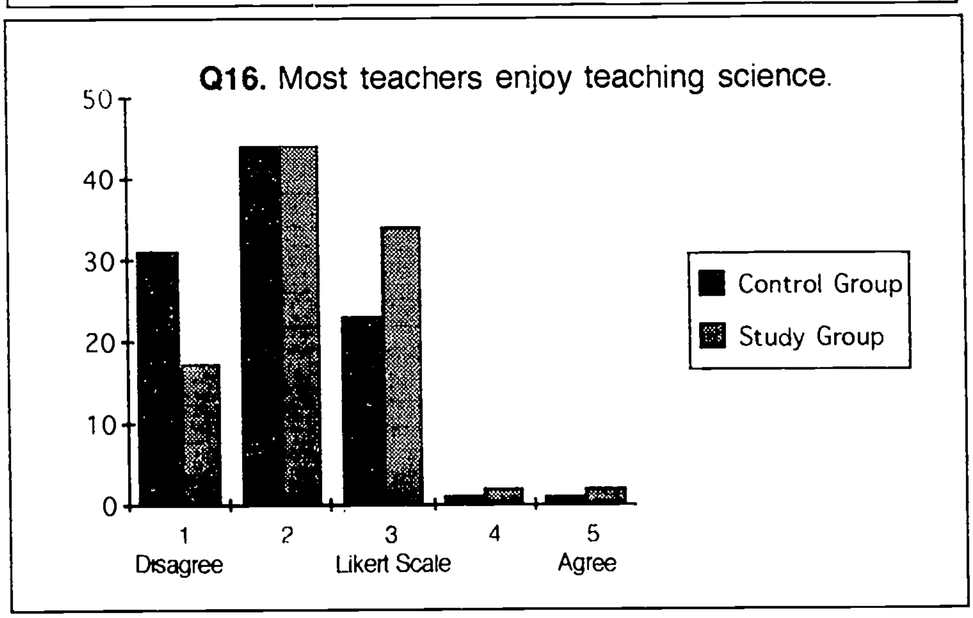
16. Most teachers enjoy teaching science.
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
2.0		2.3		(0.3)

Likert Item Response: Percentage Comparison: (1 = disagree to 5 = agree)





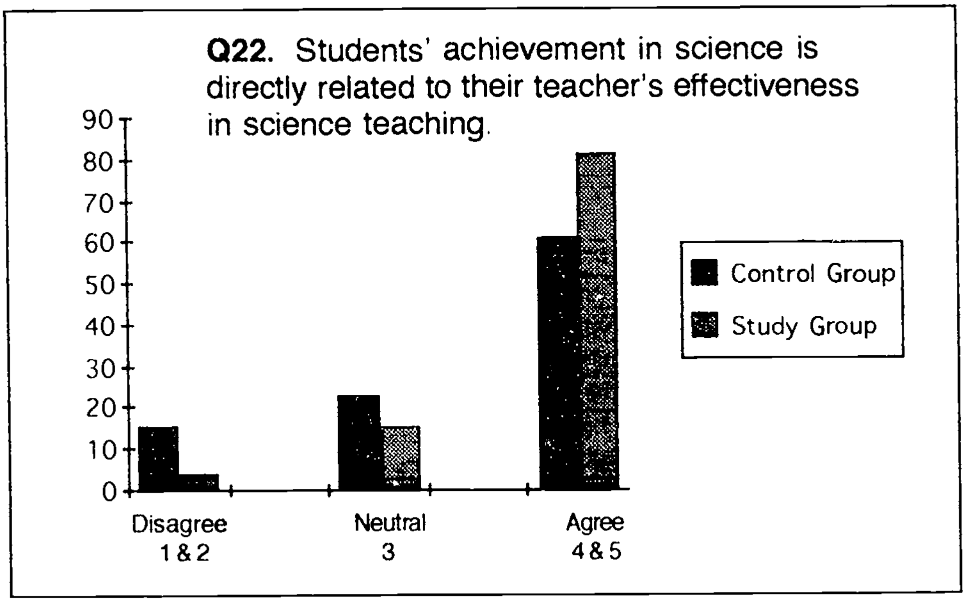
Beliefs about Teaching Science:
(continued):

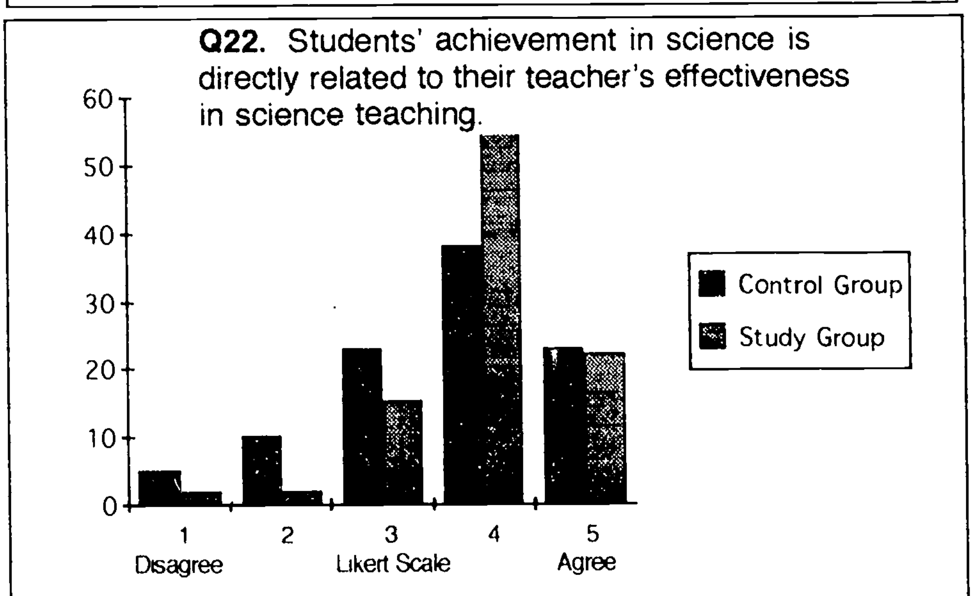
22. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
3.6		4.0		(0.4)

Likert Item Response: Percentage Comparison: (1 = disagree to 5 = agree)





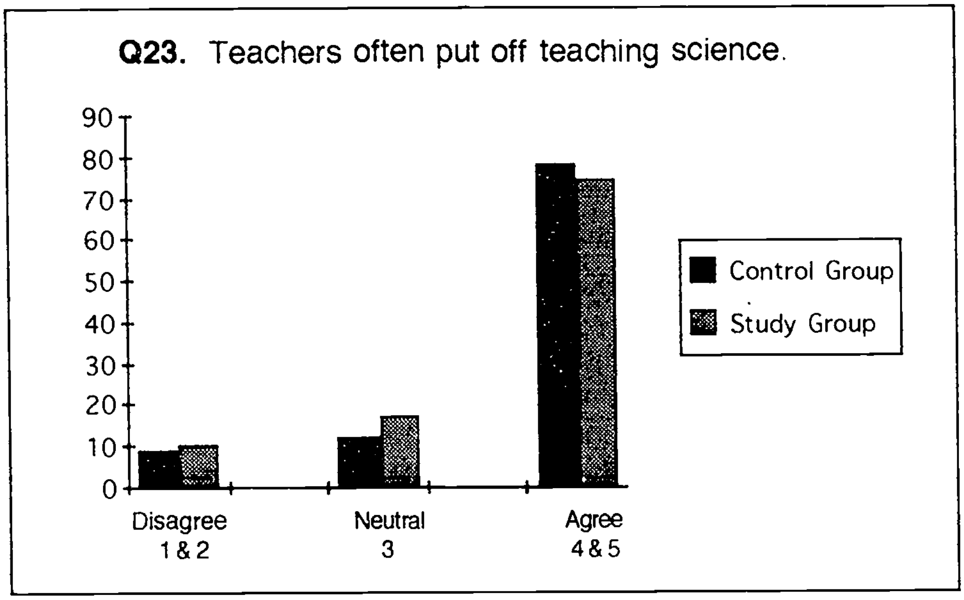
Beliefs about Teaching Science:
(continued):

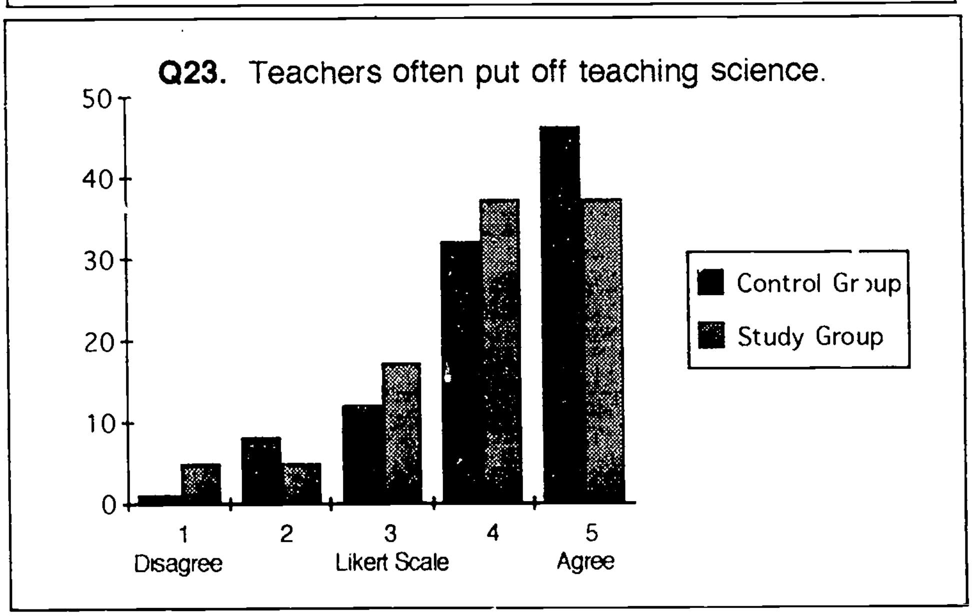
23. Teachers often put off teaching science.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
4.1		4.0		0.1

Likert Item Response: Percentage Comparison: (1 = disagree to 5 = agree)





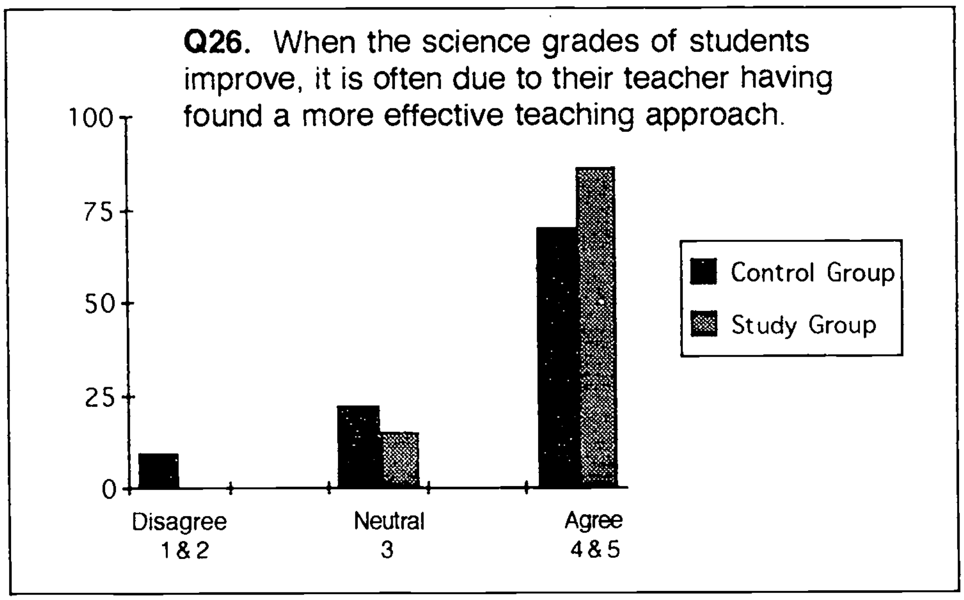
Beliefs about Teaching Science:
(continued):

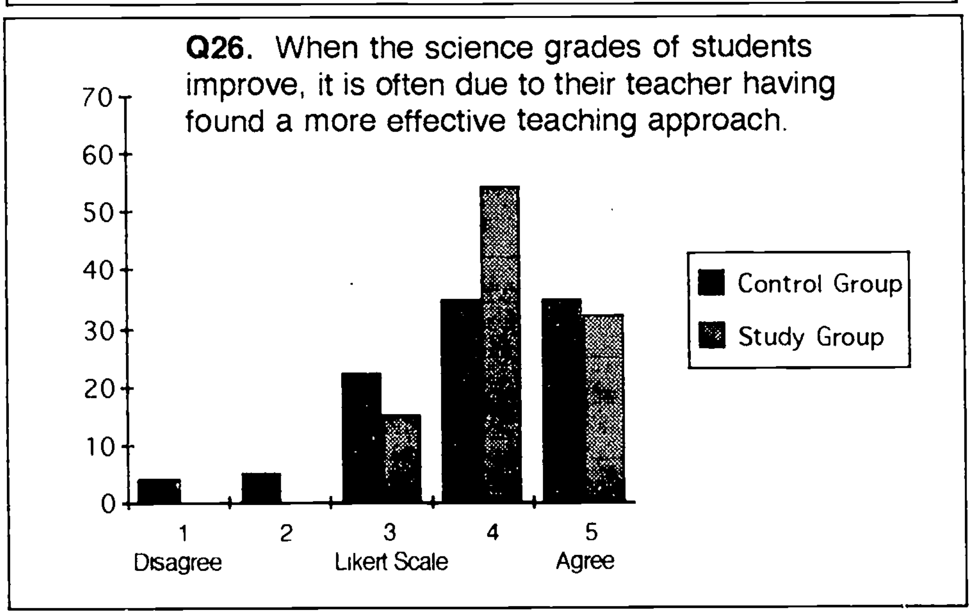
26. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
3.9		4.2		(0.3)

Likert Item Response: Percentage Comparison: (1 = disagree to 5 = agree)





Statements Regarding Teacher Confidence:

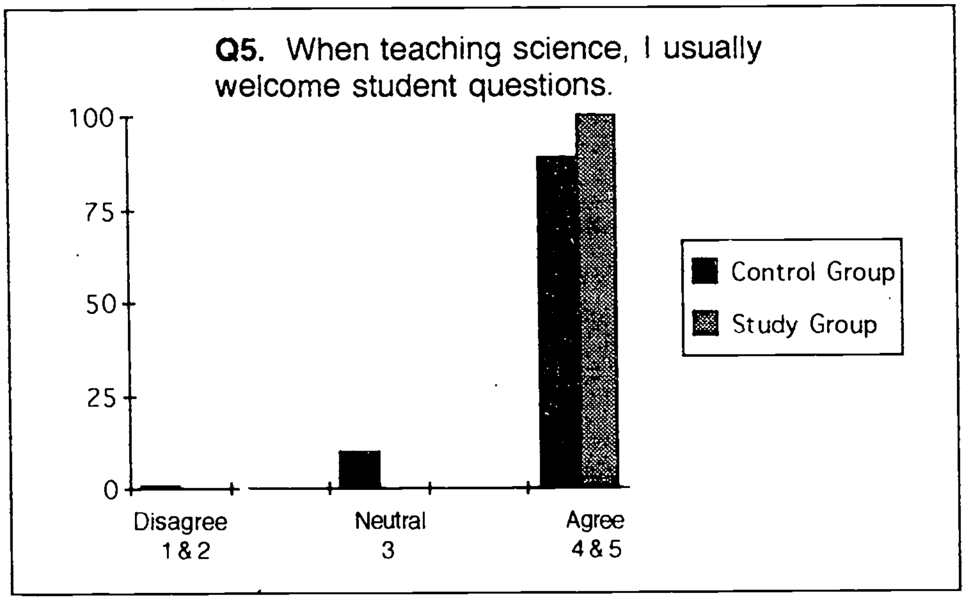
(5 point Likert questions):

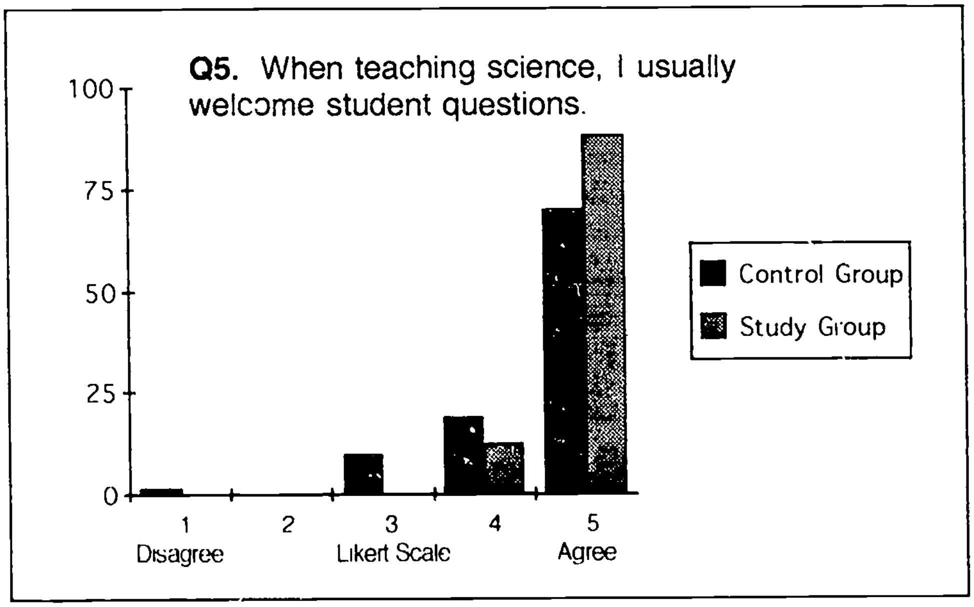
5. When teaching science, I usually welcome student questions.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
4.6		4.9		(0.3)

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





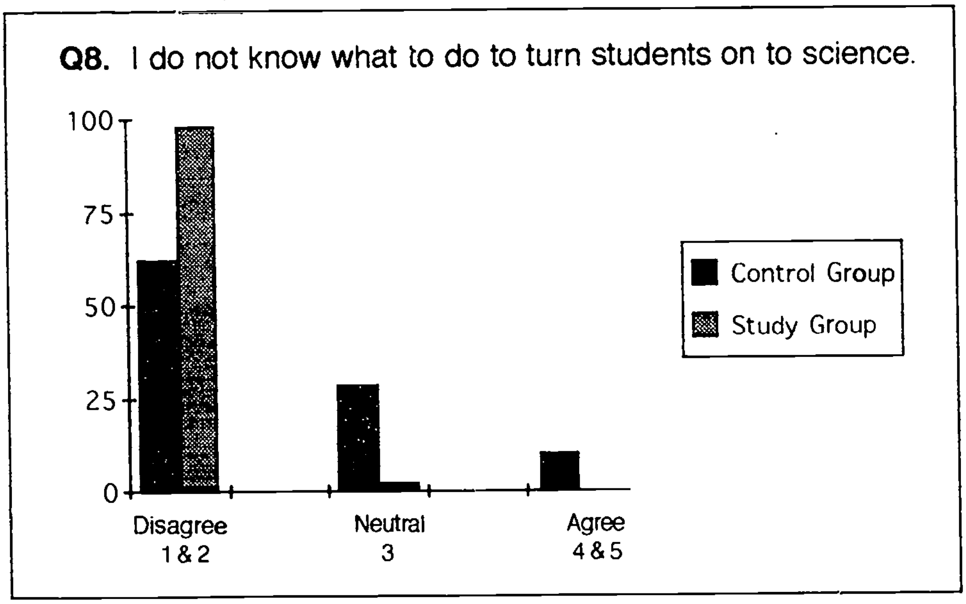
Statements Regarding Teacher Confidence:
(continued)

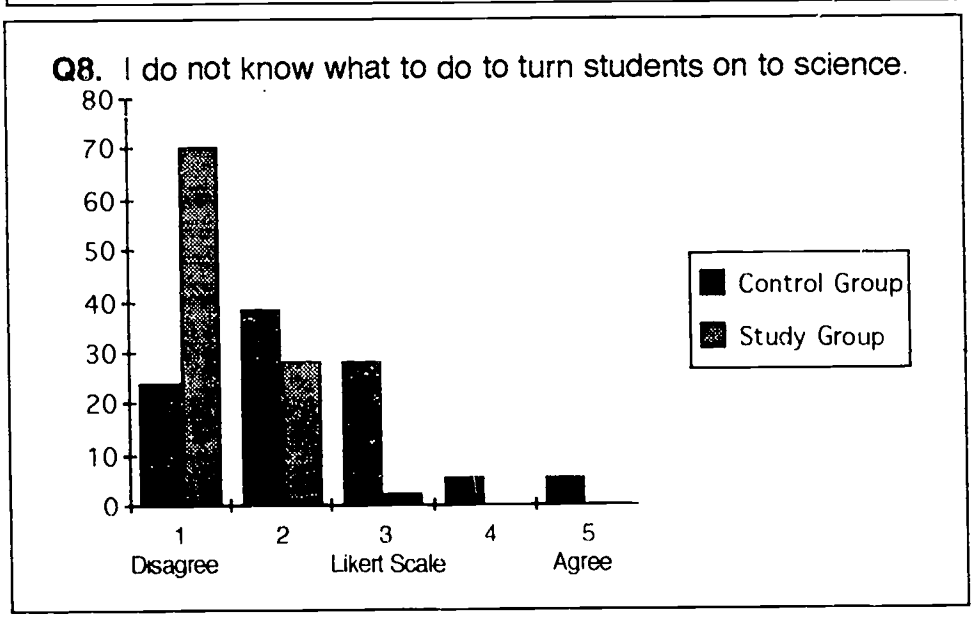
8. I do not know what to do to turn students on to science.
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
2.3		1.3		1.0

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





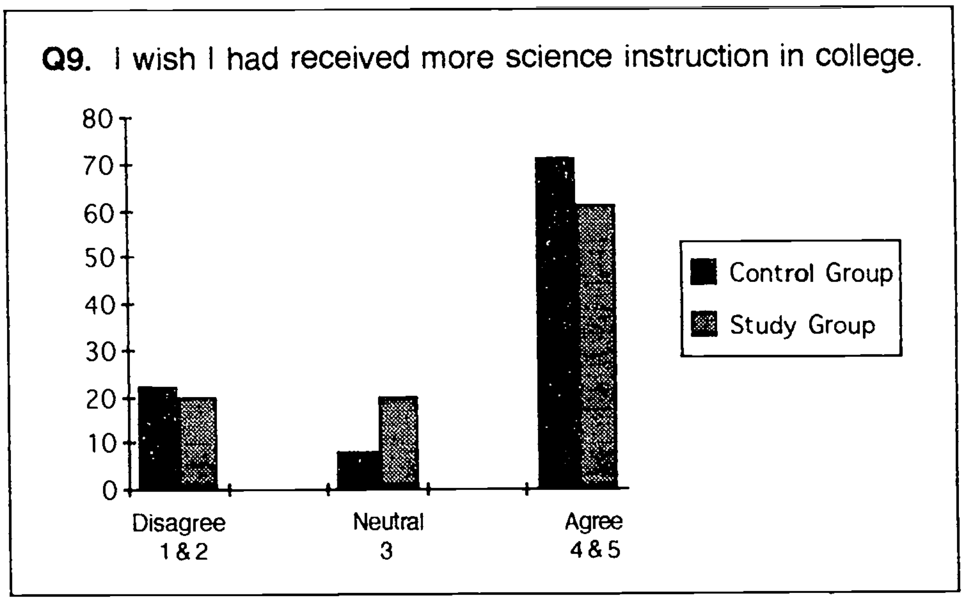
Statements Regarding Teacher Confidence:
(continued)

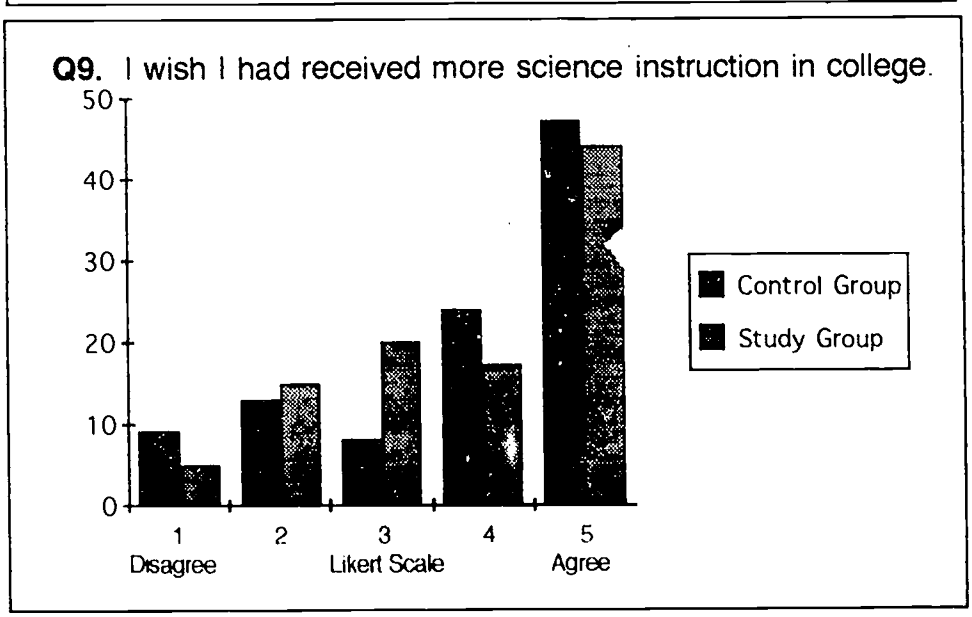
9. I wish I had received more science instruction in college.
(Expected Study group disagreement)

Likert Total Response. Average Comparison

Control Group		Study Group		Difference
3.9		3.8		0.1

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





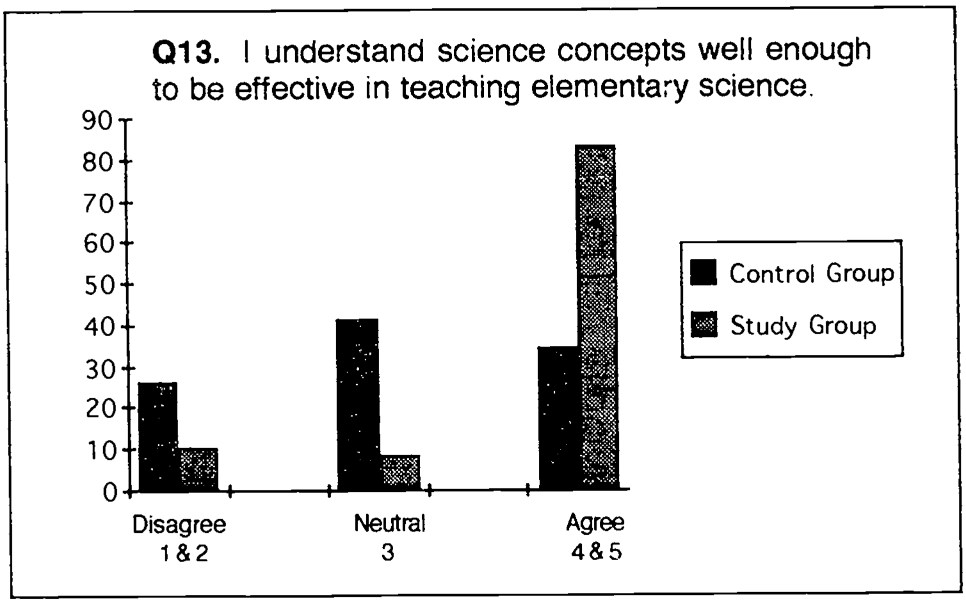
Statements Regarding Teacher Confidence:
(continued)

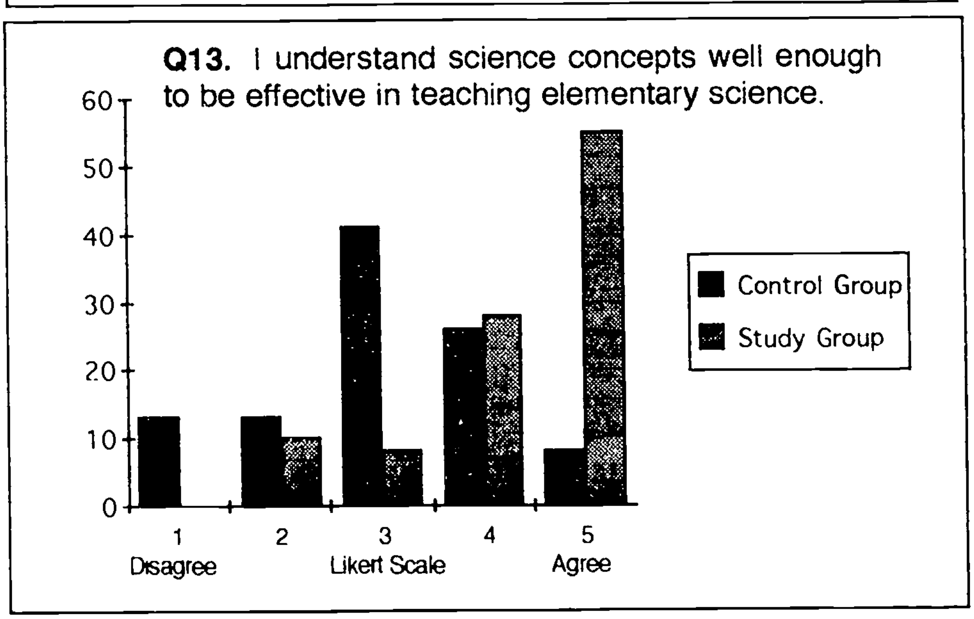
13. I understand science concepts well enough to be effective in teaching elementary science.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
3.1		4.3		(1.2)

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





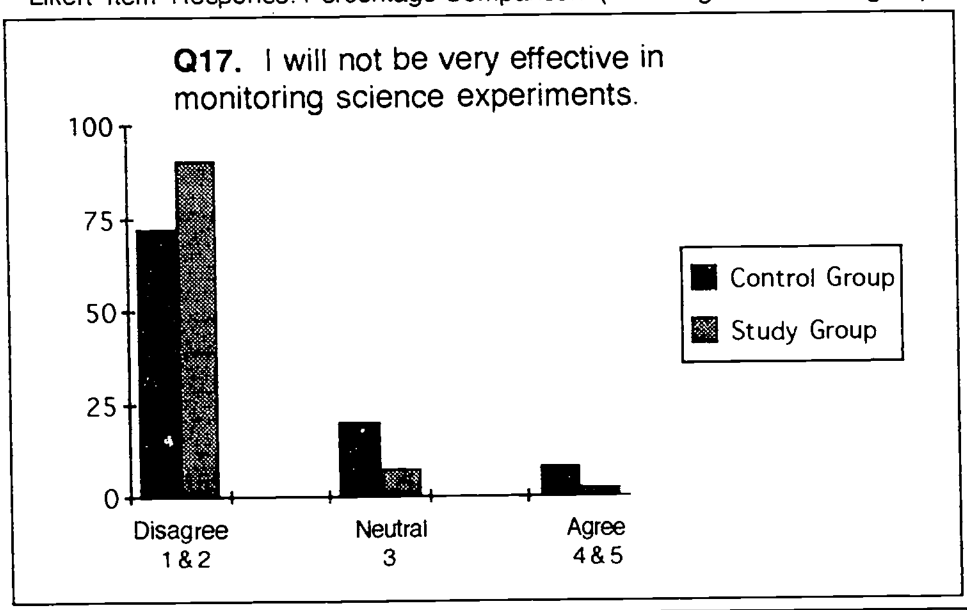
Statements Regarding Teacher Confidence:
(continued)

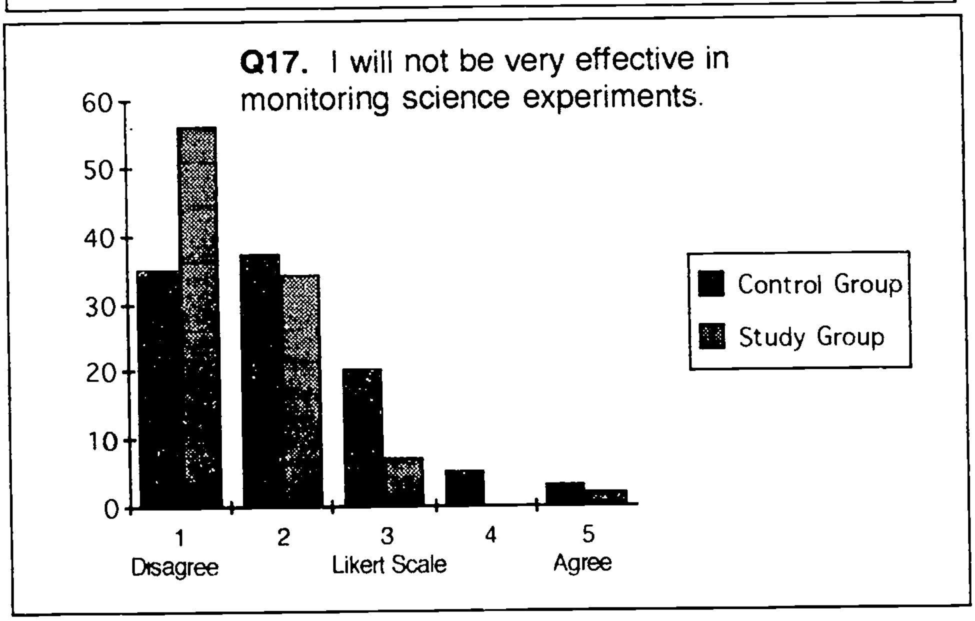
17. I will not be very effective in monitoring science experiments.
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group	Study Group	Difference
2.0	1.6	0.4

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





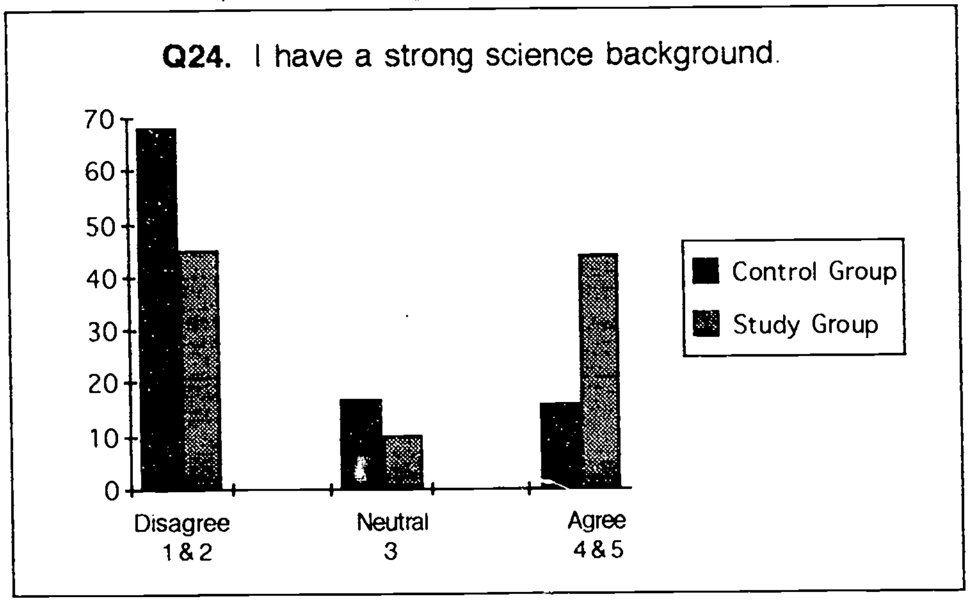
Statements Regarding Teacher Confidence:
(continued)

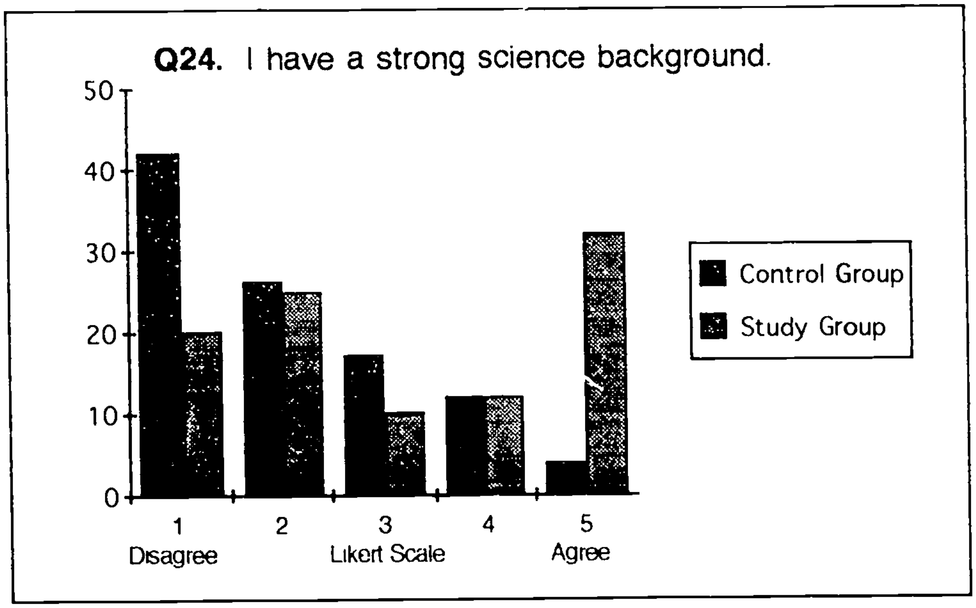
24. I have a strong science background.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
2.1		3.1		(1.0)

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





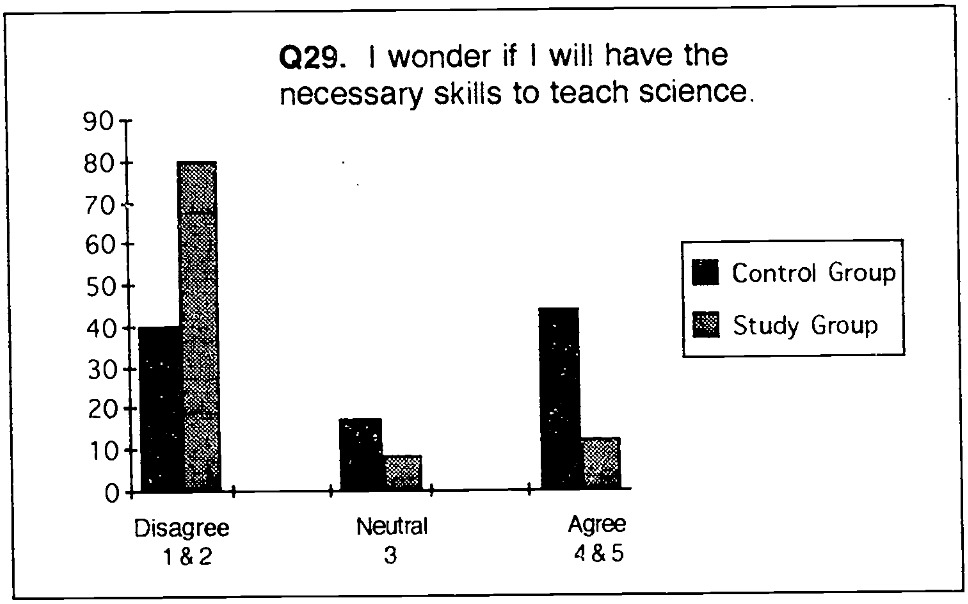
Statements Regarding Teacher Confidence:
(continued)

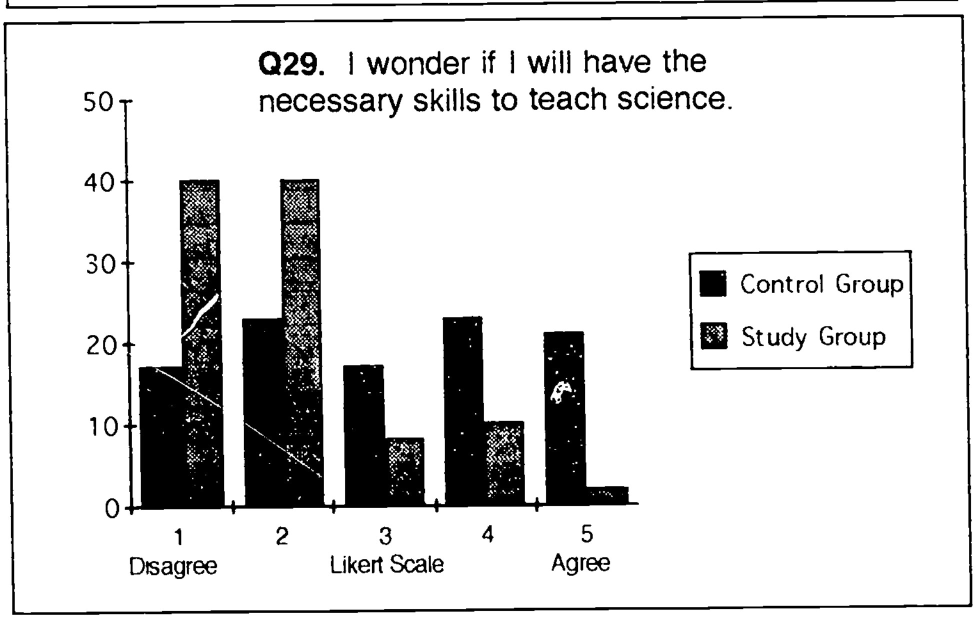
29. I wonder if I will have the necessary skills to teach science.
(Expected Study group disagreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
3.1		2.0		1.1

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





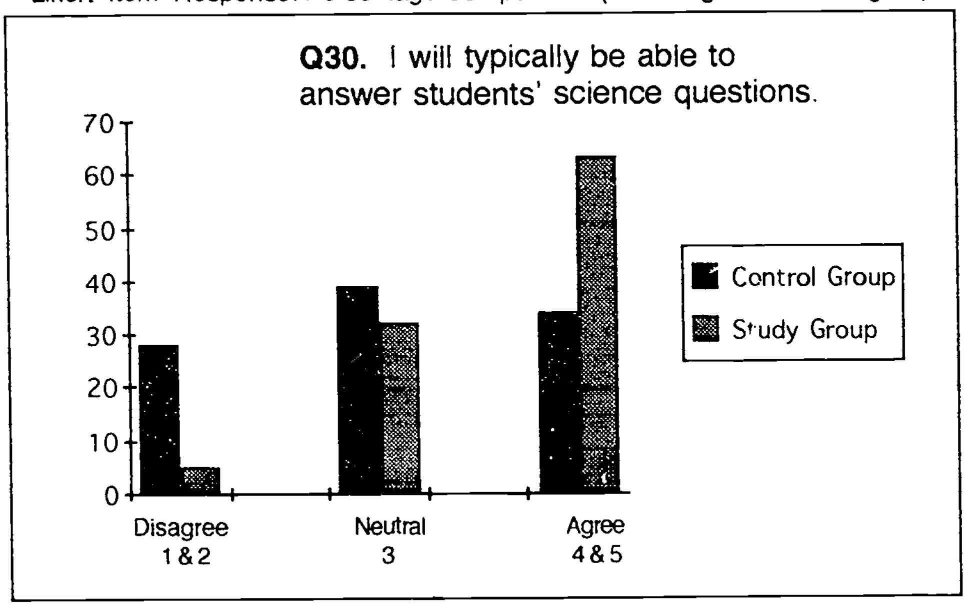
Statements Regarding Teacher Confidence:
(continued)

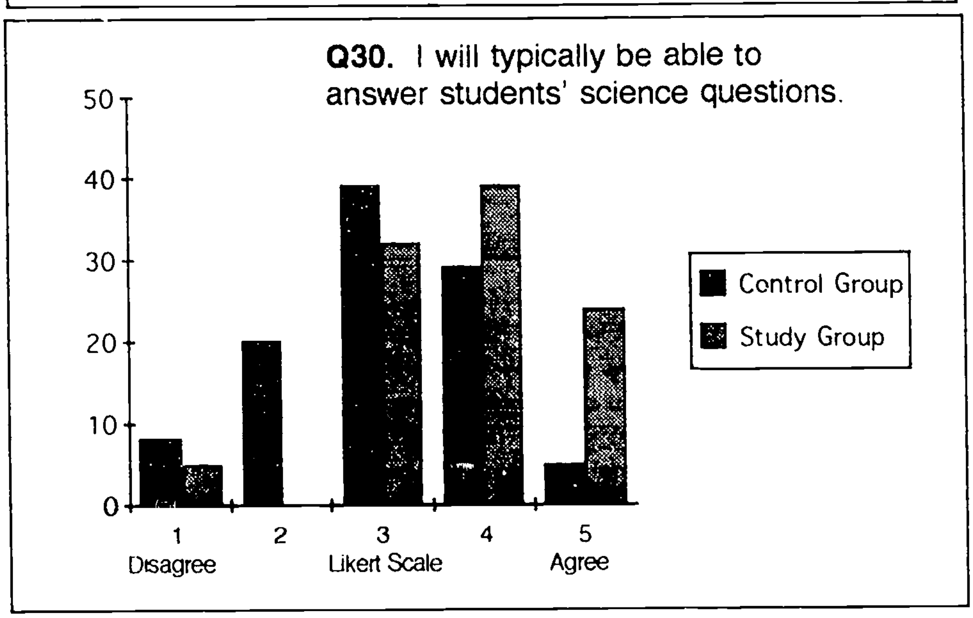
30. I will typically be able to answer students' science questions.
(Expected Study group agreement)

Likert Total Response: Average Comparison

Control Group		Study Group		Difference
3.0		3.8		(0.8)

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





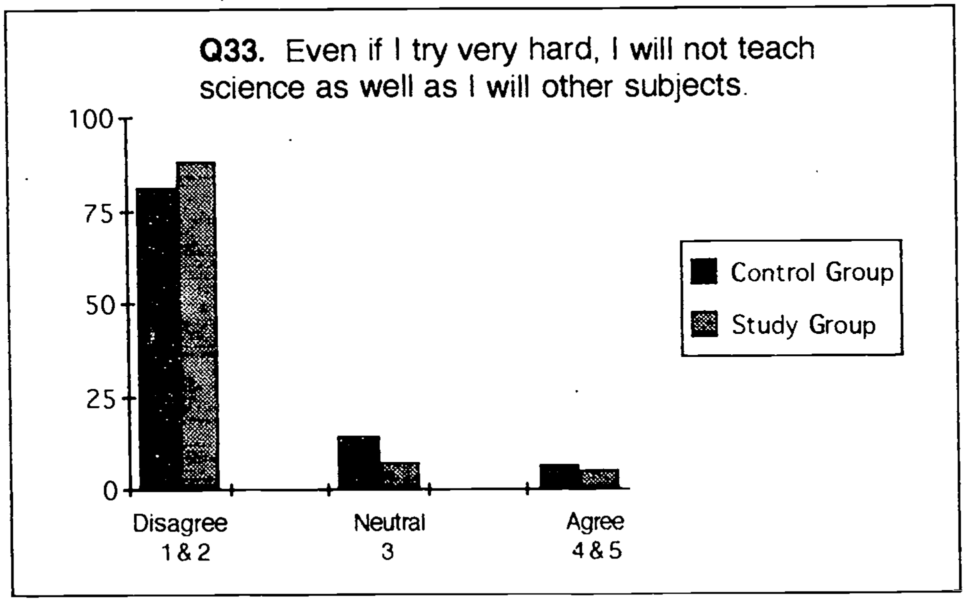
Statements Regarding Teacher Confidence:
(continued)

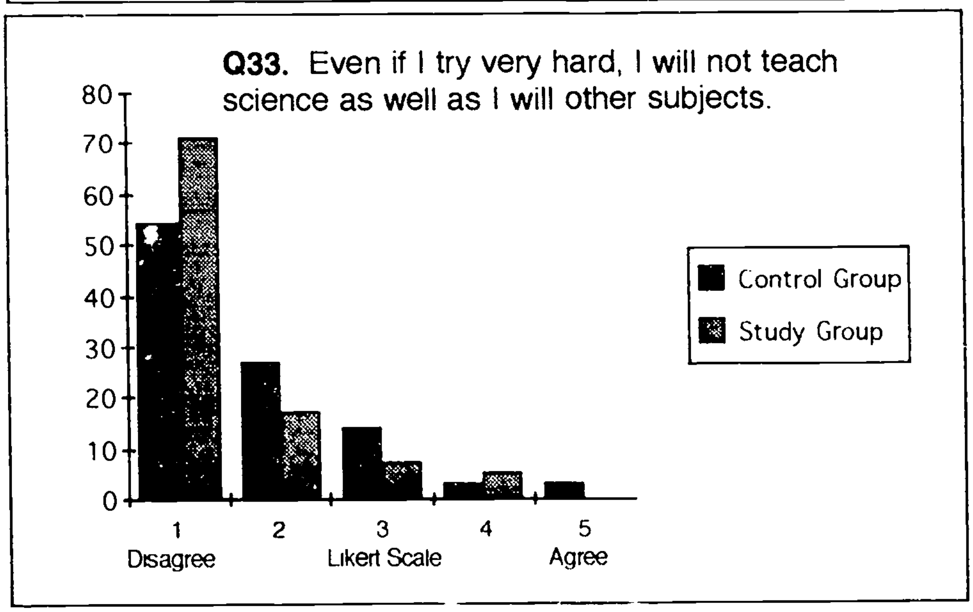
33. Even if I try very hard, I will not teach science as well as I will other subjects.
(Expected Study group disagreement)

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
1.7		1.5		0.2

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





Statements Regarding Teacher Confidence:
(continued)

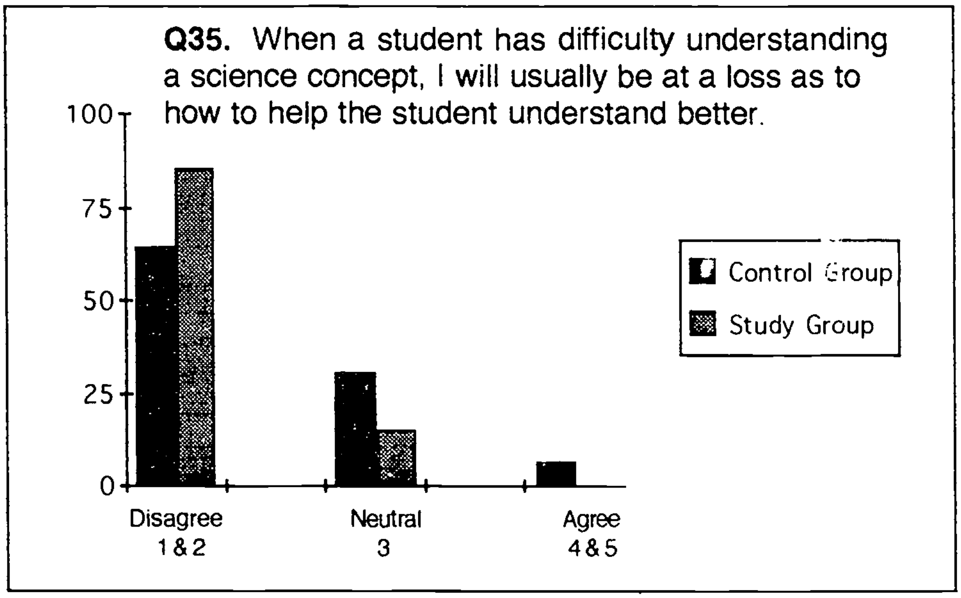
35. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand better.

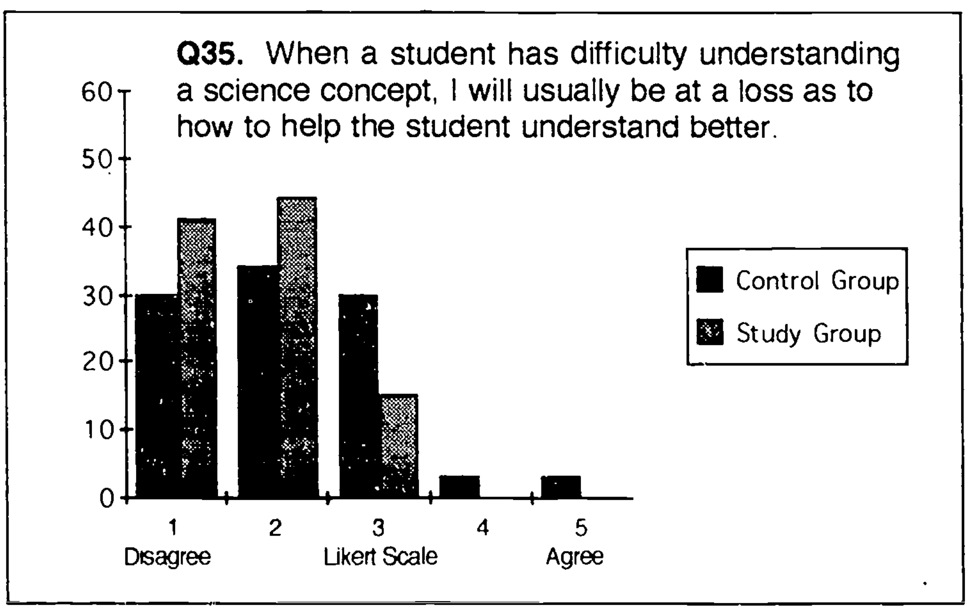
(Expected Study group disagreement)

Likert Total Response Average Comparison:

Control Group	Study Group	Difference
2.1	1.7	0.4

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





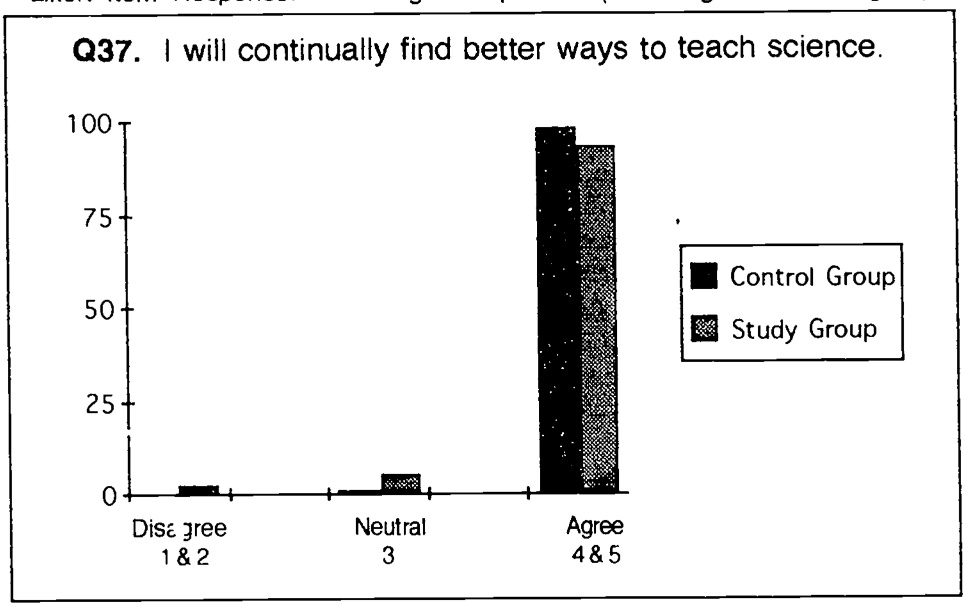
Statements Regarding Teacher Confidence:
(continued)

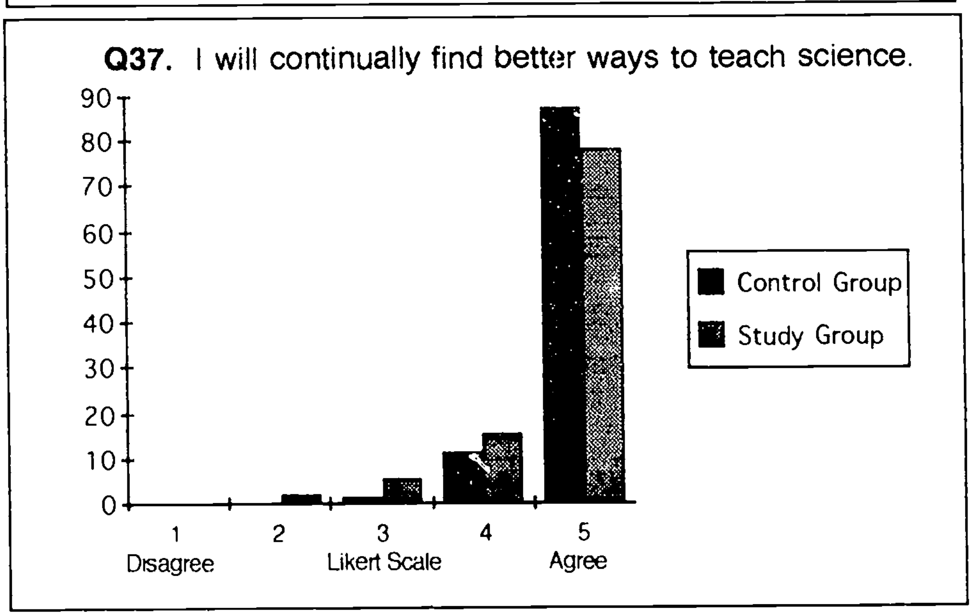
37. I will continually find better ways to teach science.
(Expected Study group agreement)

Likert Total Response Average Comparison:

Control Group	Study Group	Difference
4.9	4.7	0.2

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





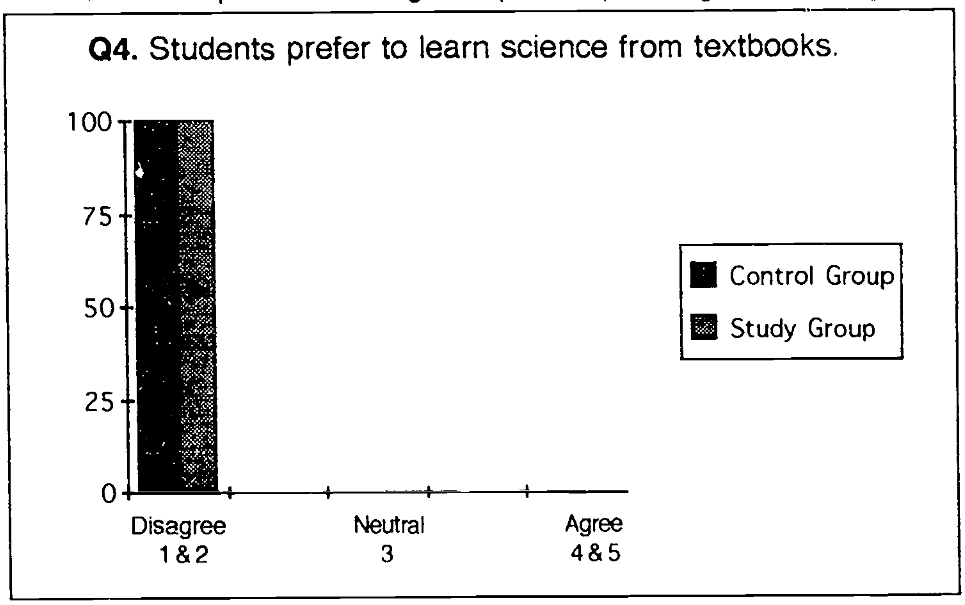
Science Teaching Methodology
Use of Hands -on:
(5 point Likert questions):

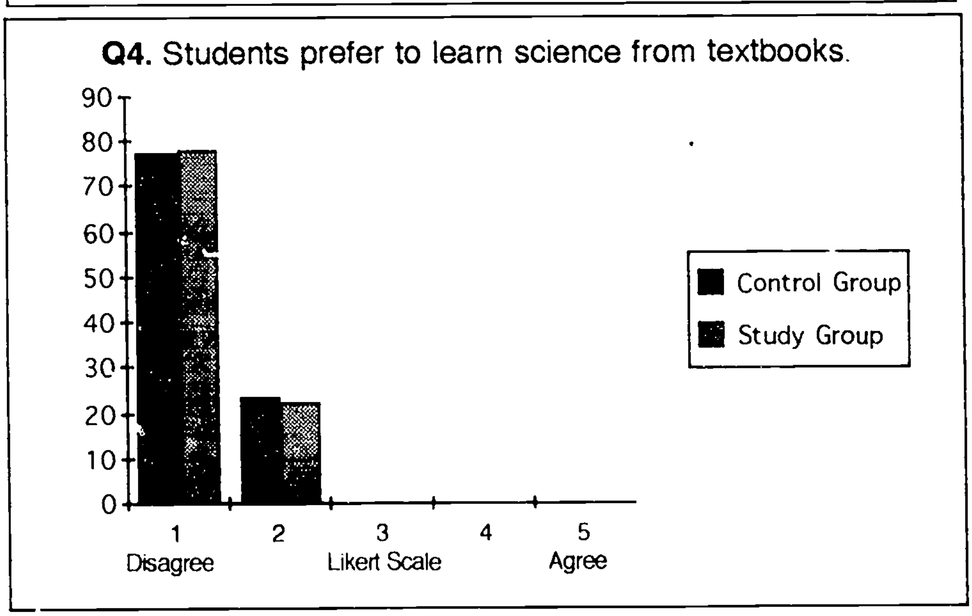
4. Students prefer to learn science from textbooks.
(Expected Study group disagreement)

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
1.3		1.2		0.1

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





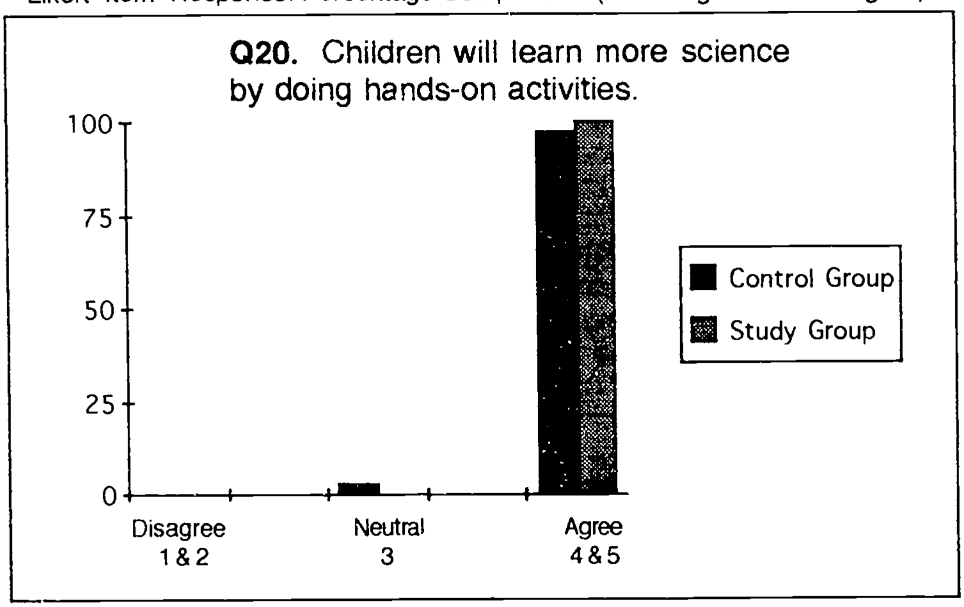
Science Teaching Methodology
Use of Hands -on:
(continued)

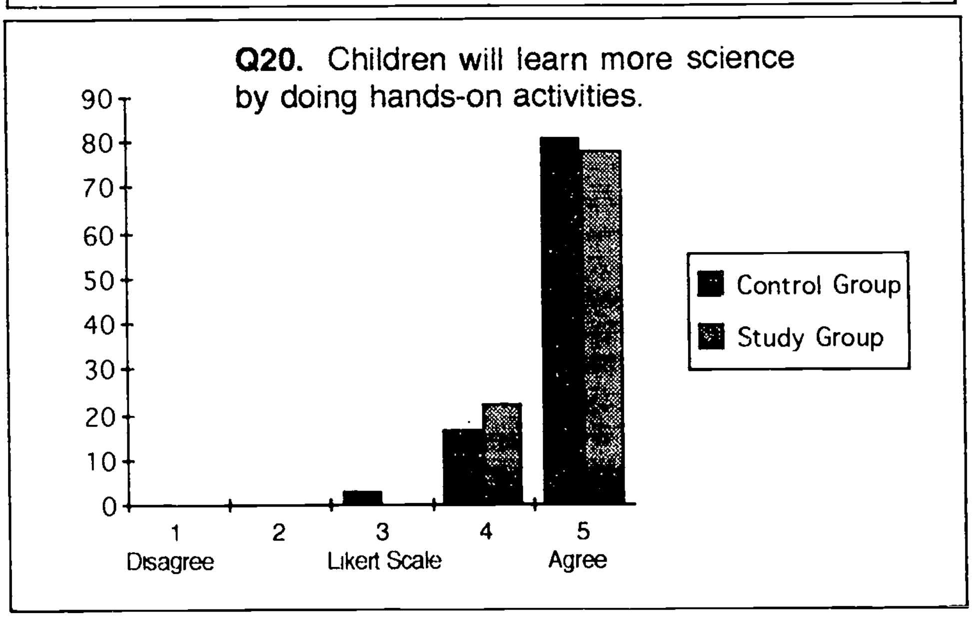
20. Children will learn more science by doing hands-on activities.
(Expected Study group agreement)

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.8		4.8		0

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





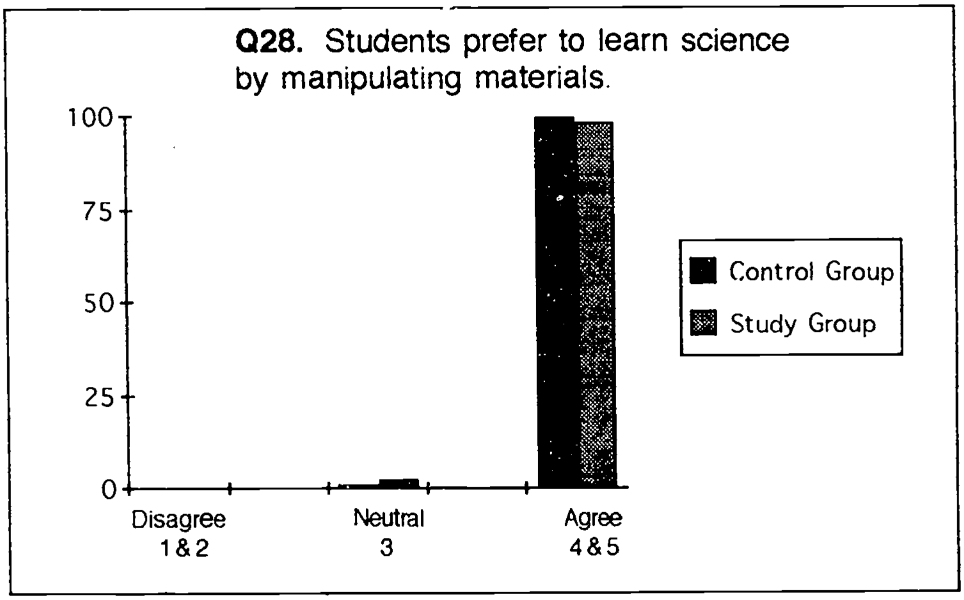
Science Teaching Methodology
Use of Hands -on:
(continued)

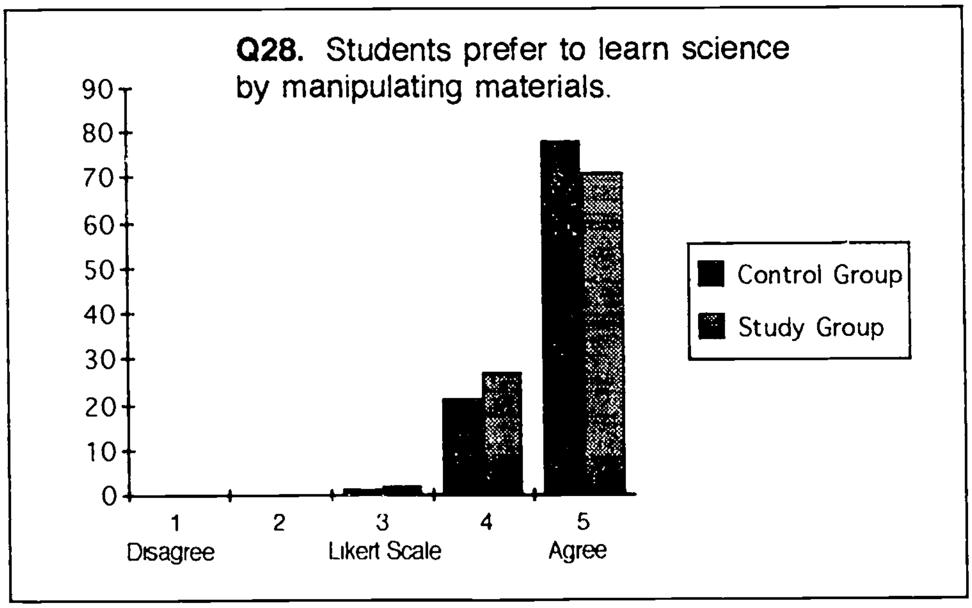
28. Students prefer to learn science by manipulating materials.
(Expected Study group agreement)

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.8		4.7		0.1

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





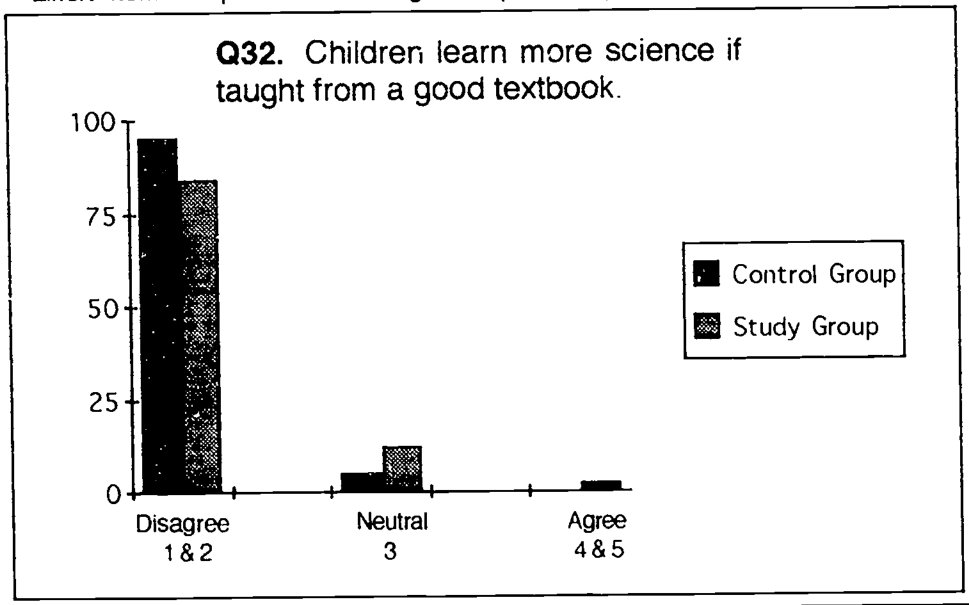
Science Teaching Methodology
Use of Hands -on:
(continued)

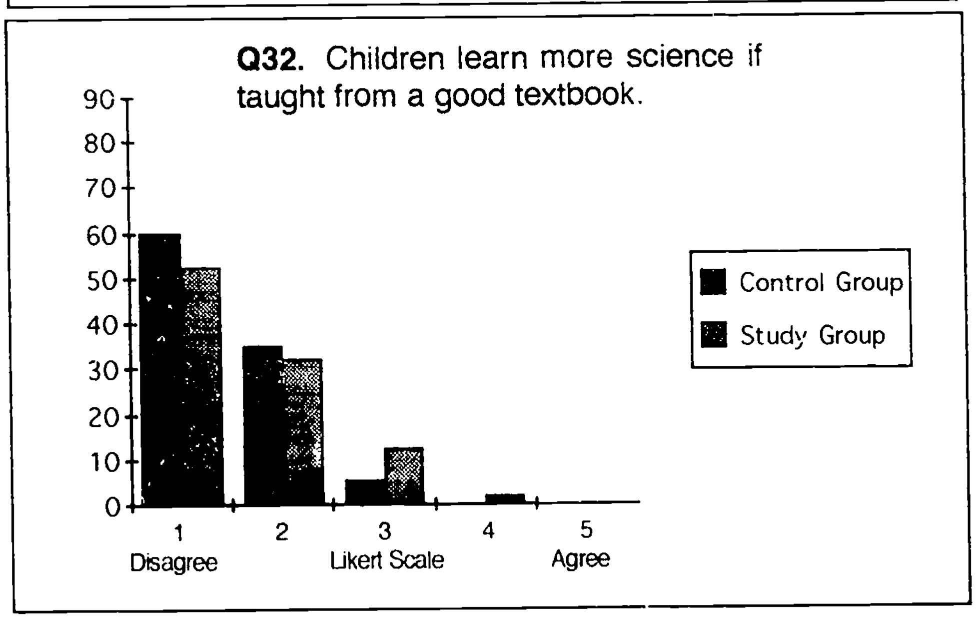
32. Children learn more science if taught from a good textbook.
(Expected Study group disagreement)

Likert Total Response Average Comparison:

Control Group	Study Group	Difference
1.5	1.6	(0.1)

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)

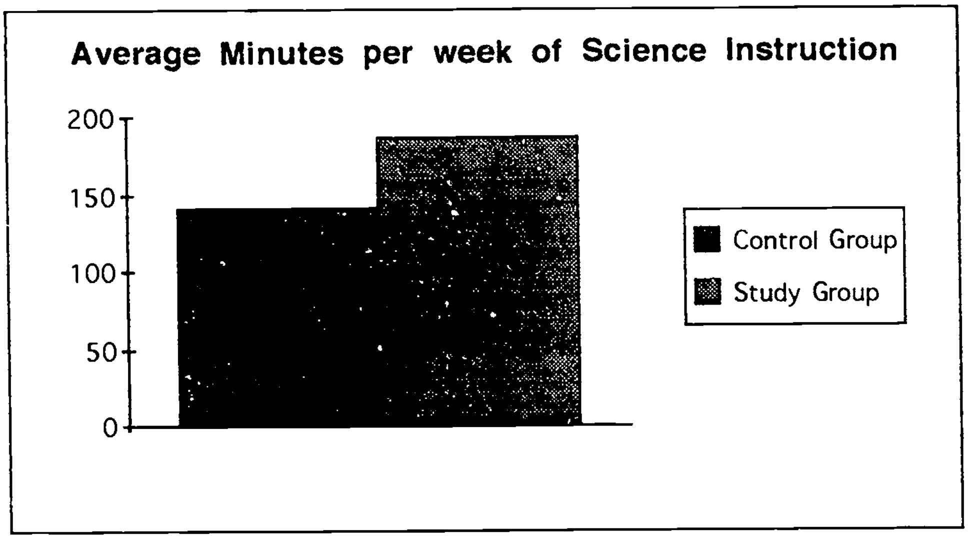




Science Teaching Methodology
Minutes Per Week
Outdoor Labs Per Year

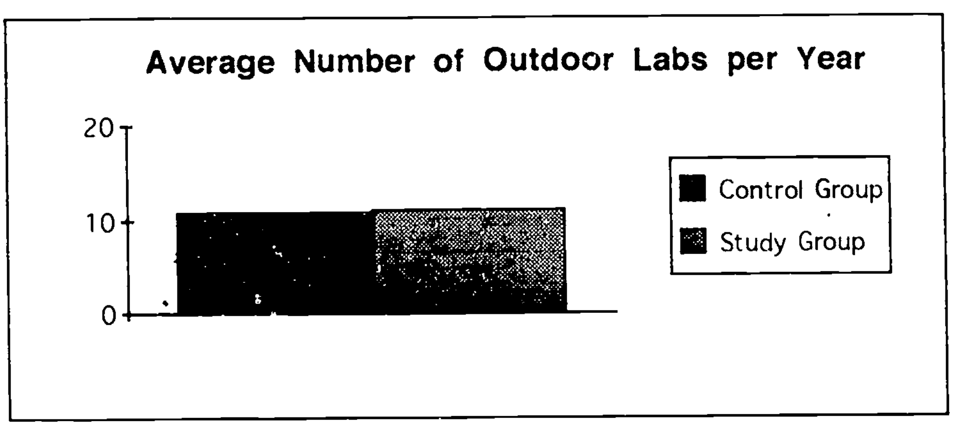
38. Time spent in teaching science in minutes per week.

Control Group		Study Group		Difference
141		186		(45)



41. Number of outdoor study labs per school year.

Control Group		Study Group		Difference
10.7		11.0		(0.3)



Science Teaching Methodology
Teaching Strategies

39. **Percent of science teaching time when method is use of "hands on."**

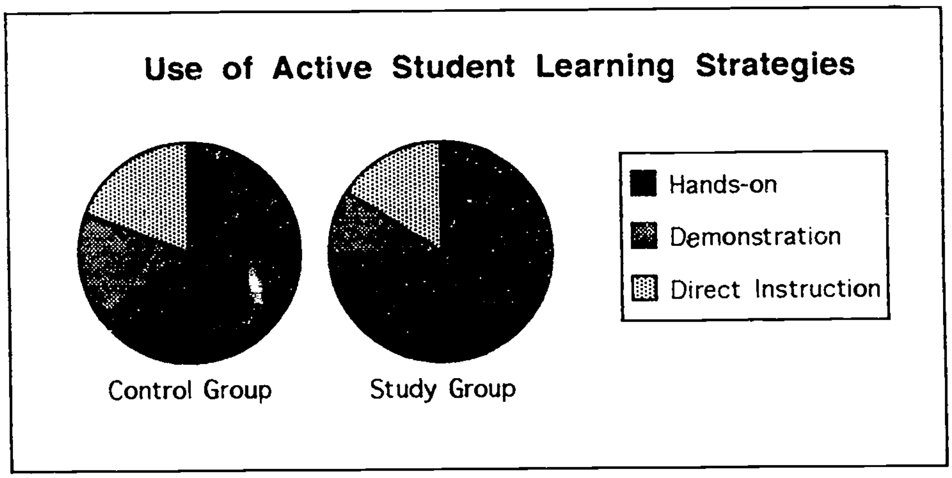
Control Group	Study Group	Difference
41%	47%	-6%

39. **Percent of science teaching time using direct instruction.**

Control Group	Study Group	Difference
10%	6%	4%

39. **Percent of science teaching time using teacher demonstration.**

Control Group	Study Group	Difference
12%	10%	2%



Science Teaching Methodology
Use of Developmental Theory
(5 point Likert questions):

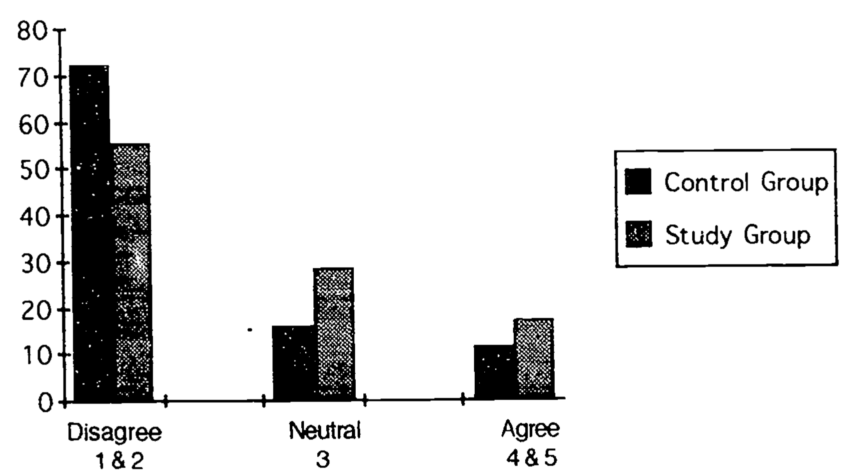
6. Adults and children learn in identical ways.
(Expected Study group disagreement)

Likert Total Response Average Comparison:

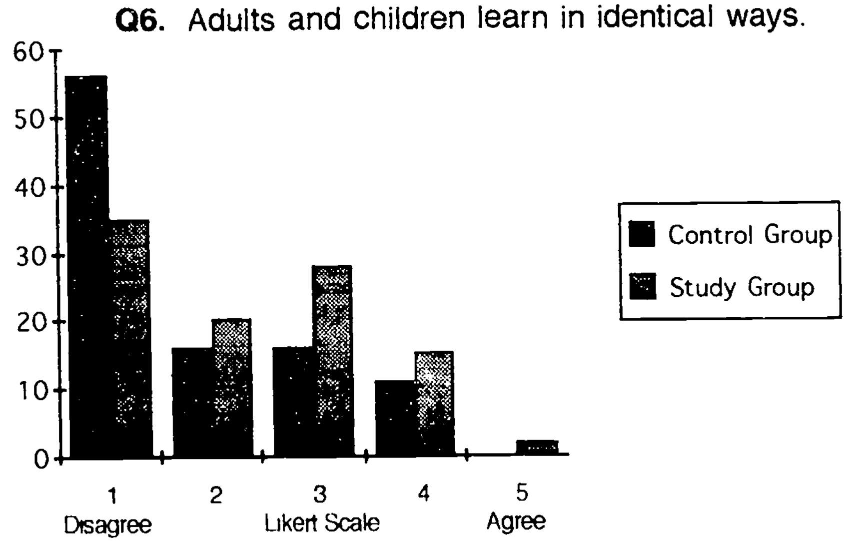
Control Group		Study Group		Difference
1.8		2.3		(0.5)

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)

Q6. Adults and children learn in identical ways.



Q6. Adults and children learn in identical ways.



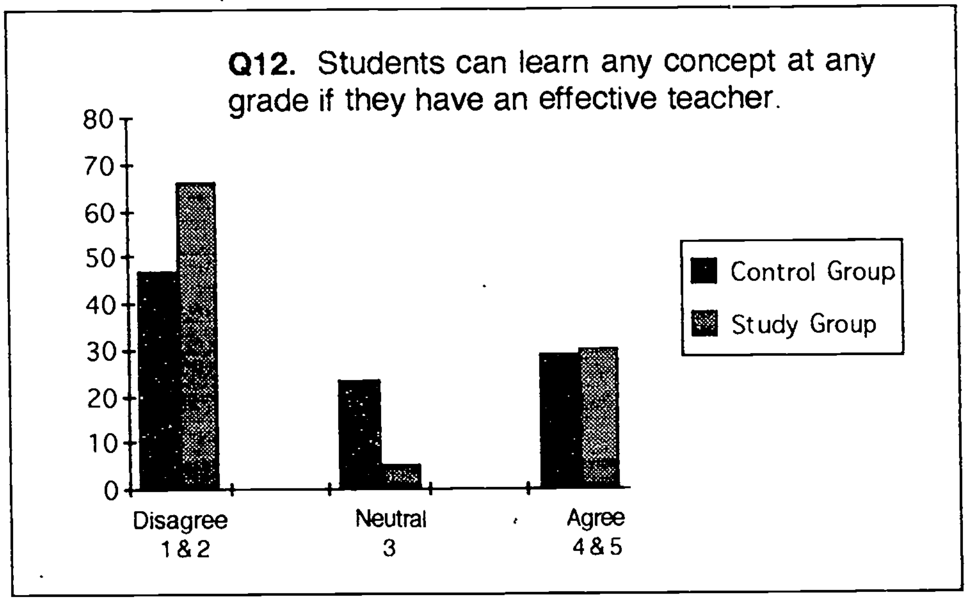
Science Teaching Methodology
Use of Developmental Theory
(continued)

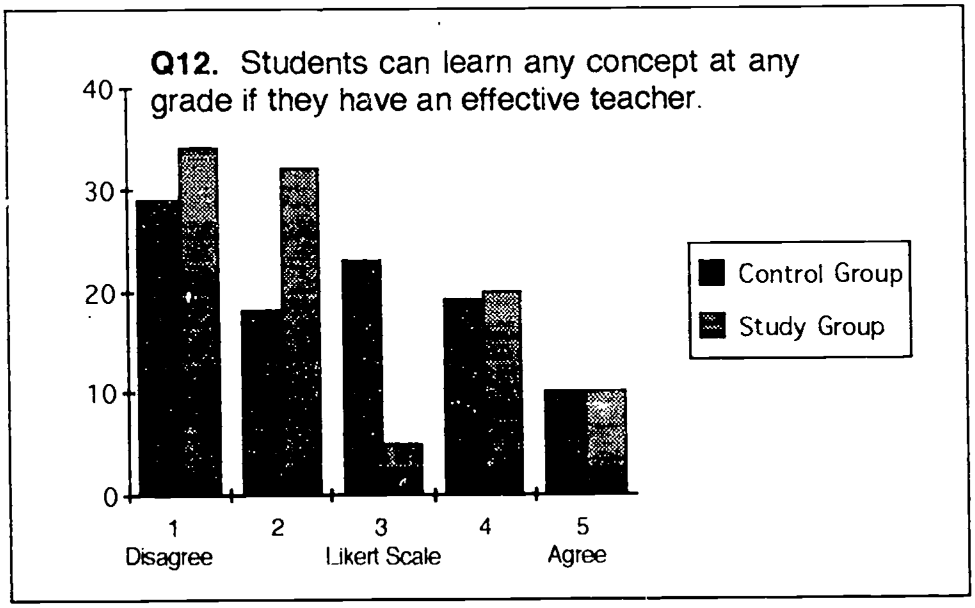
12. Students can learn any concept at any grade if they have an effective teacher.
(Expected Study group disagreement)

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.6		2.4		0.2

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





Science Teaching Methodology
Use of Developmental Theory
(continued)

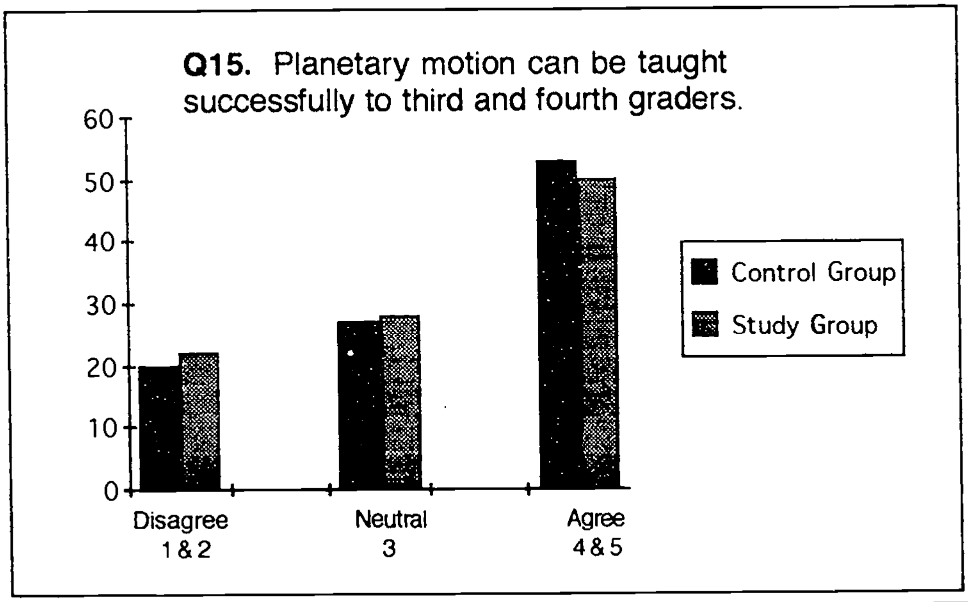
15. Planetary motion can be taught successfully to third and fourth graders.

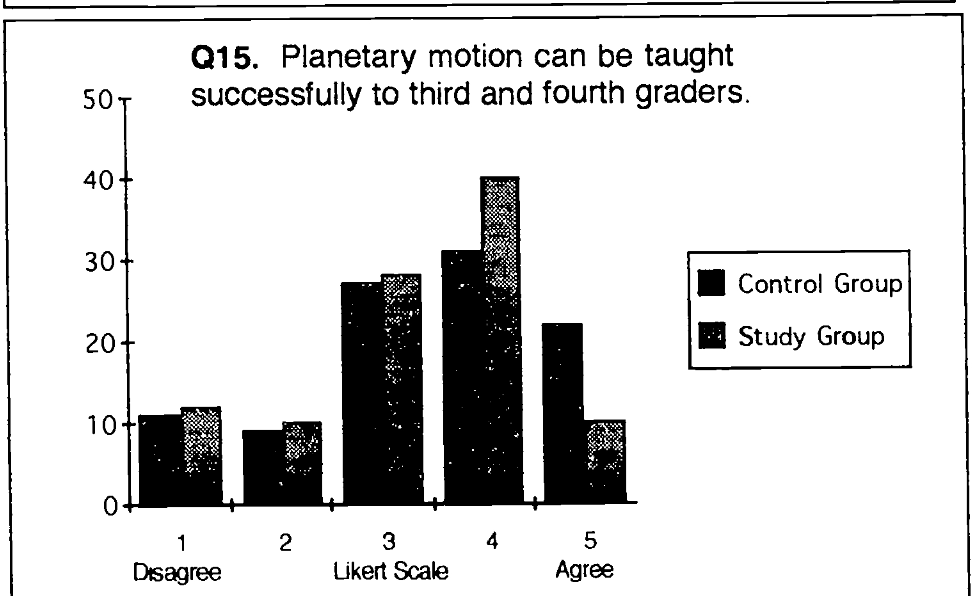
(Expected Study group disagreement)

Likert Total Response Average Comparison:

Control Group	Study Group	Difference
3.4	3.3	0.1

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





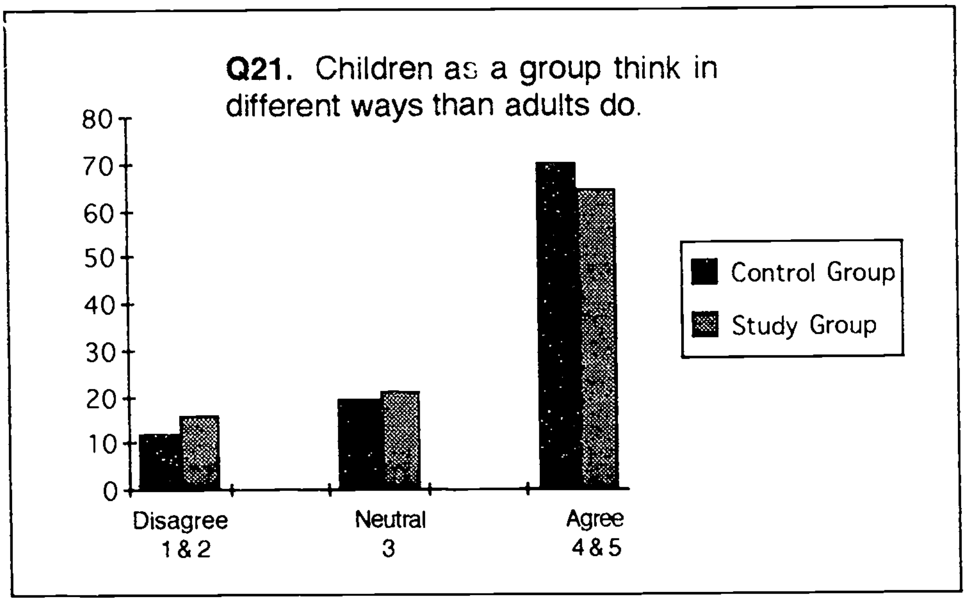
Science Teaching Methodology
Use of Developmental Theory
(continued)

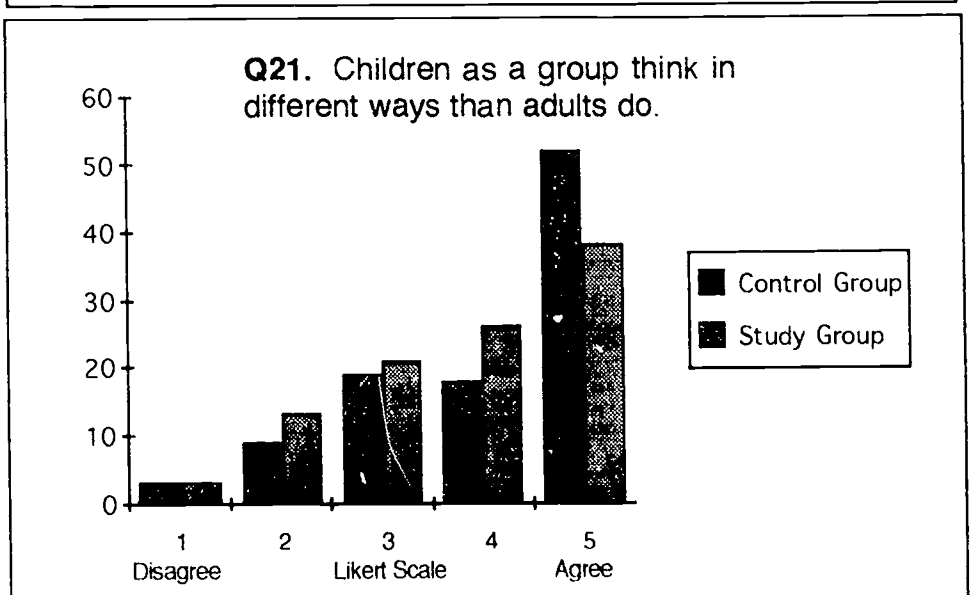
21. Children as a group think in different ways than adults do.
(Expected Study group agreement)

Likert Total Response Average Comparison

Control Group	Study Group	Difference
4.1	3.8	0.3

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





Science Teaching Methodology
Use of Developmental Theory
(continued)

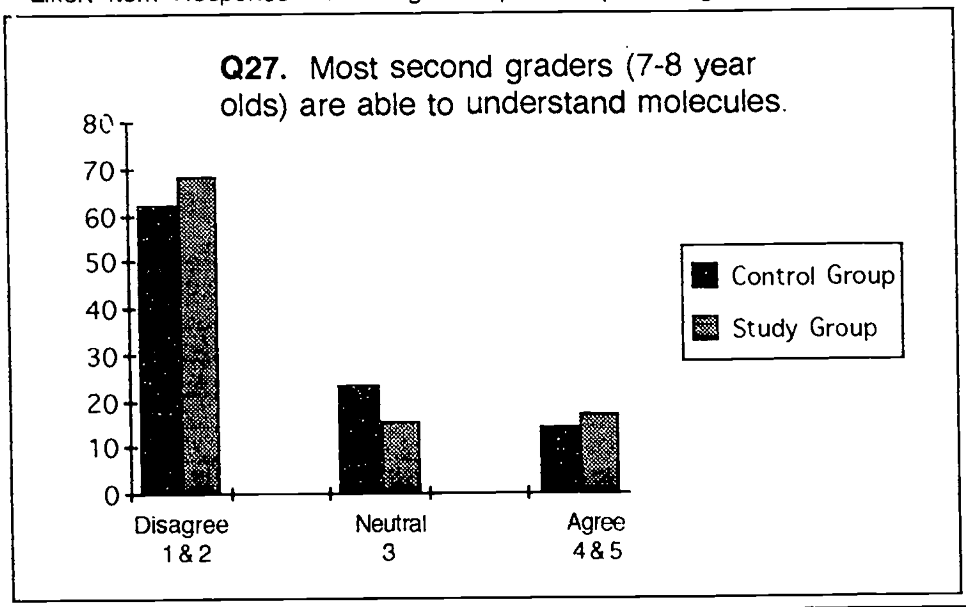
27. Most second graders (7-8 year olds) are able to understand molecules.

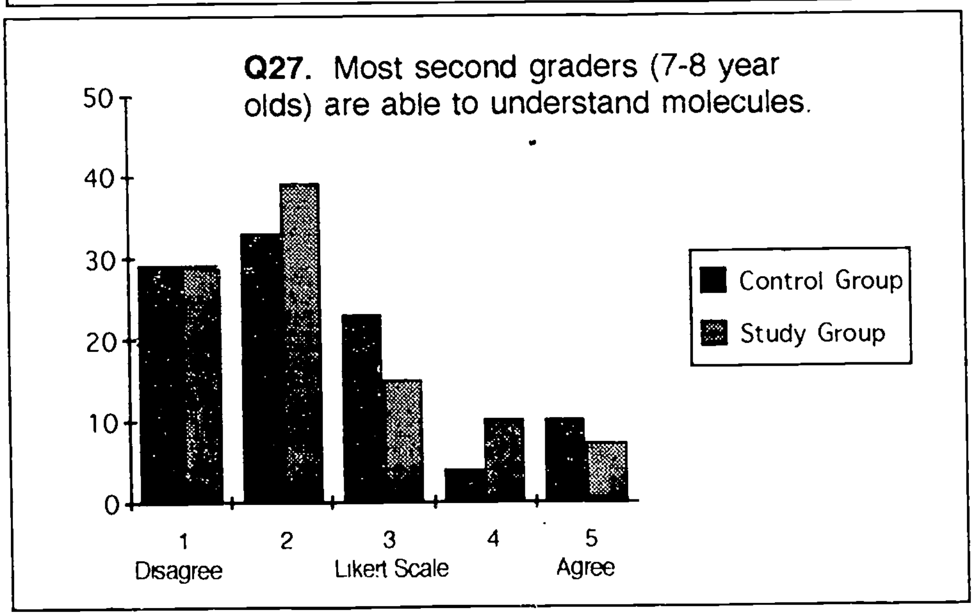
(Expected Study group disagreement)

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.3		2.3		0

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





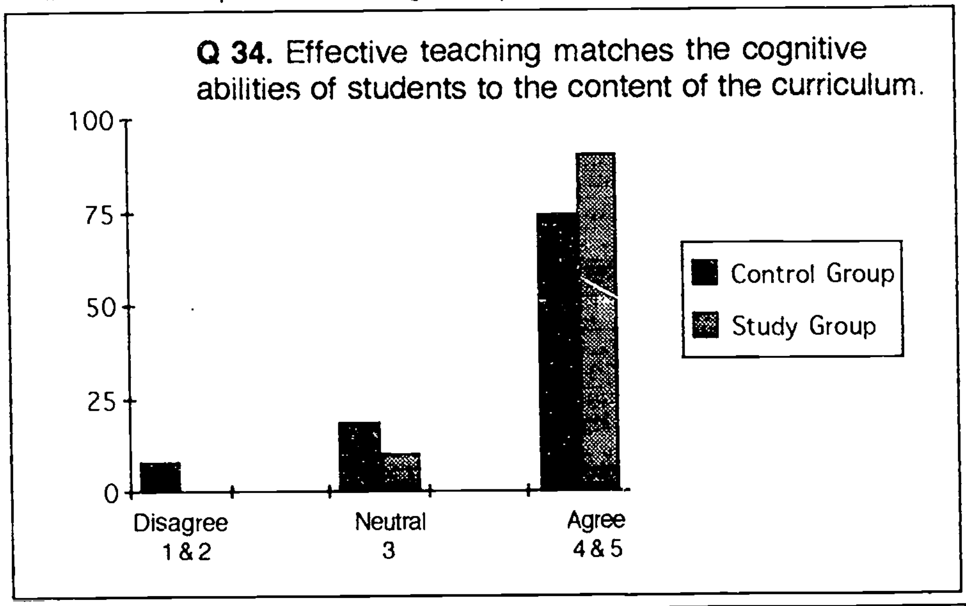
Science Teaching Methodology
Use of Developmental Theory
(continued)

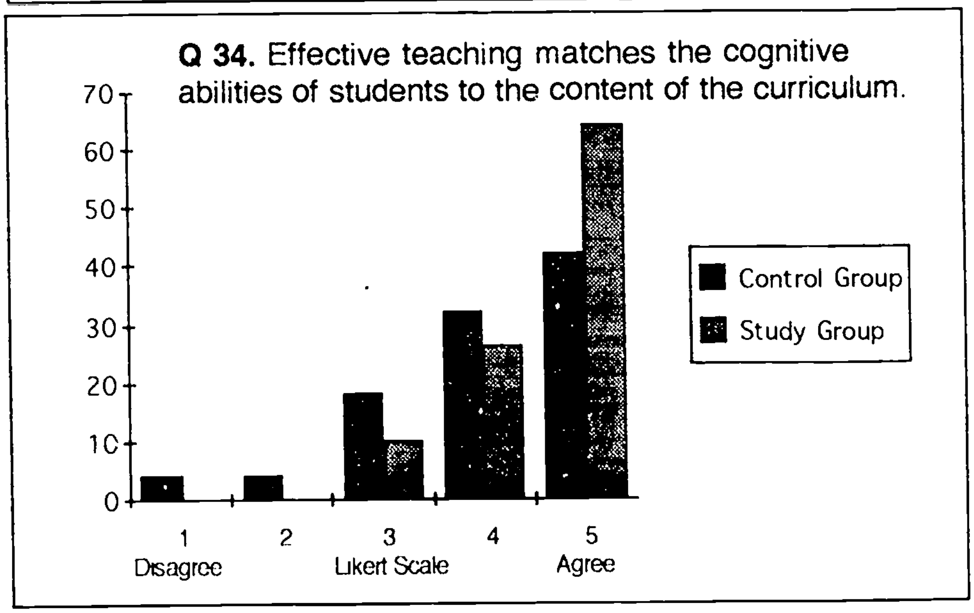
34. Effective teaching matches the cognitive abilities of students to the content of the curriculum.
(Expected Study group agreement)

Likert Total Response Average Comparison:

Control Group	Study Group	Difference
4.1	4.5	(0.4)

Likert Item Response: Percentage Comparison (1 = disagree to 5 = agree)





Science Teaching Methodology
Use of Developmental Theory
(continued)

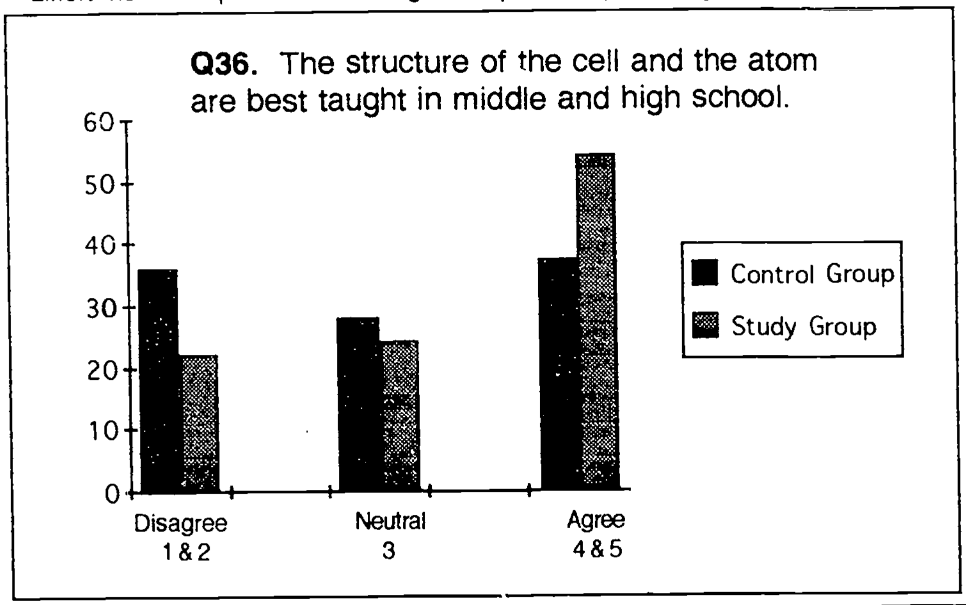
36. The structure of the cell and the atom are best taught in middle and high school.

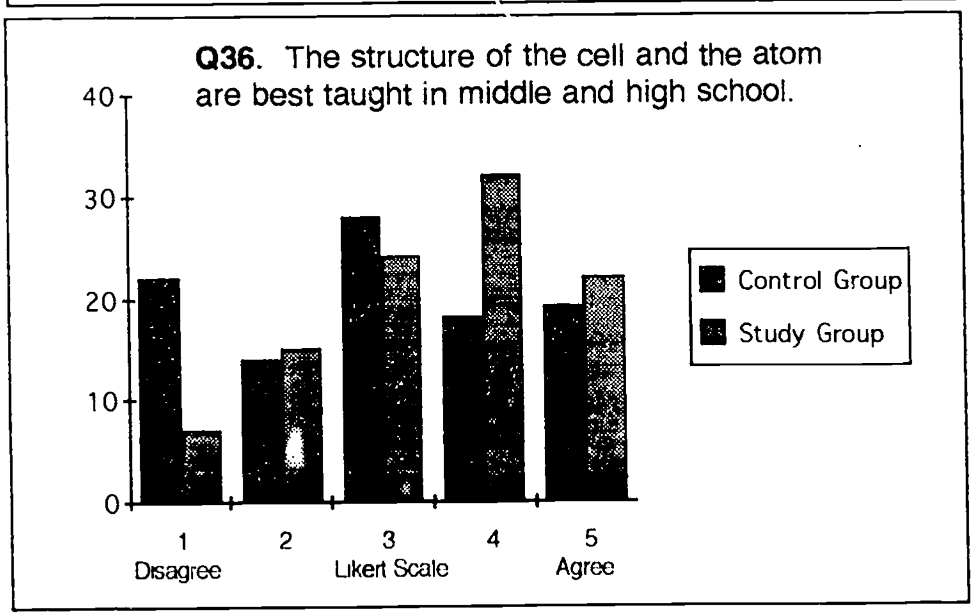
(Expected Study group agreement)

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.0		3.5		(0.5)

Likert Item Response Percentage Comparison (1 = disagree to 5 = agree)





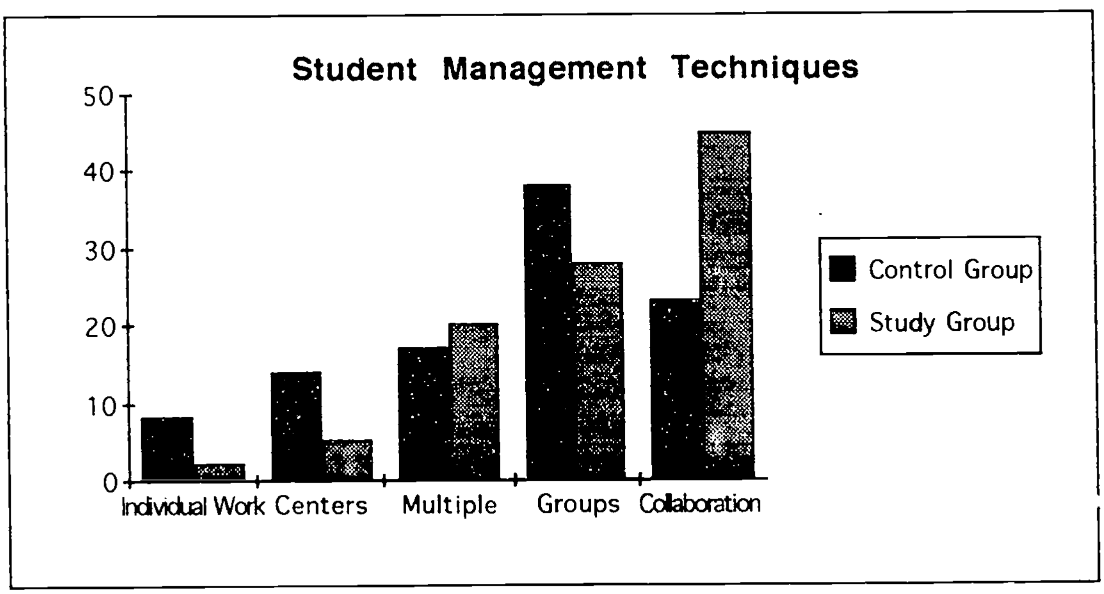
Science Teaching Methodology
Student Management

42. Student Management Techniques:

1. Individual student work (each student does own seperate work after teacher direction)
2. Student centers (part of class with teacher for lesson, class rotates to two, three centers)
3. Informal groups, cooperative groups (groups formed quickly and change oftern with task)
4. Formal groups, collaborative groups (jobs within group defined, group lasts with task)
5. Using Multiple Strategies

Comparison of Student Management Techniques

	Control Group			Study Group			Difference
	N	%		N	%		
1	6	8%		1	2%		5%
2	11	14%		2	5%		9%
3	30	38%		11	28%		11%
4	18	23%		18	45%		(22%)
5	13	17%		8	20%		(3%)
	78			40			



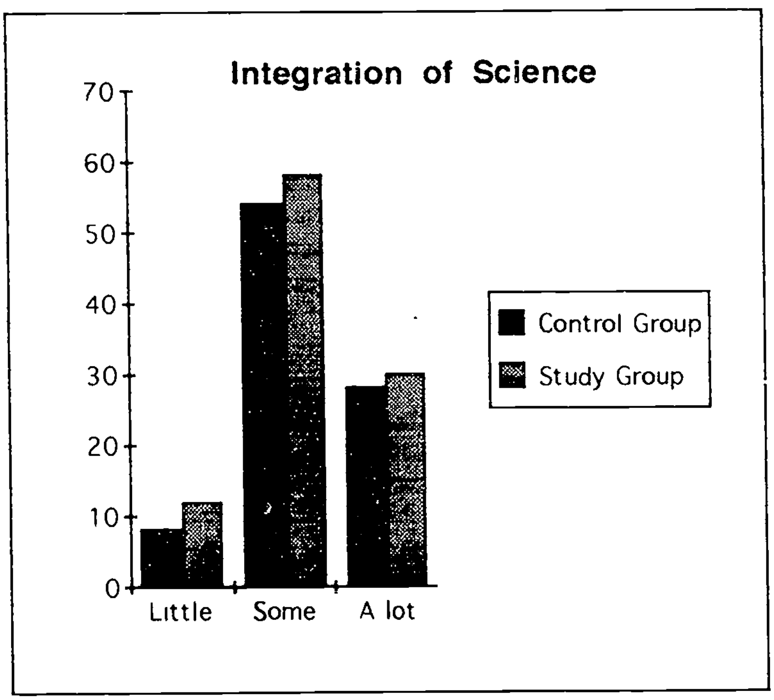
Science Teaching Methodology
Curriculum Integration

43. How much integration of science with other subjects is taking place in your program?

____little _____some _____a lot

Comparison of Curriculum Integration

	Control Group		Study Group		Difference
	N	%	N	%	
Little	6	8%	5	12%	(5%)
Some	42	54%	23	58%	(4%)
A lot	30	38%	12	30%	8%
	78		40		



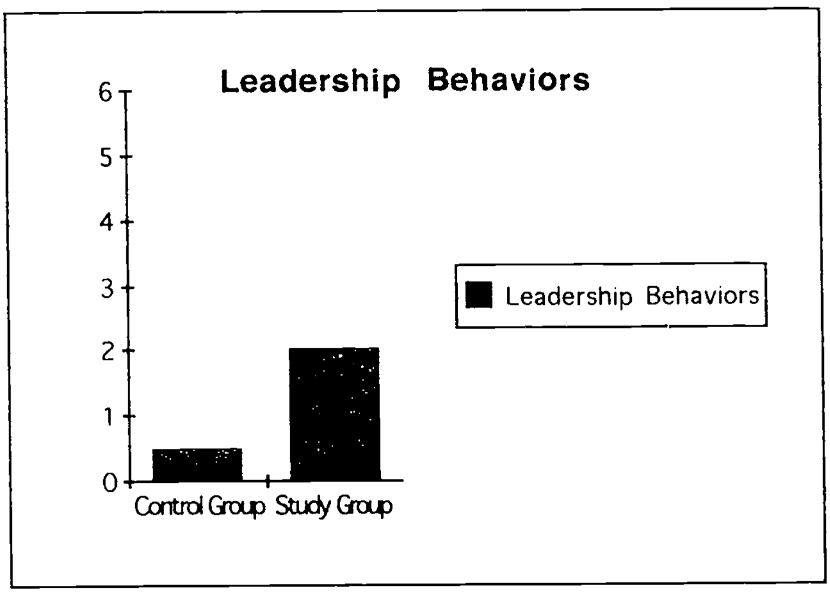
Professional Growth & Collegial Support:

44-49. Leadership Behaviors:

44 I keep a journal of my classroom practices and other professional activities.
45. I belong to the California Science Teachers Association.
46. I belong to the National Science Teachers Association.
47 I belong to another science related Association.
48. I have been a science mentor for my school & district.
49. I have made science inservice presentations to other teachers.

Average number of Leadership behaviors out of six per group:

Control Group		Study Group		Difference
0.5		2.0		(1.5)

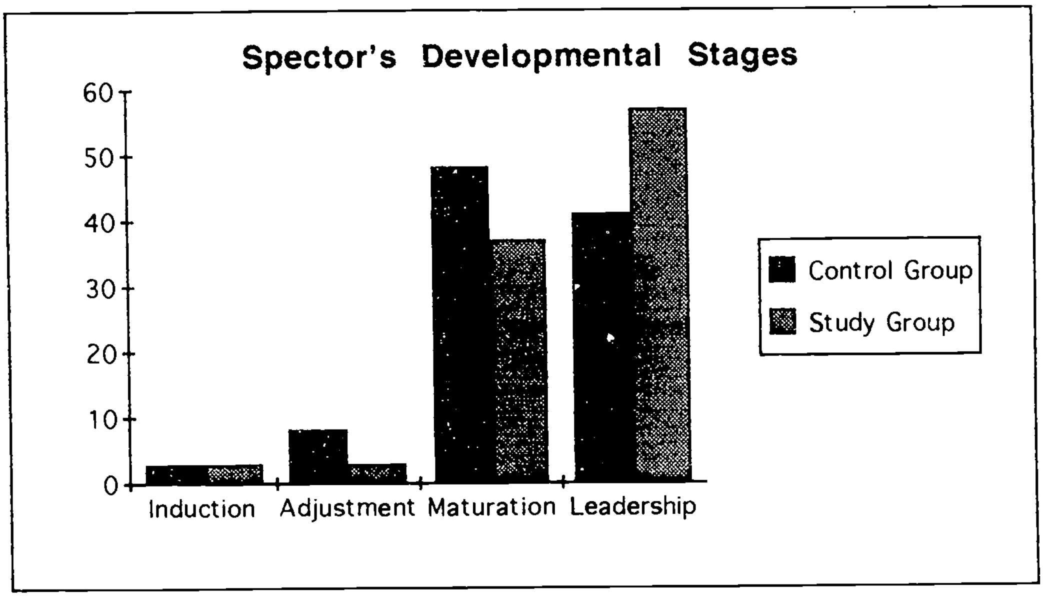


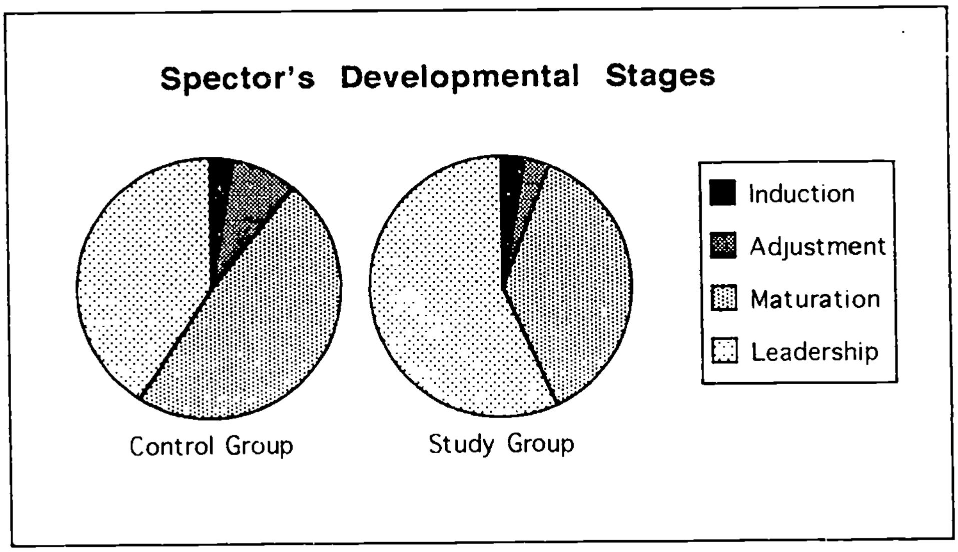
Professional Growth & Collegial Support:
(Continued)

50. Professional Maturity Index, Spector's Developmental Stages.

Comparison of Placement on Developmental Scale

Level		Control Group		Study Group	Difference
	N	%	N	%	
Stage 1: Induction	2	3%	1	3%	(0%)
Stage 2: Adjustment	6	8%	1	3%	6%
Stage 3: Maturation	34	48%	12.5	37%	11%
Stage 5: Leadership	29	41%	19.5	57%	(17%)
Total Responses	71		34		





Professional Growth & Collegial Support:
(Continued)

51. Collegial Support from teaching peers:

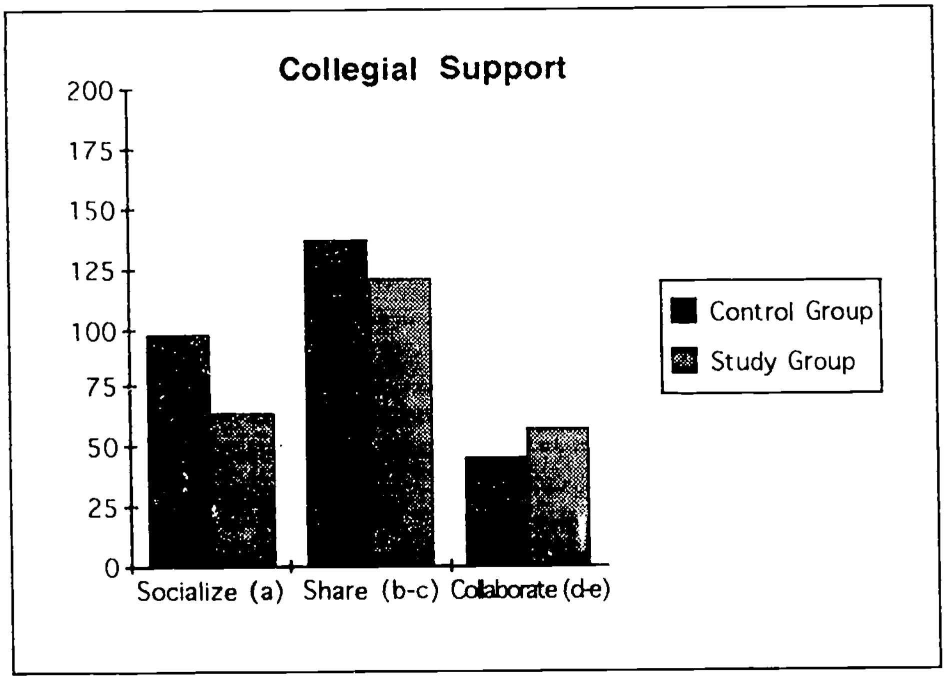
"There is a group of teachers at my site that I collaborate with "

a. We socialize outside of school and support each other at school
b. We share science ideas and materials regularly
c We plan science lessons together regularly
d. We trade students, teach each other's students regularly
e. We observe each other teaching regularly

Comparison of Collegial Support

Number of Control Group Responding: 62
Number of Study Group Responding: 34
(Participants chose multiple responses rather than one)

	Control Group			Study Group			Difference
	N	%		N	%		
a.	60	97%		22	63%		34%
b.	47	76%		31	89%		(13%)
c.	38	61%		11	31%		30%
d.	21	34%		15	43%		(9%)
e.	7	11%		5	14%		(3%)
	62			35			



Professional Growth & Collegial Support:
(Continued)

52. Support from Site Administrator

" My site administrator is . . . . "

a. a member of my planning and collaboration group
b. takes time to listen to what the group is doing in science
c. understands what we are doing in science
d. supports what we are doing with time and materials
e. works with us and students in school science events
f visits our classrooms a lot
g. was a member of our SIRC team

Comparison of Adminstrator Support
Number of Control Group Responding: 61
Number of Study Group Responding: 38
(Participants chose multiple responses rather than one)

	Control Group			Study Group			Difference
	N	%		N	%		
a.	15	25%		3	8%		17%
b.	39	64%		18	47%		17%
c.	36	59%		25	66%		(7%)
d.	51	84%		31	82%		2%
e.	29	48%		9	24%		24%
f.	27	44%		9	24%		21%
g.	0	0%		13	34%		(34%)
	61			38			

Likert Item Analysis

3. Science is a body of knowledge, facts, theories.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.4		3.2		0.2

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	5	7%		4	11%		(6%)
2	10	14%		6	16%		
3	27	36%		13	34%		2%
4	19	26%		10	26%		
5	13	18%		5	13%		4%
	74			38			

4. Students prefer to learn science from textbooks.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
1.3		1.2		0.1

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	59	77%		32	78%		0%
2	18	23%		9	22%		
3	0	0%		0	0%		0%
4	0	0%		0	0%		
5	0	0%		0	0%		0%
	77			41			

5. When teaching science, I usually welcome student questions.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.6		4.9		(0.3)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	1	1%		0	0%		1%
2	0	0%		0	0%		
3	8	10%		0	0%		10%
4	15	19%		5	12%		
5	56	70%		36	88%		(11%)
	80			41			

6. Adults and children learn in identical ways.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
1.8		2.3		(0.5)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	44	56%		14	35%		17%
2	13	16%		8	20%		
3	13	16%		11	28%		(11%)
4	9	11%		6	15%		
5	0	0%		1	2%		(6%)
	79			40			

7. Science is the most important subject at school.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.4		3.2		0.2

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	8	10%		4	10%		16%
2	16	21%		2	5%		
3	42	54%		19	48%		6%
4	10	13%		12	30%		
5	2	3%		3	8%		(22%)
	78			40			

8. I do not know what to do to turn students on to science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.3		1.3		1.0

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	19	24%		28	70%		(35%)
2	30	38%		11	28%		
3	22	28%		1	2%		25%
4	4	5%		0	0%		
5	4	5%		0	0%		10%
	79			40			

9. I wish I had received more science instruction in college.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.9		3.8		0.1

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	7	9%		2	5%		2%
2	10	13%		6	15%		
3	6	8%		8	20%		(12%)
4	19	24%		7	17%		
5	37	47%		18	44%		10%
	79			41			

10. Increased effort in science teaching produces little change in some students' science achievement.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
1.9		2.0		(0.1)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	39	51%		14	34%		(5%)
2	23	30%		21	51%		
3	7	9%		2	5%		4%
4	3	4%		2	5%		
5	5	6%		2	5%		1%
	77			41			

11. The process of seeking answers is the real nature of science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.0		4.1		(0.1)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	2	3%		2	5%		8%
2	10	13%		1	2%		
3	11	14%		6	15%		(0%)
4	19	25%		14	34%		
5	34	45%		18	44%		(8%)
	76			41			

12. **Students can learn any concept at any grade if they have an effective teacher.**

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.6		2.4		0.2

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	23	29%		14	34%		(18%)
2	14	18%		13	32%		
3	18	23%		2	5%		18%
4	15	19%		8	20%		
5	8	10%		4	10%		0%
	78			41			

13. **I understand science concepts well enough to be effective in teaching elementary science.**

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.1		4.3		(1.2)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	10	13%		0	0%		16%
2	10	13%		4	10%		
3	32	41%		3	8%		34%
4	20	26%		11	28%		
5	6	8%		22	55%		(49%)
	78			40			

14. **Reading and mathematics are more important subjects than science.**

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.6		2.2		0.4

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	11	14%		8	20%		(20%)
2	25	32%		19	46%		
3	28	35%		11	27%		9%
4	12	15%		3	7%		
5	3	4%		0	0%		12%
	79			41			

15. Planetary motion can be taught successfully to third and fourth graders.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.4		3.3		0.1

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	8	11%		5	12%		(2%)
2	7	9%		4	10%		
3	20	27%		11	28%		(0%)
4	23	31%		16	40%		
5	16	22%		4	10%		3%
	74			40			

16. Most teachers enjoy teaching science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.0		2.3		(0.3)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	24	31%		7	17%		13%
2	34	44%		18	44%		
3	18	23%		14	34%		(11%)
4	1	1%		1	2%		
5	1	1%		1	2%		(2%)
	78			41			

17. I will not be very effective in monitoring science experiments.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.0		[illegible].6		0.4

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	28	35%		23	56%		(18%)
2	29	37%		14	34%		
3	16	20%		3	7%		13%
4	4	5%		0	0%		
5	2	3%		1	2%		5%
	79			41			

18. Science is a way of thinking and asking questions.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.5		4.5		0

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	1	1%		0	0%		1%
2	0	0%		0	0%		
3	8	10%		3	7%		3%
4	19	24%		15	37%		
5	51	65%		23	56%		(4%)
	79			41			

19. Students must be taught the facts and truths of science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.6		2.6		0

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Contr Group			Study Group			Difference
	N	%		N	%		
1	8	10%		6	15%		(5%)
2	27	34%		13	33%		
3	33	41%		15	38%		3%
4	10	12%		2	5%		
5	2	2%		3	8%		2%
	80			39			

20. Children will learn more science by doing hands-on activities.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.8		4.8		0

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	0	0%		0	0%		0%
2	0	0%		0	0%		
3	2	3%		0	0%		3%
4	13	16%		9	22%		
5	64	81%		32	78%		(3%)
	79			41			

21. Children as a group think in different ways than adults do.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.1		3.8		0.3

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group		Difference
	N	%		N	%	
1	2	3%		1	3%	(4%)
2	7	9%		5	13%	
3	15	19%		8	21%	(2%)
4	14	18%		10	26%	
5	41	52%		15	38%	6%
	79			39		

22. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.6		4.0		(0.4)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group		Difference
	N	%		N	%	
1	4	5%		1	2%	11%
2	8	10%		1	2%	
3	18	23%		6	15%	8%
4	30	38%		24	59%	
5	18	23%		9	22%	(19%)
	78			41		

23. Teachers often put off teaching science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.1		4.0		0.1

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group		Difference
	N	%		N	%	
1	1	1%		2	5%	(1%)
2	6	8%		2	5%	
3	10	12%		7	17%	(5%)
4	26	32%		15	37%	
5	37	46%		15	37%	6%
	80			41		

24. I have a strong science background.

Likert Total Response Average Comparison

Control Group	Study Group	Difference
2.1	3.1	(1.0)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group		Study Group		Difference
	N	%	N	%	
1	33	42%	8	20%	23%
2	20	26%	10	25%	
3	13	17%	4	10%	7%
4	9	12%	5	12%	
5	3	4%	13	32%	(30%)
	78		40		

25. It is important to teach students about what most scientists think and believe.

Likert Total Response Average Comparison:

Control Group	Study Group	Difference
2.6	3.0	(0.4)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group		Study Group		Difference
	N	%	N	%	
1	15	19%	5	12%	26%
2	25	31%	5	12%	
3	27	34%	19	46%	(13%)
4	8	10%	9	22%	
5	5	6%	3	7%	(13%)
	80		41		

26. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.

Likert Total Response Average Comparison:

Control Group	Study Group	Difference
3.9	4.2	(0.3)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group		Study Group		Difference
	N	%	N	%	
1	3	4%	0	0%	9%
2	4	5%	0	0%	
3	17	22%	6	15%	7%
4	27	35%	22	54%	
5	27	35%	13	32%	(16%)
	78		41		

27. Most second graders (7-8 year olds) are able to understand molecules.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
2.3		2.3		0

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	23	29%		12	29%		(5%)
2	26	33%		16	39%		
3	18	23%		6	15%		8%
4	3	4%		4	10%		
5	8	10%		3	7%		(3%)
	78			41			

28. Students prefer to learn science by manipulating materials.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.8		4.7		0.1

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	0	0%		0	0%		0%
2	0	0%		0	0%		
3	1	1%		1	2%		(1%)
4	16	21%		11	27%		
5	60	78%		29	71%		1%
	77			41			

29. I wonder if I will have the necessary skills to teach science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.1		2.0		1.1

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	13	17%		16	40%		(40%)
2	18	23%		16	40%		
3	13	17%		3	8%		9%
4	18	23%		4	10%		
5	16	21%		1	2%		31%
	78			40			

30. I will typically be able to answer students' science questions.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.0		3.8		(0.8)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group		Study Group		Difference
	N	%	N	%	
1	6	8%	2	5%	23%
2	16	20%	0	0%	
3	31	39%	13	32%	7%
4	23	29%	16	39%	
5	4	5%	10	24%	(30%)
	80		41		

31. Openness is a quality of science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.7		4.6		0.1

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group		Study Group		Difference
	N	%	N	%	
1	0	0%	1	3%	(3%)
2	0	0%	0	0%	
3	3	4%	2	5%	(1%)
4	16	21%	7	18%	
5	59	76%	28	74%	4%
	78		38		

32. Children learn more science if taught from a good textbook.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
1.5		1.6		(0.1)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group		Study Group		Difference
	N	%	N	%	
1	47	60%	21	52%	10%
2	27	35%	13	32%	
3	4	5%	5	12%	(7%)
4	0	0%	1	2%	
5	0	0%	0	0%	(2%)
	78		40		

33. Even if I try very hard, I will not teach science as well as I will other subjects.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
1.7		1.5		0.2

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	42	54%		29	71%		(7%)
2	21	27%		7	17%		
3	11	14%		3	7%		7%
4	2	3%		2	5%		
5	2	3%		0	0%		0%
	78			41			

34. Effective teaching matches the cognitive abilities of students to the content of the curriculum.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.1		4.5		(0.4)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	3	4%		0	0%		8%
2	3	4%		0	0%		
3	14	18%		4	10%		8%
4	24	32%		10	26%		
5	32	42%		25	64%		(16%)
	76			39			

35. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand better.

Likert Total Response Average Comparison.

Control Group		Study Group		Difference
2.1		1.7		0.4

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	24	30%		17	41%		(21%)
2	27	34%		18	44%		
3	24	30%		6	15%		16%
4	2	3%		0	0%		
5	2	3%		0	0%		5%
	79			41			

36. The structure of the cell and the atom are best taught in middle and high school.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
3.0		3.5		(0.5)

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group		Difference
	N	%		N	%		
1	16	22%		3	7%		13%
2	10	14%		6	15%		
3	21	28%		10	24%		4%
4	13	18%		13	32%		
5	14	19%		9	22%		(17%)
	74			41			

37. I will continually find better ways to teach science.

Likert Total Response Average Comparison:

Control Group		Study Group		Difference
4.9		4.7		0.2

Likert Item Response Percentage Comparison(1 = disagree to 5 = agree)

	Control Group			Study Group			Difference
	N	%		N	%		
1	0	0%		0	0%		(2%)
2	0	0%		1	2%		
3	1	1%		2	5%		(4%)
4	9	11%		6	15%		
5	69	87%		32	78%		6%
	79			41			

NATIONAL SCIENCE FOUNDATION

Science In Rural California

Steve Essig, Project Director

Date:

Dear ____________________:

Thank you for agreeing to an follow up interview for the SIRC long term effects study. You have already given us important data in the spring questionnaire.

As we visited about on the phone, I will meet you at:

____your school on________at __________o'clock.

____other place________________on _________at__________o'clock.

The interview will take between 30 and 45 minutes. I will be brining a mini tape recorder and am asking your consent now to tape record the interview. This is strictly for me. All results in the study will be reported with personal anonymity protected. But I want to be able to hear clearly what you are saying and not just rely on my interview notes. It will be a great help to be able to play back any of your answers. After the study the tape will be destroyed. So I am asking for your consent to record in advance.

Enclosed with this letter is the list of questions I will be using as an outline. It won't be that structured but I thought if you knew the questions ahead of time, then your wheels could begin churning.

I will also be asking your principal and some of your site teacher colleagues for a brief word. I would like to ask them about your site leadership in science. So I am asking for your consent for this as well.

Please call me if any concerns or changes in arrangements come up.

Thanks,

Steve Essig

3629 Canterbury Drive • Redding, CA 96002 • (916) 222-5820

Study Group Follow Up Questionaire
Questions:

Open Ended:

•What was(were) the most important learning(s) that you received from SIRC?

•If a teaching colleague at another school was asking you about whether to apply for SIRC or not, what would you tell them?

•Is there anything else about your SIRC experience that you would like to share for this study?

About Science:

•How would you define science?

•Is this your current definition? What was your definition of science before SIRC?

•Has it changed SIRC? Is it still changing?

About the Teaching of Science:

•How important is science in the school curriculum? Why?

•Did you always feel that way?

•Statement "It is important to teach students about what most scientists think and believe " What does this statement mean to you?

•Describe your current science teaching?

•What was your science teaching like before SIRC?

About Science Teaching Confidence:

•Most respondents agreed with this statement "I wish I had received more science instruction in college " Do you agree or disagree?

•What was your confidence level or attitude about teaching science before SIRC?

•Did SIRC help change your attitude? How?

About Professional Growth and Collegiality:

•How did SIRC help in improving your science background and understanding?

•Have you engaged in any other learning activities since SIRC to improve your science knowledge and understanding? (Did the SIRC experience motivate this?)

•In what ways, outside of science, has SIRC helped you grow as a teaching professional?

•How important was your team during SIRC?

•Do you still have this same team? Do you use it?

•Do you still use this team concept in your current teaching assignment

•How important was the involvement of your site administrator during SIRC?

SIRC Long Term Effects Interview

Date:_______________________

Time:_______________________

Place:_______________________

Steve Essig 222-5820

NATIONAL SCIENCE FOUNDATION

Science In Rural California

Steve Essig, Project Director

Date:

Dear Principal of ____________________ School:

A teacher, ____________________________, at your site was involved in the training provided by Science in Rural California (SIRC) during the years 1988-92. The project is now conducting a long term effects study.

I am coming to interview with ____________________ at your school on ____________

at ___________ o'clock.

One of the pieces we are attempting to investigate is the continuing science leadership skills of past SIRC participants. I would like to take just 5 minutes of your time to ask you to be a mirror for this aspect of the investigation.

While I will be on your site this day, you might not be there or might not be available if there. I'll try to visit with you anyway. To make sure I get some reply from you I would like to suggest:

Please take 5 minutes and jot a short note about ________________ site leadership in science and return it in the stamped return envelope provided. Use the back of this letter. This way we'll get the data we need.

Thanks,

Stephen R. Essig, SIRC director.

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