A PRELIMINARY EVALUATION OF THE PROCESS-ORIENTED ELEMENTARY SCIENCE CURRICULUM PROJECT (ESCP) IN NEWFOUNDLAND SCHOOLS

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ABSTRACT

A comparison was made between two treatment groups in both grades five and six to determine the effectiveness of a process-oriented elementary science curriculum at teaching the processes of science. Experimental groups in both grades were taught the process-oriented science course and the control groups were given a content-oriented course. Control groups were given the alternate course to reduce the Hawethorne effect.

The hypothesis investigated in this experiment related to:

1. The effect of taking a process-oriented science course on the ability of students to learn and apply in new situations scientific processes. This was measured using appropriate science process tests.

Other aspects of the study was concerned with student and teacher attitudes towards the course. Student attitudes were elicited by means of a Q-sort instrument and teacher attitudes were evoked by means of a questionnaire.

The experimental data was analyzed using multiple linear regression. Scores on the postest in both grades were examined in the presence of grouping, socio-economic ranking, sex, pretest results, a measure of science knowledge and aptitude (the STEP Science Test), and intelligence (the Lorge-Thorndike Intelligence Tests).

Student and teacher attitudes were analyzed by obtaining a percentage summary of responses and by analyzing these responses on various variables of each instrument in relation to different independent variables using either the t-test or one-way analysis of variance.

It was found that there was a significant difference in treatment groups in grade five in favour of the experimental group. It was concluded that students exposed to a process-oriented science course do learn the scientific processes better than students who have not taken such a course. No significant difference was found between treatment groups in grade six, but because the testing situation appeared to have changed from pretest to postest and because of differences between the experimental and the control groups which the regression analysis did not control, it was concluded that little significance could be attributed to the results, even though the experimental group showed a greater pretest-postest gain over the control group.

An analysis of student responses revealed that student attitudes were mainly positive towards the course. The majority of students enjoyed doing the various activities in the course and felt that the course taught them how scientists think. Some negative attitudes were also expressed by a minority of students.

The sex of the teacher and class size affected student responses, with students having female teachers displaying more positive attitudes and students from very small and very large classes showing more negative attitudes than students from middle-size classes of about thirty students.

Teacher responses were mainly favourable, even though they did encounter some difficulties with the Teachers Guide and with classroom organization. No differences in responses were found between teachers with science education courses and science courses and those without them. Similarly, teaching experience and teaching certification did not affect teacher's responses on some variables.

Some of the implications of the results are the following.

This process-oriented science curriculum is more effective at teaching students the processes of science than are more content-oriented courses. Also, student attitudes towards the course are mainly positive. Even though teachers experienced some problems while teaching the course, none seemed insurmountable. This would suggest that, if the process approach to science teaching is a desired objective in elementary schools, the course can be adopted by interested schools. Teachers experienced some problems with the Teachers Guide. It should be more structured for elementary school teachers with a limited science background. Also, more inservice training, which would explain the aims and purposes of the course and the teaching methodology required to teach the course properly, is needed.

This study illustrates the need for well-developed process instruments which can be used in different grades. Instruments are especially needed which test the more complex scientific processes.

Finally, the study implies that evaluation of process science curricula is feasible and possible. Much more evaluative work on these process-oriented science curricula is needed.

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CHAPTER I

INTRODUCTION

I. BACKGROUND OF THE STUDY

There has been much ferment in the area of science education in recent years.[1] With the generous financial assistance of such agencies as the National Science Foundation, new national science curricula have been produced in most fields of science and on both the secondary and the elementary levels. Most of these new science curricula have been developed with the co-operation of educators and practicing scientists. Their aims, objectives, and general approaches have been well documented in the science literature.

Activity on the national level--mainly American, has initiated an increase in the number of local science projects. These local projects tend to reflect the aims and approaches of the national science curricula, while appearing to be more applicable to the local setting.

Yet, in spite of the apparent thoroughness with which these new national and local science curricula have been developed, many of them fail to consider seriously the evaluative component of curriculum development.[2] Consequently, there is a great need for evaluation of these new

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[1]Marshall A. Nay and others, "A Process Approach to Teaching Science," Science Education, 55(2): 197, 1971.

[2]Robert A. Roth, "Princeton Project and the Process Approach: A Critique," School Science and Mathematics, 71: 44, January, 1971.

curricula by outside agents.[3]

II. THE PROBLEM

This study attempted to evaluate one of these new, local science programs--The Elementary Science Curriculum Project: Science, Grades 1-6, which was initiated in the fall of 1969 under the directorship of Dr. R.K. Crocker at Memorial University of Newfoundland. The main objective of this course is the teaching of the processes of science. The experimental aspect of the study compared the ability to perform on process instruments of students having taken the ESCP Course with students having taken an alternate course, which does not stress the processes of science. The study attempted to show that students exposed to the ESCP Course could cope better with process-oriented problems than could students who had not taken the course.

Another aspect of program evaluation examined the attitudes of students towards various aspects of the course after they had been exposed to it. Students were asked to react to statements regarding the type of course, the course content, the teaching style used in teaching the course, their general attitudes towards the course, their attitudes towards science periods and science in general, and how their motivation towards science was affected by exposure to the course.

Finally, a third aspect of program evaluation dealt with in this study considered the attitudes of teachers towards various aspects of the course after they had taught the course. Teachers were asked to react to statements regarding the Teaching Guide, the apparatus, the teaching

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[3]Wayne W. Welch, "The Need for Evaluating National Curriculum Projects," Phi Delta Kappan, 49: 531, May, 1968.

methodology, classroom problems, evaluation of students, apparent student problems, the general attitudes of teachers towards the course and elementary science in general, and apparent student attitudes towards the course.

Definitions

Terms used in the study, which needed definition, were:

Scientific process. This is described as "a series of activities or operations performed by the scientist in his attempt to understand nature. These activities are based on various assumptions and are guided by an awareness of the nature of the outcomes and the ethics and goals of the discipline."[4]

Process approach. This is an approach to science teaching the main objective of which is to teach the complex behaviour of scientists by analyzing it into simpler activities, which can be arranged in a hierarchy of complexity for purposes of instruction.[5]

Crocker, in discussing what science is in the ESCP Teaching Guide, defines the scientific processes of concern to the study as follows:

> Classifying. The organization of objects or events according to common properties....
>
> Quantifying. Comparison of objects or events and with agreed upon standards. Involves use of numbers, measurement, and use of spatial relationships.
>
> Infering. The process of drawing conclusions based only indirectly

[4] Wayne W. Welch, "The Development of an Instrument for Inventoring Knowledge of the processes of Science," (unpublished Doctoral Thesis, University of Wisconsin, 1966), pp. 29-30.

[5] Robert M. Gagne, "Psychological Issues in Science--A Process Approach," AAAS Commission on Science Education, The Psychological Bases of Science--A Process Approach (Washington, D.C.: The Commission, 1965), p. 4.

on observations. The interpretation of observation.

Predicting. Broadly, this process involves the drawing of testable conclusions from hypotheses or theories. The ability to predict new observations is the test of success in a theory because such predictions lead to new knowledge. In a more narrow sense, prediction is used to describe the process of extrapolating from graphs or mathematical relationships.

Formulating hypotheses. The process of arriving at tentative generalizations and explainations. Hypothesizing is essentially a creative process. Any hypothesis is usually accepted as legitimate as long as it can guide further investigation.

Controlling variables. The process of deciding what variables might influence the outcomes of a particular experiment and of holding all variables constant except those the investigator wishes to manipulate. The reproducibility of experimental results depends on the ability to control the proper variables.

Interpreting data. The technique of getting the most out of data without overgeneralizing and without loss of information inherent in the data. Devices such as graphs, tables, maps, etc. which are useful in communication are also means of interpreting data.[6]

Process terms defined above are given as they were first out-lined by the Science Commission of the American Association for the Advancement of science. The commission divided the scientific endeavour into these various processes for instructional purposes.

Hypothesis

The general purpose of the study was to determine if the students taking the course were learning the processes of science better than students not taking the course. In considering this objective, one main hypothesis was formulated.

Hypothesis 1 There will be no difference in performance achieved on the science process tests between students in a process-oriented course and students in a course which does not emphasize process.

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[6] Robert K. Crocker, Elementary Science Curriculum Project, Grades 1-6: A Teaching Guide (Second Trial Edition) (St. John's: Department of Curriculum and Instruction, Memorial University of Newfoundland, 1971), pp. 9-11.

Whereas the experimental aspect of the study compared process achievement of students having taken the ESCP Course with those not having taken the course, another important phase of evaluation examined the attitudes towards the course of the people involved with it. Thus other questions investigated were:

(a) what are the attitudes of teachers towards the course, and

(b) what are the attitudes of students towards the course?

Limitations

Testing how effective this course is at teaching the processes of science was limited to grades five and six. No attempt was made to look at the achievement of students in the course from grades one to four. An examination of the more complex processes, which are given greater emphasis in grades five and six, would indicate if students have learned these processes better than students not exposed to the ESCP Course.

The experimental aspect of the study was confined to one elementary school only. It involved two grade five classes and two grade six classes. For purposes of the study, it was necessary to find co-operating schools who would be willing to introduce the ESCP Course in the middle of the school year--beginning in January, 1972. Also, suitable control groups were needed.

Because of the non-random selection of subjects in the study, generalizations had to be made on the basis of assumed similarities between the sample and the population. It was impossible to select randomly from within the school population because classes had already been formed at the beginning of the school year and this could not be changed by the experimenter.

For purposes of this study, the ESCP Course was run in the school from January, 1972 until June, 1972. The results may be different if the course were run for the entire year. A longer time would allow the teacher to move at a slower pace and more emphasis could have been given to difficult processes and topics. Also, students could have more easily progressed at their own rate in the course.

Since the approach to science taken by this course was "different" to the teachers and to the students who participated in the study, it may have taken them a while to adjust to it. Therefore, they may not have done as well as students who had been in the course from grades one up to grades five or six; and, hopefully, teachers in teaching the course, emphasized the processes of science rather than the content.

The study was also limited by the ability of the instruments used to measure process achievement. Unfortunately, no time was available for a pilot study to be carried out on these instruments prior to their use in the study.

III. SIGNIFICANCE OF THE STUDY

Evaluation is an essential step in curriculum development. Unless some form of systematic evaluation is conducted on any new curriculum, it may never attain its fullest potential. Unknown weaknesses may go undetected and teachers and pupils--who ultimately decide on the success or failure of a new program--may become disappointed and disheartened over some aspect of the course which evaluation could uncover.

Prior to this study, there had been no attempt to evaluate this program on a systematic basis. Evaluation in the first stage of development had tended to be on the basis of casual feedback from teachers who had taught the course and from observations of participating project personnel.

At the time of the study, this program was at a vital stage in its development. It could have been used in the schools on a wide basis, but the decision on adoption had not yet been made by the Department of Education. Thus, hard data at this time as to the effectiveness of the program could facilitate the decision-making process.

Also, the success or failure of the ESCP Course could have a substantial effect on how educators in Newfoundland view science for the elementary grades in the future. Proper evaluation can expose weaknesses of any program and lead to improvements which can increase its effectiveness.

The study can also serve as the beginnings of the development of a comprehensive evaluation model for the ESCP Course. Certain aspects of the study can also serve as examples of procedures that can be used in developing an evaluation model for any process-oriented science curriculum. It does not represent a full, comprehensive model for evaluation of these courses since the study looks at course outcomes only. No attempt was made to examine the processes of science in detail, the materials, the teaching technique, etc. while they were in operation within the classroom.

Finally, another implication of the study which is broader than the fact that the study attempted to evaluate a local science program, is related to process instruments. In terms of process instrumentation, the study illustrates that it is possible to develop such instruments and use them effectively. Using such models as that of the AAAS, instruments can be developed and used to evaluate the process dimension of science.

CHAPTER II

REVIEW OF THE LITERATURE

I. THE PROCESS APPROACH IN SCIENCE TEACHING

Despite the many "objectives" dealing with the processes of science which have been written by science educators for years, it was not until about the last ten years that the process dimension of science was given any serious consideration by curriculum developers and teachers.[1] In the past science teaching consisted of depicting science as a body of knowledge.[2] Students were asked to accept unquestionly the facts, theories, and principles presented by the teacher. No attempt was made to allow the student to think critically about science and if laboratory work was provided, it involved a neatly planned, step-by-step procedure which guaranteed only one possible result. The only glimpse of the work and methods of the scientist afforded the student was a presentation of the "scientific method" at the beginning of the course of study.[3] Content reigned supreme; process received lip-service only.

The mid-1950's saw the development of several new high school science curricula such as the Physical Science Study Committee (PSSC)

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[1]Eric Mokosch, "The Development and Evaluation of a Process Approach to the Teaching of Junior High School Science" (unpublished Doctoral thesis, University of Alberta, Edmonton, 1969), p. 15.

[2]Joseph J. Schwab and Paul F. Brandwein, The Teaching of Science (Cambridge, Massachusetts: Harvard University Press, 1962), p. 24.

[3]Marshall A. Nay and others, "A Process Approach to Teaching Science," Science Education, 55(2): 198, 1971.

Physics, Chemical Educational Materials Study (CHEMS), Biological Science Curriculum Study (BSCS), and the Earth Science Curriculum Project (ESCP).

> ...These science curricula had the support and guidance of many eminent scientists and leading science educators and they made many claims of alleviating the shortcomings of traditional science education. Influenced by theorists like Schwab, Brandwein and Bruner these studies advocated the selection of only the pervasive and encompassing concepts and ideas, the structuring of these for easier and more permanent learning, and greater emphasis in the teaching and learning of science on the way scientific knowledge is discovered and evolved.[4]

Even though these new science curricula succeeded in updating the content of the different sciences, they failed to emphasize adequately the process dimension of science. Thus "even less was done in the way of evaluating for pupils' understanding of the processes of science."[5]

The general dissatisfaction among science educators with more traditional curricula was expressed by Schwab in The Teaching of Science as Inquiry, the Inglis lecture for 1961.

> The effect of this growing failure of communication between enquiry and the textbook reaches its most pervasive climax in a lapse of relevance, a contridiction, between science as it functions in fact--a fluid enquiry, utalizing changing concepts, producing continuous reorganization and revision of its knowledge--and science as it is taught. It is taught as a nearly unmitigated rhetoric of conclusions in which the current and temporary constructions of scientific knowledge are conveyed as empirical, literal, and irrevocable truths.[6]

Postulating that scientific knowledge in any field will undergo complete change every fifteen years, Schwab proposed that to teach only scientific facts was entirely inadequate. Students, as future citizens, must be taught to cope with these ever increasing "scientific revolutions",

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[4]Mokosch, op. cit., p. 1-2.

[5]Ibid.

[6]Schwab, loc. cit.

as Kuhn refers to these changes.[7] As Schwab says:

> What is required is that in the very near future a substantial segment of our publics become cognizant of science as a product of fluid enquiry, understand that it is a mode of investigation, which rests on conceptual innovations, proceeds through uncertainty and failure, and eventuates in knowledge which is contigent, dubitable, and hard to come by. It is necessary that our publics become aware of the needs and conditions of such enquiry and inured to the anxieties and the disappointments which attend it.[8]

On a more general level, Parker and Rubin argues for process as content in all disciplines.

> The substance of our proposition is that process--the cluster of diverse procedures which surround the acquisition and utalization of knowledge--is, in fact, the highest form of content and the most appropriate base for curriculum change. It is in the teaching of process that we can best portray learning as a perpetual endeavor, and not something which terminates with the end of school. Through process, we can employ knowledge not merely as a composite of information but as a system for learning.[9]

Although there is a great deal of agreement on just what the goals of science education are, there is much disagreement on how to achieve them. Gagne suggests that there are three points of view which different people tend to take: the "content" view, the "creativity" view, and the "process" approach. The "content" view contends that "the best way to to learn science is to start to study physics, or biology, or chemistry, in the earliest grades." The "creativity" view contends that since scientists are creative, teachers should try to train creativity. The objective of the process approach is described by Gagne as:

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[7] Thomas S. Kuhn, "The Structure of Scientific Revolutions," International Encyclopedia of Unified Science (Chicago: University of Chicago Press, 1970), p. 26.

[8] Schwab, op. cit., p. 5.

[9] Cecil J. Parker and Louis J. Rubin, Process as Content: Curriculum Design and the Application of Knowledge (Chicago: Rand McNally and Company, 1966), p. 1.

> This approach seeks a middle ground between the extremes I have mentioned. At the same time, it attempts to capitalize upon the best features of both these other approaches. Specifically, it rejects the "content approach" idea of learning highly specific facts or principles of any particular science or set of sciences. It substitutes the notion of having children learn generalizable process skills which are behaviorally specific, but which carry the promise of broad transferability across many subject matters. The process approach also rejects the notion of a highly generalizable "creative ability" as a unitary trait. Instead, it adopts the idea that novel thought can be encouraged in relation to each of the processes of science--observation, inference, communication, measurement, and so on. The point of view is that if transferable intellectual processes are to be developed in the child for application to continued learning in science, these intellectual skills must be separately identified, and learned, and otherwise nutured in a highly systematic manner. It is not enough to be creative "in general"--one must learn to carry out critical and disciplined thinking in connection with each of the processes of science. One must learn to be thoughtful and inventive about observing, and about predicting, and about manipulating space and time, as well as about generating novel hypotheses.[10]

Furthermore, as Heathers points out, the process-oriented approach discourages three faults that usually occur in science teaching:

> ...One fault is teaching scientific facts that are not put to use in solving scientific problems... Another fault is teaching technological facts rather than teaching how scientific principles are put to work to serve practical ends... A third fault is answering children's questions instead of teaching them to answer questions through employing the scientific method of inquiry.[11]

The greater emphasis by educators in the area of science, and elsewhere, on the processes of the disciplines encouraged a re-examination of the time-honoured "scientific method" and a closer look at what the acts of scientific inquiry are. Attempts were made to include these processes not only in the objectives of science curricula, but to teach them, and to evaluate for them.

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[10] Gagne, loc. cit.

[11] Glen Heathers, "A Process-Oriented Elementary Science Sequence," Science Education, 45: 202, April, 1961.

II. MORE RECENT SCIENCE CURRICULA AND THEIR GREATER EMPHASIS ON PROCESS

The development of science curricula in North America in the last decade or so has been far from static. Some of the problems which this development creates have been stated by Crocker as follows:

> In fact, documentation pertaining to this field has become almost overwhelming; to the point where the individual who wishes to make a serious attempt to keep up to date with science curriculum faces not only the danger of becoming mired in a veritable alphabet soup of acronyms (what is the difference between ESCP and ECCP and between SCIS and ISCS?), but also the tasks of reconciling conflicting rationales, interpreting comparative studies (which generally show no significant differences), remembering that local conditions impose perturbations on even the smoothest of curriculum designs, and trying to sort out the logical and psychological foundations of science teaching.[12]

Although a lot of this activity was confined to the secondary school level in the earlier years, it has now filtered down into the elementary schools. Thus the elementary schools can boast of a wide selection of different science curricula.[13]

These new programs are activity-oriented. Emphasis is placed on "doing". Children are provided with suitable experiences which seek to allow the student to discover for himself with the guidance of the teacher basic science concepts and process skills.[14]

J. Richard Suchman undertook one of the first projects which sought to stress processes in the classroom.[15] He developed a method of looking

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[12] Robert K. Crocker, "The Structure of Science and Its Relevance to Science Curriculum" (St. John's: Department of Curriculum and Instruction, Memorial University of Newfoundland, 1969), p. 1. (Mimeographed.)

[13] Grade Teacher, "The Necessary Nine," Grade Teacher, 85: 87-90, January, 1968.

[14] Mokosch, op. cit., p. 19. [15] Ibid.

at scientific problems by having pupils view appropriate film loops and then discover scientific concepts and processes by asking yes-no questions of the teacher. He developed an instrument to measure the outcomes of inquiry learning, part of which measures process. By looking at the number and types of questions asked, the amount of progress made by the student could be determined.[16] The big limitation of Suchman's model is that it postulates that the essence of inquiry can be attained by analyzing problems at the verbal level.

Klopfer and Cooley tried to expose students to the processes of science by developing case histories of scientific works in the various fields of science and having students study, question, and debate them.[17]

The best developed and most influential process-oriented elementary science course was developed under the auspices of the American Association for the Advancement of Science's Commission on Science Education. The commission, composed of nearly a score of leading educators in the United States, was "charged with the job of developing a usable program for teaching the 'process method' in grades K to 6."[18] Thus Science--A Process Approach had its beginnings in 1963. There were several testing periods and revisions. In 1967 the course was published in its entirety and marketed to interested schools.[19]

The basic premises taken by the AAAS Commission towards the

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[16] C.L. Hutchins (senior editor), Elementary Science Information Unit: Inquiry Development Program in Physical Science (IDP): Program Report (Berkley, California: Educational Research and Development, 1970), p. 25.

[17] Mokosch, op. cit., pp. 20-21.

[18] Grade Teacher, "The Process Method of Teaching Science," Grade Teacher, 83: 60, January, 1966.

[19] AAAS, 1965, op. cit., Introduction, p. v.

process approach are:

> 1. The scientists' behaviors in pursuing science constitute a highly complex set of intellectual activities which are, however, analyzable into simpler activities.
>
> 2. These intellectual activities (processes) are, as most scientists would agree, highly generalizable across scientific disciplines. It is not difficult for a physicist to become a biochemist, or vice versa, so long as language and techniques are learned. It is not even difficult for a meteorologist to become a psychologist--predicting the weather and human behavior may have comparable degrees of uncertainty.
>
> 3. These intellectual activities of scientists may be learned, and it is reasonable to begin with the simplest ones and build the more complex activities out of them, since this seems to be in fact the way they are organized.
>
> 4. Accordingly, one can construct a reasonable sequence of instruction which aims to have children acquire process skills, beginning with simple kinds of observation, and building progressively through classifying, measuring, communicating, quantifying, organizing through space and time, to the making of inferences and prediction. As further building occurs, one finds it possible for students to learn how to make operational definitions, how to formulate testable hypotheses, how to carry out experiments, and how to interpret data from experiments. At this point, probably, one may well have a pretty sophisticated student on his hands.
>
> 5. At the end of such instruction, the student will not necessarily know anything which can be identified as physics, or chemistry, or biology, or geology. What will he know, then? Perhaps something like this: A scientist should be able to tell this student what he (the scientist) is studying, and the techniques he is using, and what he has found, in a relatively brief fashion, and have the student display a rather profound understanding of it immediately. Presumably, such a student will <u>not</u> have to take a course in the philosophy of science in order to display this understanding.[20]

The main objective of each activity taught in the course is to teach one or more of the processes of science.[21]

> ...Exercises for kindergarten through grade three develop the child's skills in these processes: observing, classifying, measuring, communicating, recognizing space-time relations, recognizing and using

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[20] <u>Ibid</u>., pp. 4-5.

[21] <u>Ibid</u>., Introduction, p. v.

number relations, infering, and predicting.

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> Exercises for grades four through six develop the child's skills in these processes: formulating hypotheses; making operational definitions; controlling and manipulating variables; experimenting; formulating models; interpreting data.[22]

Another science program, the Elementary Science Study (ESS) was developed by the Educational Services Incorporated to provide science experiences for children. A large number of materials was produced so that students would become skillful in investigating, testing, communicating, drawing conclusions and inferences, etc.[23] The main objective of the work of the project was to "encourage children to work individually and independently, to devise experiments and to direct their questions to the material."[24]

Robert Karplus directed the development of a third program, the Science Curriculum Improvement Study (SCIS) at the University of California. The program teaches children science by direct experiences. It stresses the importance of the concepts of science. Besides having a strong conceptual framework in the physical and life sciences, the course also stresses the process-oriented concepts of property, reference frame, system, and model. "These concepts, together with the others that relate to specific units, are at the heart of the processes of observing, describing, comparing, classifying, measuring, interpreting evidence, and experimenting."[25]

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[22] Arthur H. Livermore, "AAAS Commission on Science Education: Elementary Science Program," Journal of Chemical Education, 43: 270-271, May, 1966.

[23] Grade Teacher, 1968, op. cit., p. 88.

[24] Deborah P. Wolfe, "Trends in Science Education," Science Education, 54: 74, January-March, 1970.

[25] Robert Karplus (director), Environments: Teachers Guide-SCIS (New York: Rand McNally and Company, 1970), pp. 8-9.

The Elementary School Science Project (ESSP-USU) was initiated under the leadership of John K. Wood to provide qualitative and quantitative experiments for children from five to seven years of age. Methods and techniques used by scientists are emphasized to solve interesting problems which eventually leads to scientific concepts. A series of lessons based on the biological and physical sciences were developed for grades K-2 "designed to reveal some of the basic unifying ideas of science through investigation of everyday experiences."[26]

Most new elementary science curricula seek to teach to some extent the processes of science. Science--A Process Approach is completely process-oriented. Besides being an excellent curriculum in itself, it is also important because it has served as a model, or catalyst, for the development of other process-oriented curricula on a more local basis. These local programs are justified in that local conditions may dictate the inadequacy of a national curriculum in terms of content, cost of introducing it, etc. even though the philosophy, the objectives, and the basic assumptions are acceptable. Also, this type of curriculum can be expanded into other grades. Such was the case, for example, when Nay and his associates undertook to develop a three-year sequence of science courses at the Junior high school level in 1965. As Nay explained, the framework used to develop the program included several features of Science --A Process Approach, Schwab's theory on the structure of the disciplines, their perception of the nature of science, and different aspects of science teaching. Rather than use the process inventory developed by the AAAS Commission, they first produced their own inventory and developed the course

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[26]Wolfe, op. cit., p. 73.

on this basis. In developing their own inventory, they prefered to use their own method of selecting and organizing the scientific processes.[27]

The Elementary Science Curriculum Project (ESCP) was initiated in the fall of 1969 with the aim of developing a science program suitable for use in elementary schools in Newfoundland. This program subscribes to the main objectives and basic assumptions that are expounded in the AAAS Science course. Yet, an adoption of the AAAS program into Newfoundland schools would have been impossible mainly because of the high cost of the apparatus kits for each grade level.

Some of the premises which the ESCP Course is based on are as follows:

> 1. A science program must be based on the premise that science is for all students, not simply for those who are potential scientists. The general aim should be a common literacy in science based on a comprehension of the nature, purposes, and methodology of science, of the major concepts - generalizations, and theories of modern science, and of the role of science in our society.
>
> 2. Science teaching at the elementary school level must take into account the levels of development of the thinking capabilities of children. At present, the only comprehensive theory of child development which deals with the logical thinking capabilities of children is that of Piaget and his associates. The Piagetian model should therefore be used in organizing the program to meet the capabilities of children at different grade levels.
>
> 3. It is possible to draw a direct parallel between the increasing complexity of scientific processes (from simple observation to classifying, induction, model building and others) and the levels of child development...[28]

Based on these premises and taking into account certain local

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[27] Nay, op. cit., pp. 199-200.

[28] Robert K. Crocker, "Elementary Science Curriculum Project: Progress Report and Proposals for Future Development" (St. John's: Department of Curriculum and Instruction, Memorial University of Newfoundland, 1972), p. 2. (Mimeographed.)

constraints, such as poor teacher education in the area of science and the general lack of moneys for the introduction of expensive science programs, certain decisions were made regarding the structure of the project. They were:

> 1. The program should be based on the provision of direct experiences which exemplify scientific processes and which lead to a comprehension of the dynamics of science.
>
> 2. The program should be organized along process rather than content lines. The processes developed by the AAAS for the program Science - A Process Approach were considered sufficiently comprehensive to form the basis of organization.
>
> 3. The emphasis on direct experience implies a de-emphasis on the textbook as the main vehicle of instruction. A more legitimate use of the textbook is as a reference. It is therefore not necessary for each student to have his own copy of a text. Rather a variety of texts should be made available in the classroom or school library.
>
> 4. A comprehensive teaching guide should serve as the core of the program. The guide should be designed to serve at least partly as a means of inservice training...
>
> 5. A detailed list of apparatus should be compiled, with details of procurement, improvisation, and construction. Emphasis should be on simple, inexpensive, and easily obtained apparatus. The apparatus should be supplied in the form of class kits designed to relieve the teacher of the time-consuming task of acquiring apparatus as needed for specific activities.[29]

During the period from May to September, 1970 two full time assistants were hired and with their help a teachers guide for grades four, five, and six and kits of apparatus for six pilot study classes were developed. In the school year of 1970-71 the program was taught by six teachers representing four school districts. Experiences gained formed the basis for an extensive revision, which was made during the summer of 1971. In particular, the program was extended to include grades one, two, and three. In early 1971, the Department of Education agreed to produce

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[29] _Ibid._, p. 3.

one hundred apparatus kits for use in a larger scale trial program for 1971-72. In addition, several school districts expressed an interest in adoption of the program and were prepared to pay the full cost of producing apparatus.

Further developmental activities that were planned for the program at the time of this study were: the Teaching Guide was to be revised further with the view to balancing the various processes and subject matter, provision of supplementary reading material was being considered, and an analysis of apparatus cost was to be carried out.[30]

III. EVALUATION IN SCIENCE EDUCATION

There is no denying that much has been done since the "first influential statement of the role of science in the elementary schools appeared in the Thirty-First Yearbook of the National Society for the Study of Education..."[31] This is especially true of activities in more recent years. But there is a definite need for further evaluation of these "new" science courses.[32] Yet, despite the fact that curriculum specialists contend that evaluation is an intimate part of any curriculum development,[33] many of these programs lack adequate evaluation.[34] Hardy

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[30] Ibid., pp. 5-6.

[31] Jacqueline V. Mallinson, "The Current Status of Science Education in the Elementary Schools," School Science and Mathematics, 61: 253, April, 1961.

[32] Paul DeHart Hurd, "New Directions in Science Teaching, K-College," Education, 87: 213, December, 1966.

[33] Hilda Taba, Curriculum Development: Theory and Practice (New York: Harcourt, Brace, and World, Inc., 1962), p. 377.

[34] Robert A. Roth, "Princeton Project and the Process Approach: A Critique," School Science and Mathematics, 71: 44, January, 1971.

quotes Worthen as saying:

> Education cannot afford further neglect in evaluating its programs. Failure to meet this requirement will likely result in diminished funds, as well as in a lack of progress. In order to improve, it is necessary to know the defects and without evaluation these can only be surmised.[35]

Welch, while discussing the need for independent evaluations of the impact of the national projects in science, has stated:

> Both the foundations that support these projects and the schools that use them require a spectrum of unbiased information for guidance in making judicious use of resources. Thus far this guidance has not been forthcoming.[36]

Due to the lack of evaluating for process objectives in the past and because of the newness of process-oriented science curricula, very few evaluation instruments exist which attempt to measure this dimension of science education. As Nedelsky states: "most science tests now in use measure primarily knowledge."[37] There have been several more recent attempts to produce process-oriented instruments but there still remains a great need for general tests of this nature, which are reliable, valid, and standardized.

The first step in this direction was taken by Klopfer and Cooley, who recognized the need for "new" types of tests to accompany novel efforts in the teaching for the nature of science and scientific inquiry. They produced the Test on Understanding Science (TOUS).[38] This test measures

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[35] Clifford A. Hardy, "CHEM Study and Traditional Chemistry: An Experimental Analysis," Science Education, 54: 273, July, 1970, citing Blaine R. Worthen, "The Innovation Dilemma," Strategies for Educational Change Newsletter, 1: 3-4, December, 1966.

[36] Wayne W. Welch, "The Need for Evaluating National Science Curriculum Projects," Phi Delta Kappan, 49: 532, May, 1968.

[37] Leo Nedelsky, Science Teaching and Testing (New York: Harcourt, Brace and World, Inc., p. 120.

[38] Mokosch, op. cit., p. 31.

primarily knowledge, but it concerns procedures scientists employ in their work and the relation of science and scientists to society.[39] Several forms have since been produced. Similarly, the BSCS Processes of Science Tests and the Portland Science test attempt to measure the processes of science.[40]

Welch developed an instrument for inventoring knowledge of the processes of science for students in grades ten, eleven, and twelve, but not for the elementary grades.[41]

A unique aspect of Science--A Process Approach is that a method of evaluation was integrated into the course. At the end of each series of activities, Individual or Group Competency Measures are available to test the students on the processes they have learned.[42] Because behavioral objectives have been written for each activity, these items could be developed for each specific objective, even though the content was varied. Also, the AAAS Commission on Science Education developed a more general process instrument but it has not yet been fully validated and is being used for research only.[43] Items from these instruments were selected and modified slightly for use in this study.

Jean Beard developed group achievement tests for two basic processes

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[39] Nedelsky, op. cit., p. 228.

[40] Mokosch, op. cit., p. 33.

[41] Wayne W. Welch, "The Development of an Instrument for Inventoring Knowledge of the Processes of Science" (unpublished Doctoral thesis, University of Wisconsin, 1966).

[42] AAAS Commission on Science Education, Science--A Process Approach, Parts A-E (New York: Xerox Education Division, 1970).

[43] AAAS Commission on Science Education, Science Process Instrument: Experimental Edition (Washington, D.C.: The Commission, 1970).

of AAAS Science--A Process Approach. A series of 35-mm colored slides of basic laboratory situations was "the visual focus of the tests developed". The slides were in a sequence with a synchronized tape recording, which orally provided instructions for the pupils, stated the problem to be considered, and electronically signalled slide changes. Each pupil indicated his answer to each question by marking his answer sheet as directed by the tape.[44] Beard developed these tests for the primary grades and choosed the multi-media approach to avoid problems associated with attention span, coordination, and lack of reading or writing skills, or both.[45]

David A. Morgan used 8-mm motion picture film loops to present problems to grades six, seven, and eight students. A set of multiple-choice questions was developed to trigger the processes to be evaluated.[46] Although 1971 was the first year the tests were used, Morgan and his colleagues are pleased with the results and plan to do further developmental work on these tests.[47]

No other process instruments have been reported in the current science education literature. Thus for purposes of this study, suitable instruments had to be developed by the experimenter.

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[44] Jean Beard, "Group Achievement Tests Developed for Two Basic Processes of AAAS Science - A Process Approach" (unpublished Doctoral thesis, Oregon State University, Corvallis, 1970).

[45] Jean Beard, "The Development of Group Achievement Tests for Two Basic Processes of AAAS Science - A Process Approach," Journal of Research in Science Teaching, 8(2): 179, 1971.

[46] David A. Morgan, "STEP - A Science Test for Evaluation of Process Skills," Science Teacher, 38: 77, November, 1971.

[47] David A. Morgan, Private Correspondence, December, 1971.

IV. SUMMARY

With the latest upsurge of interest and activity in the field of elementary science education has come a greater interest in the processes of science. Although objectives which emphasize the process dimension of science have been stated by science educators for years, until recently these objectives were given limited consideration in the actual teaching of science. It became apparent that this important area of science should no longer be ignored. Prominent science educators, after considering the nature of science and the ever increasing rapidity with which scientific knowledge changes, began to condem the more traditional approaches to science teaching and called for new approaches and new emphasis in science education. This call was answered with the development of science curricula which gave greater emphasis to the processes of science, or they were completely process-oriented. Many of these curricula also gave consideration to the latest developments in the field of child psychology and the organization of the content of science around various scientific concepts.

Yet, in spite of this greater interest in the processes of science, or because of it, there has been a lack of sufficiently comprehensive evaluation of some of these courses. Also, suitable process instruments which could be used in evaluation are limited and inadequate for use in many situations. There is a great need for careful development of more general process-oriented instruments which can be used to evaluate any of these courses and until this need is met, thorough evaluation by the developers of these courses will continue to be difficult and hence limited.

CHAPTER III

METHODS AND MATERIALS

The materials and procedures used in the study are outlined in this chapter. There were essentially three different aspects to the study which required different samples, different materials, and different procedures. The three different aspects of the study were related to:

1. The Process objectives. For this experimental aspect of the study it was necessary to develop suitable process instruments. These instruments required validity and reliability studies. Also, the results from several standardized tests, both intelligence and achievement, were used as control and reference variables.

The sample used in this aspect of the study consisted of four classes of grades five and six students from the Integrated Elementary School in Springdale, Newfoundland. One class at each grade level served as an experimental group and were exposed to the ESCP Course, and the other class at each grade level served as a control group and were given a science course which did not emphasize the processes of science. Experimental and control groups were compared in terms of process achievement. The process tests were administered at both grade levels at the beginning of the study as pretests, and they were also administered again at the end of the study as postests.

Analysis of data was carried out using multiple linear regression in order to control partially for effects of some covariates.

2. Student attitudes. In considering student attitudes towards the ESCP

Course, it was necessary to develop an appropriate instrument. A Q-sort instrument was developed which examines student attitudes towards various aspects of the course.

The sample used for this part of the study consisted of students at the grades five and six levels from six schools in which the ESCP Course was being taught. These schools were selected from different regions of the province on the basis of accessability to the experimenter.

This data was analyzed by examining the percentages of similar responses to the different items in the Q-sort. Also, it was possible to consider how different independent variables affected responses on different sub-groups of items within the Q-sort.

3. Teacher attitudes. In considering teacher attitudes towards various aspects of the course, it was necessary to develop an appropriate instrument. This instrument was developed in the form of a Likert-type questionnaire.

The sample used for this aspect of the study consisted of all teachers who were teaching the course in Newfoundland schools at the time of the study.

The data was analyzed by obtaining the percentages of similar responses to the different items in the questionnaire. As well, it was possible to examine the effects of different independent variables on responses to different sub-groups of items in the questionnaire.

I. SAMPLES USED IN THE STUDY

For the Experimental Aspect of the Study

The sample used in this study for purposes of examining process achievement of students in the course was confined to the grades five and six levels, even though the course was developed for use in grades one through to six. The sample used consisted of students from two grade five classes and students from two grade six classes from the Integrated Elementary School in Springdale, Newfoundland. A random selection of students in a particular grade for assignment to treatment groups was impossible because of administrative constraints. Therefore, selection had to be on the basis of whole classes. One class from each grade served as a control group, and one class from each grade served as an experimental group. Selection of these classes for experimental and control groups was made by the experimenter and not the school personnel. A discussion with the principal revealed that classes were organized on the basis of ability, with an upper and a lower class in each grade. Groupings were based on intelligence and achievement ability as expressed on class tests. An arbitary decision was made to run the ESCP Course in the top grade five class, consisting of the smarter students in that grade, and the lower grade six class, consisting of the more backward students in that grade. The control group in grade five was the lower class and the control group in grade six was the upper class. An examination of Table I will reveal that classes in grade five differed noticeably in average intelligence; similarly, classes in grade six differed noticeably in average intelligence. Thus it is apparent that control and experimental groups in each grade certainly did not have pre-experimental sampling equivalence. There were one hundred and forty-nine students involved in this aspect of the study. Table II, page 28, shows the distribution of these students by sex, class, and grouping.

To Examine Student Attitudes

The sample used to examine student attitudes towards the course

TABLE I

MEAN IQ SCORE ON THE LORGE-THORNDIKE INTELLIGENCE

TESTS FOR GRADES FIVE AND SIX CLASSES

USED IN EXPERIMENTAL STUDY

Grade	Experimental $\overline{X}$	Control $\overline{X}$
Five	102.2	88.9
Six	86.3	105.8

TABLE II

DISTRIBUTION OF STUDENTS IN THE

EXPERIMENTAL SETTING

Group	Experimental		Control	
Grade	5	6	5	6
Boys N	16	15	32	14
Girls N	16	18	23	15
Class N	32	33	55	29
Total N		149		

consisted of students in grades five and six from selected schools in which the course was being taught. Classes selected for this purpose were chosen so that they would be representative of schools in different parts of the province. Table III shows the distribution of these schools. A random selection of classes from schools in which the ESCP Course was being taught would have been administratively impossible because the Q-sort instrument had to be administered to each class by the experimenter. Also, a stratified selection representing different areas of the province was considered to be a better procedure since it would be more representative of the larger population. Because of the relatively small number of schools in which the course was being taught, a meaningful stratified random sample would have been impossible to obtain. Therefore, classes from accessible schools in different regions of the province were selected as the sample. Table IV, page 31, shows the number of students doing the Q-sort by school, grade, and sex.

To Examine Teacher Attitudes

The attitudes of teachers towards the ESCP Course were obtained by sending an appropriate questionnaire to all teachers who were teaching the course in Newfoundland schools. These teachers came from schools who had adopted the course. Since these schools were the first to adopt the course, it could be argued that the administration and teachers of these schools may differ from those of schools who had not yet adopted the course. But since the course was in operation for three years and since the total number of schools who had adopted the course was fairly large, this may not be a serious limitation on generalizability of results based on these returns. Table V, page 32, gives the distribution of teachers teaching the course at the time of this study according to school board

TABLE III

DISTRIBUTION OF SCHOOLS IN WHICH THE Q-SORT

WAS ADMINISTERED, BY GRADE

Place	School	Grade 5	Grade 6
Labrador	A.P. Low Elementary	*	
	J.R.S. Collegiate	*	
Pt. Leamington	Integrated Elementary	*	
Springdale	Integrated Elementary	*	*
St. John's	Curtis Academy		*
Windsor	St. Alban's	*	*

TABLE IV

DISTRIBUTION OF STUDENTS DOING Q-SORT

BY SCHOOL, GRADE, AND SEX

School	Grade	Boys N	Girls N	Class N
A.P. Low Elementary	5	11	13	24
Curtis Academy	6	21	15	36
J.R.S. Collegiate	5	6	7	13
Pt. Leamington Integrated	5	11	16	27
Springdale Integrated	5	16	16	32
	6	13	18	31
St. Alban's	5	12	10	22
	6	12	20	32
Total N				217

TABLE V

DISTRIBUTION OF TEACHERS TEACHING THE ESCP COURSE

BY SCHOOL BOARD AND NUMBER OF SCHOOLS

School Board	Number of Schools	Approximate Number of Teachers
Avalon Consolidated	2	21
Avalon North Integrated	22	24
Bay of Islands-St. George's (Integ.)	1	5
Bonavista-Trinity-Placentia (Integ.)	8	9
Burin Peninsula Integrated	2	2
Conception Bay North (R.C.)	2	4
Exploits Valley Integrated	11	25
Ferryland R.C. Consolidated	1	5
Gander-Bonavista (R.C.)	2	11
Green Bay Integrated	1	2
Labrador West Integrated	5	32
R.C. School Board (St. John's)	2	2
Total N	59	142

and the number of schools under each board. Approximately seventy-five per cent of the questionnaires sent out were returned. The exact percentage was difficult to assertain since questionnaires were sent to the schools and in some cases the school boards, instead of individual teachers, whose names were not known. Some schools who had planned to introduce the course and who were sent questionnaires did not teach it because of administrative problems. For example, several schools did not receive the apparatus kits and thus could not teach the course. Therefore, it seems fair to assume that the actual percentage of returns from teachers who had taught the course was somewhat higher than the seventy-five per cent estimated.

II. PROCEDURES

For the Experimental Setting

The experimental aspect of this study was similar in design to quasi-experimental design ten as outlined by Campbell and Stanley. The groups used for experimental and control purposes did not have "pre-experimental sampling equivalence". Rather, they constituted "naturally assembled collectives such as classrooms", as similar as circumstances permitted.[1]

The study began in January, 1972 with the administration of the process instruments to all four classes involved. A decision was made to run the ESCP Course in the top grade five class and the lower grade six class--the experimental groups. An alternate science course, which did

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[1]Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research (Chicago: Rand McNally and Company, 1963), p. 47.

not stress the processes of science, was introduced into the lower grade five class and the upper grade six class--the control groups. The purpose of running the alternate course in the control groups was to control for the Hawethorne effect. Each class was exposed to two science periods per week.

Students in the experimental group were taught the ESCP Course as outlined in the Teaching Guide. The classroom teacher, in each case, was responsible for teaching the science. Since teachers were aware of the experimental set-up, a possible Hawethorne effect could have resulted.

In the control groups science was also taught by the classroom teachers. The teacher was supplied with different science texts and reference books, science films, etc. The organization of the course depended on the wishes of the individual teacher. It was unstructured, but students were learning science. No attempt was made to have the teacher emphasize the processes of science in the control groups.

The courses were run in the school from January, 1972 until June, 1972. The postests were administered the second week in June to all four classes involved. The same process tests were used for pretest and postest purposes.

To aid in establishing how similar the experimental and control groups were in each grade, a standardized science test (the STEP Science Test) was administered during the time the experiment was running in the school. Also, comparisons between classes were made on the basis of results on an intelligence test (the Lorge-Thorndike Intelligence Tests). Along with the other independent variables of sex and socio-economic standing the results from these tests were used to compare experimental and control groups. These results served as covariates in the analysis of data.

Socio-economic standing was determined on the basis of the occupation of the student's father, using the Blishen scale.[2] The values assigned to different occupations in the Blishen scale were rounded off to the nearest whole number for use in the study.

Variation from initial design. Because the teacher variable could not be controlled adequately--it was originally planned to change the teachers in the experimental groups to the control groups, and vice versa, at the mid-point in the study, but this proved administratively impossible, it was necessary to administer the process tests in classes outside of the experimental setting, who were also doing the ESCP Course. A comparison of results from these classes with those from the experimental groups helped in determining how much the uncontrolled teacher variable interfered with the results obtained in the experimental setting. Even though there are obvious limitations to comparisons of this nature --similarities or differences could be due to other factors besides differences in the teachers, they at least indicated roughly how serious this problem was in the study.

For Examining Student Attitudes

A Q-sort instrument was administered to different classes of grade five and six students in order to see how students felt about the course. Students were asked to sort forty cards, each having either a positive or a negative statement about the course, on a five point scale. Each card was numbered and students were required to write the number in the appropriate column on the response card provided. If any reading

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[2] Bernard R. Blishen, "A Socio-Economic Index for Occupations in Canada," Canadian Review of Sociology and Antropology, 4: 44-50, February, 1967.

problems were encountered while reading the different statements, students were given assistance. Enough time was provided to allow students to finish at their own pace.

For Examining Teacher Attitudes

In order to obtain teacher attitudes towards the ESCP Course, a questionnaire was sent to all teachers teaching the course. This comprehensive questionnaire was prepared during the spring of 1972, the purpose of which was to obtain feedback from teachers teaching the course. This feedback provided guidelines for a new edition of the Teaching Guide that was to be prepared during the summer of 1972. Part II of this questionnaire was designed to explore teacher attitudes. It is in the form of a Likert scale. Teachers were required to rank statements related to teaching the course according to the amount of agreement or disagreement with the different statements. Questionnaires were sent to all teachers teaching the course by mail when it was not possible to contact then personally. Rather than having to depend on the teachers returning the questionnaires by mail, many of the questionnaires were collected personally. Approximately seventy-five per cent of these questionnaires were returned.

III. TESTING INSTRUMENTS

Science Process Tests

Because of the lack of process instruments, it was necessary to develop suitable tests for this study. Two tests were developed--one for each grade.

The first step in the development of these instruments involved an analysis of the ESCP Teaching Guide by the experimenter which revealed the scientific processes which were stressed at both grade levels and what proportion of the total work in each grade was concerned with such process. This aided in deciding what processes the tests should attempt to get at and how much emphasis each should be given. Next, a pool of possible test items was accumulated on index cards and each card was identified according to the process the item would test. These items came from the Competency Measures of the AAAS: Science--A Process Approach. Only minor modifications of these items were necessary before they could be used. For example, in some cases washer weights rather than grams were used as the unit of measurement. From the pool of test items for each grade, items were selected so that they reflected the different processes under study. Some items were selected on the basis of content as well; the content of such items was similar to that dealt with in the course. Items were also selected on the basis of difficulty as judged by the experimenter. Most items were developed by the AAAS for these grades. No actual testing of students was done for this purpose. The number of items that would test different processes varied depending on the emphasis that these processes were given in the course.

Besides reflecting the validity of the AAAS Competency Measures, which were prepared by science educators and which have process emphasis according to the AAAS Model, the tests were further validated by submitting them to two faculty members in the Department of Curriculum and Instruction at Memorial University, who are science specialists and who are familiar with the course.

Furthermore, since these tests were developed to conform to a particular process model, as outlined in the introduction to the ESCP Teaching Guide, they have content validity. Based on the postulation that the scientific endeavour can be divided into different discrete processes and that these processes can be organized and sequenced for learning purposes, items were developed to test these processes.

The reliability of these instruments was established by administering them to several groups of people. The test-retest method was used. There was a period of two weeks between administration of the test and the retest.

The tests, for purposes of reliability estimation, were given to four groups of students at Memorial University who were doing an elementary science education course in the Faculty of Education. This was deemed necessary since it was believed that these students could more likely cope with the items in the tests than students in grades five and six. Reliability estimates based on the latter groups could be misleading, since many of the test items could be omitted each time. But a limitation of this procedure was that university students were unlike the subjects in the experiment. Table V shows reliability estimates found in this way. Because there was not enough time available to allow students to complete the grade six test during each testing, the reliability of the first half of the test was calculated and the Spearman-Brown Prophecy formula was used to estimate the reliability of the entire test.

The two tests were also administered to a grade five and a grade six class of students, using the same procedure as above. These students had done the ESCP Course for the particular grade they were in. This gave another estimate of reliability of the instruments, as shown in Table V, from students who were at the level of those in the study.

Items on these process tests were norm referenced and considered to have a sufficient range of difficulty to discriminate a range of achievement. Hence, in constructing a scoring key to these items, an acceptable range of achievement on the items was established which would

TABLE VI

RELIABILITY ESTIMATES OF TESTS[a]

Test	Reliability
STEP Science Test	.91 K
Lorge-Thorndike Intelligence Tests	
Level 2	.761 A F .586 O-E
Level 3	
Nonverbal	.814 A F .940 O-E
Verbal	.896 A F .940 O-E
Process Science Test (Grade Five)	
Grade Five Students	.77
University Students	.79
Process Science Test (Grade Six)	
Grade Six Students	.64
University Students	.71* .74**
Student Q-Sort	.64

[a]Test-Retest over two weeks except where postscripted by K which indicates a Kuder-Richardson Formula 20 calculation, A F which indicates an Alternate-Forms reliability estimate, and O-E which indicates an Odd-Even reliability estimate.

*Reliability estimate for the whole test.

**Reliability estimate for the whole test based on the first half and using the Spearman-Brown Prophecy Formula.

indicate that the process being tested had been learned, or partially learned, by the student. Answers within this range were marked correct. There is a total possible score of forty points on the grade five process instrument and a total possible score of sixty points on the grade six process instrument.

Acceptable answers to the various questions were established prior to test administration and all scoring was done by the experimenter. No attempt was made to identify the treatment group of the student tested until all the paper had been marked.

S.T.E.P. Science Test

Characteristics of the Sequential Tests of Educational Progress (S.T.E.P.) prepared by Educational Testing Services Inc., in most subject areas have been well documented.[3,4] For this study the General Science Test, form 4A, for upper elementary grades was used as a control and reference variable in the analysis of postest results from the experimental setting. This test is designed to measure scientific knowledge and aptitude. Reliability estimates as published in the S.T.E.P. Technical Report are reproduced in Table VI, page 39.[5] Validity was considered to be acceptable.[6] This test was administered to the students at the beginning of the study.

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[3] Leo Nedelsky, op. cit., pp. 226-227.

[4] Anne Anastasi, Psychological Testing (third edition; New York: Macmillan Company, 1968), pp. 397-402.

[5] STEP Technical Report (Princeton, N.J.: Educational Testing Services, Cooperative Testing Division, 1957), p. 10.

[6] Ibid., p. 9.

Lorge-Thorndike Intelligence Tests

According to Freeman, this intelligence test "is among the best group test available, from the point of view of the psychological constructs upon which it is based and that of statistical standardization."[7] For this study, results on forms 2A and 3A from the students' cumulative records served as another control and reference variable in the analysis of the data. Reliability estimates for these forms as published in the Lorge-Thorndike Intelligence Tests Technical Report are reproduced in Table VI, page 39.[8] The validity of these tests is acceptable for the purpose of which the tests were used in the study.[9]

Student Q-Sort Instrument

This instrument was developed for use in the study. The instrument is intended to record student attitudes towards various aspects of the ESCP Course. It consists of forty different items each of which is a statement, either positive or negative, about some aspect of the course. Twenty of these statements are positive and twenty are negative. The different statements pertain to the type of course, course content, teaching style, students' general attitudes towards the course, students' attitudes towards science periods and science in general, and students'

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[7] Frank S. Freeman, "Lorge-Thorndike Intelligence Tests," The Fifth Mental Measurements Yearbook, O.K. Buros (ed.), (Highland Park, N.J.: The Grypon Press, 1959), pp. 479-481.

[8] Irving Lorge and Robert L. Thorndike, The Lorge-Thorndike Intelligence Tests Technical Manual for Administrators, Directors of Testing and Research (revised edition; Boston: Houghton Mifflin Company), pp. 8-9.

[9] Ibid., pp. 14-23.

motivation towards science due to the course. Each statement is printed on a three by five inch index card and assigned a number, forty cards making the full "deck", which each student sorts into five different categories depending on the amount of agreement or disagreement with the different statements. The greater the amount of agreement with the different statements--both positive and negative, the higher the value assigned to the category. The highest value is five and the lowest value is one.

The validity of these items were determined by submitting them to two science educators in the Department of Curriculum and Instruction at Memorial University for judging. Judges were asked to determine if the items were suitable for eliciting the attitudes of students at the grades five and six levels towards different aspects of the ESCP Course. They agreed that most items were suitable. Judging of the items was based on an acceptable-unacceptable basis. Any item considered to be unacceptable by any one judge was discarded. From these acceptable items, forty were then selected so that they would measure attitudes towards different aspects of the course and so that twenty would be positive and twenty negative.

Reliability of the Q-sort was obtained by the test-retest method over a two-week period using a grade five class not otherwise connected with the study. The responses of ten of the students, which were selected at random from the group, on the test and retest were correlated with themselves and an average correlation, as shown in Table VII, was obtained using the Fisher-Additive tables.

<u>Teacher Questionnaire</u>

The over-all purpose of this questionnaire was to elicit feedback

TABLE VII

TEST-RETEST CORRELATIONS ON STUDENT Q-SORT

Subject	Correlation r	Fisher-Additive Transformation Z_r
1	.895	1.447
2	.528	.590
3	.628	.741
4	.888	1.422
5	.480	.523
6	.832	1.188
7	.671	.811
8	.388	.412
9	-.113	-.116
10	.528	.590
	Total	7.608

Average Z_r = .761

Average r = .640

from teachers who had taught the course. Part II of the questionnaire was developed with the objective of obtaining teacher attitudes towards various aspects of the course. Most of the items were in the form of a Likert scale, each teacher being required to check an appropriate space on the different scales according to the amount of agreement or disagreement with the different statements given. The more agreement with a statement--either positive or negative, the higher the number assigned to the category checked by the teacher. The highest category value was five and the lowest category value was one. The various statements included in the questionnaire sought the teachers' opinions towards the Teaching Guide, the apparatus, the teaching methodology required to teach the course, classroom problems related to teaching the course, evaluation of students, apparent student problems related to the course, the attitudes of teachers towards the course, the attitudes of teachers towards elementary science, and apparent student attitudes towards the course.

The validity and appropriateness of the different items were determined by a science educator familiar with the course. No reliability studies of this instrument were carried out but sufficient alternate-response items were included to provide an indication of the consistency of response. Correlations between the alternate-response items, as shown in Table VIII, indicate that teachers responded fairly consistently on these items. It can be assumed that this consistency applies to all items used in the instrument. Formal reliability studies proved administratively impossible.

TABLE VIII

CORRELATIONS OF ALTERNATE-RESPONSE ITEMS ON

TEACHER ATTITUDE QUESTIONNAIRE

Item Number	Item Number	Correlation r
5	37	.4817
7	36	.5135

IV. STATISTICAL DESIGN

Experimental Data

With the advent of high speed computers, multiple linear regression has been recognized as having great potential for investigating the relationships between a set of independent variables (predictors) and a dependent variable (criterion).[10] The theory behind this technique and its usefulness has been well documented.[11,12]

This technique proved to be useful for analyzing the data from the experimental setting because it was possible to partially control for some of the differences between the experimental and the control groups which could not be eliminated during the study itself.

The basic assumption of multiple linear regression is that there exists a linear relationship between a set of predictors and a criterion (Y).[13] Each predictor is assigned a weighted coefficient so as to minimize the error sum of squares (ESS) between the predicted criterion $\hat{Y}$, and the measured values of Y. This is calculated over the N individuals for whom observations have been made. Data may be either categorical or continuous.

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[10] Joe H. Ward, Jr., "Multiple Linear Regression Models," Computer Applications in the Behavioral Sciences, Harold Borko (ed.) (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962), pp. 205-207.

[11] Robert A. Bottenberg and Joe H. Ward, Jr., Applied Multiple Linear Regression, Clearinghouse for Federal Scientific and Technical Information. U.S. Department of Commerce, Technical Documentary Report PRL-TDR-63-6 (Washington: Government Printing Office, 1963).

[12] Dave Flatham, "Hypothesis Testing with Multiple Regression" (Edmonton, Alberta: Educational Research Services, University of Alberta, 1968). (Mimeographed.)

[13] Ward, op. cit., pp. 207-236.

The observed product-moment correlation (R) between Y and $\hat{Y}$ is a measure of the goodness of fit between observed and predicted values of the criterion. Its square, the squared multiple correlation (RSQ), represents the amount of variance of the criterion which the full, linear equation, usually called Model 1, accounts for.

To investigate the effect of a particular variable, a second equation, the restricted equation, usually called Model 2, is used omitting that particular variable. The full equation uses all possible prediction information; the restricted equation restricts the variable under consideration. It is possible to test the significance of the contribution of any one variable in the presence of the others by writing an F ratio, which incorporates the difference between the squared multiple correlation of the full model and that of the restricted model. The correct degrees of freedom can be determined.

The predictor variables used in this study in analyzing the data were scores on the pretest, scores on a science achievement test (S.T.E.P. Science), scores on an intelligence test (Lorge-Thorndike Intelligence Tests), socio-economic standing, sex, and grouping. All these variables were considered to have a possible effect on postest achievement and, therefore, they were included in the regression equation to allow the analysis to examine postest achievement between groups in their presence. The contribution of each variable to the variance on the postest could then be determined.

The particular application of multiple linear regression in this study is essentially an analysis of covariance. This technique is used to "adjust" criterion scores for the effects of several covariates in order to compare two different treatments. However, as Elashoff points out, it must be applied and interpreted with care.[14]

> The covariance procedure [can] reduce possible bias in trestment comparisons due to differences in the covariate[s] x and increase the precision in the treatment comparisons by reducing variability in criterion scores "due to" variability in the "covariate" x.[15]

This technique is valid for testing for differences in average criterion scores among treatments if the following assumptions can be made:

a) random assignment of individuals to treatments,
b) within each treatment, criterion scores have a linear regression on x scores,
c) the slope of the regression line is the same for each treatment (there is no slope-treatment interaction),
d) for individuals with the same score x, in the same treatment, criterion scores, y, have a normal distribution,
e) the variance of the distribution of y scores for all students with the same x score in a particular treatment is the same for all treatments and x scores,
f) criterion scores are a linear combination of independent components: an overall mean, a treatment effect, a linear regression on x, and an error term.[16]

Because some of these basic assumptions cannot be fully justified in this particular study, interpretation of results based on the analysis used had to be done with caution. For example, individuals were not randomly assigned to treatment groups and although the covariance technique can be used where the experimenter has to work with "intact groups", it must be used with caution.[17]

One basic assumption of multiple linear regression is that the criterion and the predictors are linearly related. This has to be assumed in this study and the assumption can be questioned. This is especially true for the relationships between the postest criterion and socio-economic

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[14] Janet D. Elashoff, "Analysis of Covariance: A Delicate Instrument," American Educational Research Journal, 6: 383, May, 1969.

[15] Ibid., p. 384.

[16] Ibid., p. 385.

[17] Ibid., p. 387.

standing and sex.

Thus it is evident that the analysis technique used in this study is an application of a mathematical model which has definite limitations under these circumstances.

The computer services at Memorial University allowed for the use of a suitable program called MULR05 which enabled the different computations to be made.

For Analysis of Q-Sort and Questionnaire Responses

The Q-sort and questionnaire responses were analyzed using descriptive statistics. The responses on certain sub-groups of items were examined in terms of different independent variables. Differences were examined for statistical significance using the t-test and analysis of variance. A percentage summary of responses over all subjects was also obtained in both cases.

In each case, it was possible to use the computing services at Memorial University to perform the various computations.

CHAPTER IV

RESULTS AND ANALYSIS I: EXPERIMENTAL DATA

In this chapter the results of the experimental portion of the study is considered in relation to the major hypothesis. A regression analysis of the postest scores and certain referent variables is given for each grade. A number of other considerations are explored as well.

A descriptive analysis of the responses of pupils and teachers as to their attitudes towards the ESCP Course will be dealt with in the next chapter.

Because it was necessary to use whole classes of students for experimental and control purposes, there was a need to control for certain differences between groups in analyzing the data. As was stated previously, a random selection of subjects for control and experimental purposes from the population was impossible. This is a continuing problem in educational research, where investigations have to be made within the confines of the administrative organization of the school. Multiple linear regression enabled the researcher to control partially on a statistical level for certain group differences other than the experimental variable under study while examining the effects of that variable.

I. RESULTS FOR GRADE FIVE

In order for the analysis of grade five results on the postest to be viewed in perspective, the intercorrelations among the variables used in the regression equation are given in Table IX. With the exception of

TABLE IX

INTERCORRELATIONS AMONG VARIABLES IN GRADE FIVE

N = 76

Socio-Economic Ranking	1.00	0.15	0.19	0.42	0.30
Pretest		1.00	0.77	0.62	0.47
Postest			1.00	0.60	0.35
STEP Science				1.00	0.52
Lorge-Thorndike Intelligence Test					1.00

socio-economic ranking correlating with the pretest and the postest, all other variables intercorrelated fairly highly. Of these, the intercorrelations of pretest and postest scores with each other and with the STEP Science test scores were the most significant. As expected, STEP Science scores correlated well with intelligence scores. Since the STEP Science test gives a measure of aptitude and achievement, a higher intelligence would help the student score higher on this test.

An examination of the correlations between the postest criterion of the regression equation with the predictor variables reveals that correlations between the criterion and pretest, and STEP Science were the highest. Correlations of postest scores with intelligence were fairly low and correlations of postest with socio-economic ranking were quite low. This would suggest that of these predictor variables, intelligence and socio-economic ranking would contribute less in accounting for the postest variance. This was borne out in the regression analysis.

Hypothesis 1

This hypothesis postulated no significant difference across treatment groups with respect to process achievement on the postest. In testing this hypothesis using a regression equation, seventy-six of a possible eighty-four subjects were used. Subjects missing one or more scores on any of the variables had to be omitted. A number of predictor variables were included in the regression equation and each one tested for significance of contribution using the F test. The results are recorded in Table X. Results for a particular variable have meaning only in the presence of the other variables included in the equation. This was done for all variables to indicate which ones contributed significantly in the

TABLE X

CONTRIBUTIONS OF VARIABLES WITH POSTEST

AS CRITERION IN GRADE FIVE

N = 76

	Restriction	RSQ	Difference	df	F Ratio	Probability
X_1, X_2	Grouping	.6432	.0366	1/69	7.89	0.00646
X_3, X_9	Sex	.6619	.0179	1/69	3.85	0.05
X_4	Socio-Economic Ranking	.6782	.0016	1/69	0.35	N.S.
X_5	Pretest	.5598	.1199	1/69	25.85	0.00000
X_7	STEP Science	.6585	.0213	1/69	4.60	0.03554
X_8	Lorge-Thorndike Intelligence Test	.6733	.0064	1/69	1.39	N.S.

REGRESSION EQUATION

$$Y = 3.27X_1 - 1.77X_3 + 0.02X_4 + 0.83X_5 + 0.13X_7 - 0.04X_8 - 23.72$$

RSQ = .6798

analysis. All variables except socio-economic ranking and intelligence scores contributed significantly in the analysis. An examination of the regression weights for each variable in the equation, as shown in Table X, page 53, will verify these findings. The largest significant contribution was made by the pretest scores and the second largest contribution was made by grouping.

Statistically there was a very significant difference ($p < .01$) in performance on the pretest between experimental and control groups. On the basis of this, the null hypothesis can be rejected for grade five. But accepting the alternate hypothesis that because students were exposed to the ESCP Course, they performed significantly better on the pretest, process test than students not taking the course must be done with caution. Because thirty-two per cent of the variance on the postest was unaccounted for in the regression analysis, it can be concluded that multiple regression did not make the experimental and control groups completely equivalent on the basis of the covariates used. There was no way of knowing if this unexplained variance was systematically related to group membership or not. If it were, the observed differences could well be not significant. Also, in interpreting these results, other limitations of the analysis, already examined, must be considered.

Group means and standard deviations, as shown in Table XI, illustrate the gain by the experimental group on the postest over the pretest, whereas the control group's performance was almost equivalent each time. Means and standard deviations for the other variables show how these two groups compared with each other. There was a greater variability in postest scores than there was in the pretest scores.

II. RESULTS FOR GRADE SIX

The intercorrelations among the variables used in the grade six

TABLE XI

MEANS AND STANDARD DEVIATIONS OF VARIABLES

FOR GRADE FIVE

Variable	Experimental $\bar{X}$	Experimental S.D.	Control $\bar{X}$	Control S.D.
Pretest	19.3	2.8	13.9	3.4
Postest	23.3	5.4	14.9	4.6
STEP Science	252.1	7.1	242.3	10.8
Lorge-Thorndike Intelligence Test	102.2	8.9	88.9	17.2
Socio-Economic Ranking	41.8	15.1	37.9	12.5

N = 76

regression equation are given in Table XII, so that the analysis of results on the postest can be viewed in perspective. Correlations were high between STEP Science scores and intelligence scores, pretest scores and STEP Science and intelligence. A very important observation is that there was either a very low positive or a very low negative correlation between results on the postest and those on the pretest, STEP Science, and intelligence. This would suggest that postest results would be unaffected by any of these predictor variables in a regression analysis. This was borne out by the results of the regression analysis. These low correlations of the postest with the other variables could be due to changes between the pretest and postest testing situations for some unknown reason, the postest testing situation having changed in some way..

Hypothesis 1

This hypothesis stated that there would be no significant difference in performance on the process instrument between the experimental and the control groups. A number of other variables besides that of the postest results were included in the regression analysis. Each variable was tested for significance of contribution to the variance of the postest using the F test. The results shown in Table XIII, page 57, indicate clearly that none of the variables contributed significantly to the analysis. Moreover, the squared multiple correlation of the full model accounted for only a very small per cent of the variance of the criterion.

On the basis of these results, the null hypothesis must be accepted. Statistically there is no significant difference between performance of the experimental and the control groups on the postest for grade six. Students in the experimental group, who were exposed to the ESCP Course, performed only marginally better on the process instrument. Yet, it

TABLE XII

INTERCORRELATIONS AMONG VARIABLES IN GRADE SIX

N = 37					
Socio-Economic Ranking	1.00	0.19	-0.13	0.39	0.55
Pretest		1.00	0.08*	0.55	0.48
Postest			1.00	0.07*	-0.11
STEP Science				1.00	0.70
Lorge-Thorndike Intelligence Test					1.00

* Not Significant

TABLE XIII

CONTRIBUTIONS OF VARIABLES WITH POSTEST

AS CRITERION IN GRADE SIX

N = 37

	Restriction	RSQ	Difference	df	F Ratio	Probability
X_1, X_2	Grouping	.0866	.0718	1/30	2.56	N.S.
X_3, X_9	Sex	.1518	.0065	1/30	0.23	N.S.
X_4	Socio-Economic Ranking	.1435	.0148	1/30	0.53	N.S.
X_5	Pretest	.1539	.0044	1/30	0.16	N.S.
X_7	STEP Science	.1131	.0453	1/30	1.61	N.S.
X_8	Lorge-Thorndike Intelligence Test	.1581	.0003	1/30	0.01	N.S.

REGRESSION EQUATION

$$Y = 4.31X_1 - 0.81X_3 - 0.12X_4 + 0.10X_5 + 0.18X_7 + 0.01X_8 - 26.88$$

RSQ = .1583

should be pointed out that, as shown in Table XIV, the difference between scores on the pretest and the postest was greater for the experimental group than for the control group. But since this process instrument proved to be very difficult--as is evident by the low scores of all students, these differences may be due partly to a regression effect. Each group could be expected to regress upward on the postest, but since the experimental group scored lower on the pretest than did the control group, it could be expected that the experimental group would regress more than the control group. Thus the difference in scores between pretest and postest for the experimental group would tend to be greater regardless of treatment.

Comparison of group means, as shown in Table XIV, illustrates clearly that the control group performed better on the intelligence test and the standardized science test. Yet, despite the fact that the control group performed better than the experimental group on the intelligence test and the STEP Science Test, the experimental group's performance was better than that of the control group on the postest and the experimental group showed a greater improvement on the postest over the pretest than did the control group. As did the control group in grade five, the control group in grade six improved only marginally on the postest over scores on the pretest. Thus, in the case of the grade six results, a duller class of students scored higher on the postest than did a class of better students. Some of this performance by the experimental group can possibly be due to the fact that they were exposed to the ESCP Course.

For various reasons, out of a total of sixty-two subjects in the experimental setting in grade six, only the results of thirty-seven subjects could be used in the regression analysis. Subjects with one or more scores missing for variables used in the regression equation could not be

TABLE XIV

MEANS AND STANDARD DEVIATIONS OF VARIABLES

FOR GRADE SIX

	Experimental		Control	
Variable	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Pretest	12.2	3.0	15.1	3.9
Postest	19.2	4.3	17.4	4.7
STEP Science	247.0	5.8	260.5	7.9
Lorge-Thorndike Intelligence Test	86.3	6.3	105.8	10.1
Socio-Economic Ranking	30.8	4.1	34.4	7.3

N = 37

included. Because of this limitation, a second multiple linear equation was developed which considered only the predictor variables of sex and pretest results. This equation permitted the use of fifty-two subjects. The results of this analysis are given in Table XV. Once again, on the basis of these results, the null hypothesis must be accepted. The elimination of socio-economic ranking, STEP Science scores, and intelligence scores as predictor variables did not reduce the squared multiple correlation greatly. With these variables present in the equation, the RSQ was 0.1583; with these variables absent, the RSQ was 0.1394. As before, sex did not contribute significantly in accounting for the criterion variance for grade six.

III. THE EFFECT OF THE TEACHER VARIABLE

A possible contaminating variable in this study was recognized to be that of the teachers themselves. Because of administrative difficulties, the teacher variable could not be controlled in the experimental setting. To check for the effect of the teacher variable, the process tests were administered to grades five and six students outside of the experimental setting who had done the course for that particular grade. Of the two classes at each grade level in this school, the upper grade five class, consisting of the smarter students in that grade, and the lower grade six class, consisting of the duller students in that grade, were tested. These groups compared with those of the experimental setting in this way. A comparison of the means of these two groups with those of the experimental setting was made using the t-test. These results are shown in Table XVI, page 62.

In order to minimize the possibility of making a Type II error in

TABLE XV

CONTRIBUTIONS OF GROUPING AND SEX WITH POSTEST

AS CRITERION AND USING THREE PREDICTORS

ONLY FOR GRADE SIX

N = 52

	Restriction	RSQ	Difference	df	F Ratio	Probability
X_1, X_2	Grouping	.0717	.0676	1/48	3.77	N.S.
X_3, X_6	Sex	.1376	.0018	1/48	0.10	N.S.

REGRESSION EQUATION

$$Y = 2.83X_1 + 0.42X_3 + 0.44X_4 + 10.48$$

RSQ = .1394

TABLE XVI

COMPARISON OF PROCESS TESTS MEANS BETWEEN EXPERIMENTAL SUBJECTS AND OTHER STUDENTS WHO HAD DONE THE ESCP COURSE

Grade	Means		df	t Value	Probability
	Experimental	Other			
5	23	19	59	3.08	<.01
6	20	16	39	2.76	<.01

this analysis, a .25 level of significance was defined. Results indicate that there was a significant difference between these groups in both grades. Because of other possible uncontrolled differences between the classes in question, it is not possible to attribute the observed differences in means directly to the teacher variable. It is clear, however, that the higher mean scores for the experimental group may have been due to factors other than the program itself. One of these factors could have been very proficient teachers or some interaction between program and teacher. However, these results present only a very small amount of evidence regarding the effect of the teacher variable in the study and the problem of the uncontrolled teacher variable is a definite limitation that has to be considered in interpreting the results.

IV. SUMMARY

This chapter has presented the statistical analysis of the results from the experimental setting. Using the technique of multiple linear regression, it was possible to compare the scores on the postests for both experimental and control groups in the presence of other variables such as sex, socio-economic ranking, pretest, STEP Science, and intelligence as measured by the Lorge-Thorndike Intelligence Tests. An analysis of the results for grade five indicated that there was a significant difference between the experimental and control groups. Results showed that the experimental group performed significantly better than the control group on the postest. Students showed an increase in performance on the process test after exposure to the ESCP Course; whereas, students who had not taken the course showed little increase in performance on the process test. Because of limitations in the analysis used in the study and because the teacher variable was uncontrolled, the differences at the grade five level in favour of the experimental group had to be interpreted with caution. Yet, in spite of these limitations, it can be concluded that the course did improve the performance of the students exposed to it. No such evidence of improvement on the postest as a result of exposure to the ESCP Course was evident from the analysis of results in grade six. In this case, the null hypothesis was accepted. It was apparent from low correlations between the postest and the pretest and other variables examined that the testing situation during administration of the postest must have been fouled up in some way. Thus in the regression equation used to analyze the results of the postest between the groups, the predictor variables accounted for only a very small percentage of the variance. Yet, the experimental group performed better than the control group on the postest even though on science achievement and intelligence they had lower mean scores than the control group. Improvement in scores from the pretest to the postest was greater for the experimental group, and even though some of this could possibly be attributed to a regression effect, exposure to the ESCP Course could account for some of these improvements.

Thus, in spite of the limitations of the study which tend to restrict interpretation of the results, the results indicate that students who have taken the ESCP Course do better on process instruments than students who have not taken the course. This suggests that the course is teaching the processes of science but whether or not these processes are being attained at a satisfactory level in the course cannot be established from these results.

CHAPTER FIVE

RESULTS AND ANALYSIS II: COURSE ATTITUDES

In addition to the experimental phase, an attempt was made in the study to seek the reactions of pupils and teachers towards the ESCP Course. The findings are presented in descriptive form in this chapter. As stated previously, pupil attitudes were evoked by a Q-sort instrument designed for this purpose. Teacher attitudes were obtained by means of a questionnaire. The responses of students are considered in the first part of this chapter and teacher responses are examined in the second part of the chapter.

I. *STUDENT ATTITUDES TOWARDS THE ESCP COURSE*

From responses to the forty different items on the Q-sort instrument, it was possible to ascertain whether or not students were mainly positive or negative in their reactions to the course. Also, the type of items included in the Q-sort examined various aspects of the course. Did the students like doing the activities? Would they have prefered a textbook? Did they find the course challenging? Some items were about science in general. These were included to facilitate interpretation of responses on the other items.

To facilitate in the analysis of responses on the Q-sort, all items were classified into the following seven sub-groups:

1. Teaching style.
2. General attitudes towards the course.
3. Reactions to different aspects of an activity-oriented course.

4. Reactions to science periods.

5. Attitudes towards the course.

6. Course content.

7. Motivation towards science as a result of doing the ESCP Course.

The Q-sort required students to respond to different statements about various aspects of the course according to their amount of agreement or disagreement. The five units on the different scales of the different statements which students could check were: strongly disagree, disagree, neutral (or undecided), agree, and strongly agree. Values from one to five were assigned the different units of the various scales from strongly disagree, which had a value of one, to strongly agree, which had a value of five.

Percentage Summary of Responses Over All Students

To help summarize the data, the percentage responses of all students over all five units of the scales for the different items was computed. A suitable computer program was available for this purpose. This program made available the number responding to a particular item, the number of students who omitted it, the response percentage, and the adjusted percentage based on the number of students responding. Table XVII, pages 67-69, gives the adjusted percentages on the different items and the number who omitted it.

An examination of Table XVII shows that on items pertaining to various aspects of the course, the majority of students responded in a positive manner but on many of these same items there were students who responded negatively or who were neutral in their opinions. Even though these negative attitudes were expressed by a minority of students, this must, nevertheless, be considered in a final evaluation of how students

TABLE XVII

PERCENTAGE SUMMARY OF RESPONSES ON PUPIL Q-SORT

Number	*Item*	Number *Omitted*	Adjusted Percentages *1**	*2**	*3**	*4**	*5**
1.	This course taught me little about science.	0	43	17	8	11	22
2.	I always put my best efforts into the science periods.	0	9	6	10	18	57
3.	Elementary school science is for smart students only.	1	72	9	11	2	6
4.	A lot of things to work with often served to make learning difficult.	0	29	20	24	15	13
5.	This course should be taught in all elementary schools in Newfoundland.	1	6	5	7	17	66
6.	I enjoyed working out science problems with my friends in the classroom.	0	6	4	7	12	71
7.	I like the way in which the new program presents the basic ideas of science.	2	6	9	11	28	48
8.	I learned a lot about science in this course.	0	5	8	8	19	59
9.	Science this year has made me more interested in doing other science courses.	1	12	4	10	22	53
10.	Science was my worst subject in school this year.	1	70	13	6	5	6
11.	There should be more science periods in a school week.	0	13	9	9	19	50
12.	Most of the activities in the course were too easy and unchallenging.	1	37	23	14	13	13
13.	The activities in this course were always challenging.	2	12	17	19	18	35
14.	I would have learned more science were I doing some other science course.	0	36	17	24	14	10
15.	Some parts of this science program should be gotten rid of.	0	49	16	16	8	10

TABLE XVII (continued)

Number	Item	Number Omitted	Adjusted Percentages 1*	2*	3*	4*	5*
16.	The teacher should act as a guide to students in the classroom rather than always talking to them.	3	26	12	16	17	31
17.	*Science periods are boring.*	0	68	14	11	3	4
18.	This course has decreased my interest in science.	1	43	10	13	14	20
19.	There is a great deal of needless material in this program.	0	37	16	14	15	18
20.	This science course seems to be "over my head".	0	47	17	18	11	7
21.	The study of science in this course does not bore me.	3	9	9	10	21	53
22.	This course taught me much about how scientists think.	1	11	9	18	22	40
23.	Students can learn a lot about science from their fellow students.	1	18	18	19	23	23
24.	A good deal of the material in this science course must have been dreamed up by university scholars who have never worked with children.	0	38	17	27	7	12
25.	The teacher should answer all the student's questions on science, instead of expecting the student to find his own answer through experimenting.	1	44	15	13	8	20
26.	If I could pass this grade without doing science, I would not have done this course.	1	54	13	14	8	13
27.	There should be fewer science periods in a school week.	1	60	13	8	7	12
28.	I found the new program exciting.	1	7	5	7	16	66
29.	I would encourage my friends to do this course.	1	9	9	15	20	47
30.	Science is just as important as the other courses in the elementary grades.	0	9	10	8	16	57

TABLE XVII (continued)

Number	Item	Number Omitted	Adjusted Percentages 1*	2*	3*	4*	5*
31.	This science course often seems to make what is easy appear difficult.	1	25	19	22	17	19
32.	If I had a choice between courses, I would choose to do this one.	3	10	11	18	17	47
33.	This course has increased my interest in science.	4	9	8	6	25	54
34.	The student needs continual help from the teacher while doing the activities in this course.	1	19	22	17	18	24
35.	Many of the activities in this course were too difficult for me.	1	42	30	12	10	7
36.	I would learn better with a text-book than by doing the science activities.	1	61	12	10	9	9
37.	I learn science better by doing rather than by reading a textbook.	2	12	7	13	14	55
38.	There should be more courses like this one.	1	12	8	7	22	52
39.	This course taught me little about how scientists think.	0	28	19	12	20	21
40.	I like to do experiments in science.	1	5	4	2	6	83

* 1 strongly disagree
2 disagree
3 neutral (or undecided)
4 agree
5 strongly agree

reacted to the course. Eighty-two per cent either agreed or agreed strongly that they found the new program exciting; twelve per cent disagreed with this statement; and, seven per cent were undecided. Most of the students would recommend this course to their friends. Sixty-nine per cent indicated that they would encourage their friends to do this course; eighteen per cent would not encourage their friends to do this course; and, fifteen per cent were undecided. Sixty-seven per cent of the students would have done the course even if they did not have to do it to pass the particular grade they were in; fourteen per cent were undecided about this statement; and, twenty-one per cent disagreed with it. These examples indicate that most students enjoyed doing the course.

Most students prefered this type of course to the more traditional approach. Eighty-three per cent claimed that they enjoyed working out science problems with their friends; ten per cent did not enjoy working out science problems with their friends; and, seven per cent were undecided about this statement. Seventy-three per cent of the students disagreed with the statement that they would have learned better with a textbook than by "doing" the science activities; eighteen per cent agreed with this statement; and, ten per cent were undecided. Responses on other items demonstrate the preference of most students for an activity-oriented course.

On the other hand, a minority of students expressed opinions about the type of course which would suggest that they did not like certain aspects of it. Twenty-eight per cent felt that a lot of things to work with often served to make learning difficult; twenty-four per cent were undecided about this statement; and, forty-nine per cent disagreed with the statement. Thus fifty-one per cent agreed with or were undecided about this statement. Thirty-eight per cent of the students disagreed with the statement that the teacher should act as a guide to student activity in the classroom rather than always talking to them; sixteen per cent were undecided about this statement; and, forty-eight per cent agreed with it. Thirty-six per cent felt that they could learn little science from their fellow students; nineteen per cent were neutral about this statement; and, forty-six per cent agreed with the statement. Twenty-eight per cent felt that the teacher should answer all the student's questions on science, instead of expecting the student to find his own answers through experimenting; thirteen per cent were undecided about this statement; and, fifty-nine per cent disagreed with the statement. Even though negative attitudes expressed by the students on these items are in the minority, when it is considered that a basic premise of the course is that science is for all students, these minority opinions are certainly important for interpreting student attitudes.

Seventy-six per cent of the students liked the way in which the course presented the basic ideas of science; eleven per cent were undecided about this statement; and, fifteen per cent disagreed. Seventy-eight per cent agreed that they learned a lot about science in the course; eight per cent were undecided with this statement; and, thirteen per cent disagreed. On the other hand, thirty-three per cent felt that the course taught them little about science; eight per cent were undecided; and, sixty per cent disagreed with this statement. Even though fifty-three per cent of the students agreed that the activities in the course were always challenging, twenty-nine per cent disagreed with this statement; and, nineteen per cent were undecided. Twenty-six per cent of the students felt that the activities were too easy and unchallenging; fourteen per cent were undecided about this statement; and, sixty per cent disagreed. Seventeen per cent claimed that many of the activities in the course were too difficult for them; twelve per cent were undecided about this statement; and, seventy-two per cent disagreed with this statement.

It seems apparent from responses on the Q-sort that the motivation towards science of the majority of students had increased after doing the course. Seventy-five per cent said that science this year had made them more interested in doing other science courses; ten per cent were undecided about this statement; and, only sixteen per cent disagreed. Seventy-nine per cent claimed that the course had increased their interest in science; only six per cent were undecided about this statement; and, only seventeen per cent disagreed with the statement. But on an alternate but similar item, thirty-four per cent said that the course had decreased their interest in science; thirteen per cent were undecided about the statement; and, fifty-three per cent disagreed with this statement. This apparent increase in motivation towards science as a result of doing the ESCP Course must not be over-emphasized because of the lack of comparative data. Also, these results may be subject to a strong Hawethorne effect, i.e., any new program might have given the same results.

Furthermore, a comparison of response percentages on the last two items discussed in the previous paragraph will indicate that responses, at least on some items of the Q-sort, may not be completely reliable. For example, during the administration of the Q-sort some students had difficulty understanding the difference between "increase" and "decrease" and even though difficult words were explained by the experimenter, some students may have been too shy to inquire. This example illustrates that responses on this type of instrument may not be completely reliable and, hence, results should be interpreted taking this into consideration.

This brief summary indicates that, according to responses on the Q-sort instrument used, the majority of students had a positive attitude towards the ESCP Course, even though on some items there were a significant minority of students who were negative or undecided about certain aspects of the course.

Analysis of Student Attitudes in Relation to Certain Independent Variables

In order to examine student responses in relation to certain independent variables, the values of one to five on the different units of each scale was used to get a mean response score for each student on the seven different sub-groups of items in the Q-sort. To do this, the responses on the negative items had to be converted to a positive mode. A suitable computer program was available to make the necessary calculations. A mean score of more than three would indicate that a student responded positively on a particular sub-group of items--for example, items related to course content. Students' mean scores on these sub-groups of items were then examined in terms of the independent variables of student sex, teacher sex, class size, and geographical region.

As Table XVIII reveals, pupil responses to the different items were unaffected by sex. There were no significant differences between boys and girls on any of the seven sub-groups of items. Both boys and girls enjoyed the course to a similar degree. This is desirable since science should appeal to both sexes indiscriminately.

When student responses were examined in connection with teacher sex, there were significant differences between means on four of the seven sub-groups of items. This data is given in Table XIX, page 75. Students with female teachers were more positive in their responses relating to general attitudes towards the course; they experienced fewer problems in

TABLE XVIII

EFFECT OF PUPIL SEX ON RESPONSES ON DIFFERENT

VARIABLES OF THE PUPIL Q-SORT

Variable	Code* Name	Male $\overline{X}$	Female $\overline{X}$	t Value	Probability
1	TST	3.17	3.26	-0.63	N.S.
2	GAC	3.78	3.88	-0.86	N.S.
3	TOC	3.72	3.83	-1.00	N.S.
4	SP'S	4.02	3.99	0.27	N.S.
5	SA	4.28	4.38	-0.92	N.S.
6	CC	3.60	3.68	-0.79	N.S.
7	SMC	3.86	4.03	-1.59	N.S.

* TST teaching style
GAC general attitudes towards the course
TOC type of course
SP'S science periods
SA attitudes towards science
CC course content
SMC motivation towards science due to course

TABLE XIX

EFFECT OF TEACHER SEX ON RESPONSES ON DIFFERENT

VARIABLES OF THE PUPIL Q-SORT

Variable	Code* Name	Male $\overline{X}$	Female $\overline{X}$	t Value	Probability
1	TST	3.19	3.24	0.38	N.S.
2	GAC	3.64	4.05	3.67	0.0003
3	TOC	3.73	3.83	0.98	N.S.
4	SP'S	3.86	4.18	2.50	0.01
5	SA	4.25	4.43	1.56	N.S.
6	CC	3.55	3.76	2.27	0.02
7	SMC	3.84	4.09	2.34	0.02

* TST teaching style
GAC general attitudes towards the course
TOC type of course
SP'S science periods
SA attitudes towards science
CC course content
SMC motivation towards science due to course

the course; course content was more appealing to them; and, these students were motivated more towards science as a result of doing the course than students who had male teachers. Even though the differences between the means of the other four variables were not significant, the attitudes of students who had female teachers were more positive when compared with those of students who had male teachers. These differences are difficult to explain. Some possible explainations for these differences are that the teaching styles of male and female teachers were different, personality characteristics may have differed, or the students' expectancies varied with the sex of the teacher. The direct cause of these differences cannot be determined from the information available.

A one-way analysis of variance was carried out on student responses in relation to class size. Four different ranges of class size were compared. Table XX shows the results of this analysis. Mean differences were significant for all sub-groups of item· except that of teaching style. A closer examination of these means show that students in small classes of fewer than twenty-four students and students in very large classes of more than thirty-five students were not as positive in their attitudes towards the course as were students in middle-size classes ranging from twenty-five to thirty-five students.

It is possible that the results for the very large classes can be explained in terms of the lack of equipment to allow each student to do the various activities in the course. The apparatus kits were designed to accommodate thirty students. In a very large class of more than thirty-five students, it would be quite difficult to do justice to the objective that this course be "activity-oriented". Also, the larger classes would have more classroom organization problems and individual help from the

TABLE XX

EFFECT OF CLASS SIZE ON RESPONSES TO DIFFERENT VARIABLES OF THE PUPIL Q-SORT

Variable	Code* Name	Group Means**				F Ratio	Probability
		$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$		
1	TST	2.92	3.08	3.31	3.40	2.03	N.S.
2	GAC	3.49	3.96	4.06	3.36	9.34	0.00002
3	TOC	3.69	3.49	3.97	3.71	4.85	0.003
4	SP'S	3.58	3.86	4.28	3.83	6.20	0.0005
5	SA	4.03	4.33	4.55	4.03	5.81	0.0008
6	CC	3.53	3.68	3.80	3.26	6.30	0.0004
7	SMC	3.56	4.12	4.17	3.51	10.74	0.000006

* TST teaching style
GAC general attitudes towards the course
TOC type of course
SP'S science periods
SA attitudes towards science
CC course content
SMC motivation towards science due to course

** $\bar{X}_1$ class size less than or equal to twenty-four
$\bar{X}_2$ class size between twenty-five and thirty
$\bar{X}_3$ class size from thirty-one to thirty-five
$\bar{X}_4$ class size of more than thirty-five

teacher would be minimal. These arguements cannot be used to explain the poorer attitudes of students in very small classes. One possible explaination for these poorer attitudes is that because of a small group of students, group participation was not as motivating as in larger classes. The mean score of these small groups on items related to science motivation was certainly lower than any of the other groups of students.

The effect of region on responses on items in the different subgroups was for the most part not significant, as Table XXI indicates. The means of samples of students from four different regions were compared. These students came from Labrador City, St. John's, central Newfoundland, and Springdale. There were significant regional differences in response to items related to general course attitudes and course content. In each case, students from Labrador City were most positive in their responses; students from Springdale were the second less positive group; students from central Newfoundland were the third less positive group; and, students from St. John's were least positive in their responses. Considering the fact that a region may be represented by only one class from a particular school, as was the case for St. John's, and that on the other five subgroups of items there were no significant differences in responses between students from different geographical regions, very little importance can be placed on these minimal regional variations.

Summary

An analysis of responses on the Q-sort administered to several classes of students revealed that the majority of students expressed positive attitudes towards the ESCP Course. These students liked the approach taken by the course; they found the course content to be mainly suitable; and, the material was not too difficult--yet it was challenging. However,

TABLE XXI

EFFECT OF REGION ON RESPONSES ON DIFFERENT

VARIABLES OF THE PUPIL Q-SORT

Variable	Code* Name	Group Means** $\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$	$\overline{X}_4$	*F Ratio*	*Probability*
1	TST	3.32	3.40	3.10	3.21	0.87	N.S.
2	GAC	4.10	3.36	3.77	4.03	6.74	0.0003
3	TOC	3.71	3.71	3.74	3.89	0.75	N.S.
4	SP'S	4.11	3.83	3.87	4.21	2.15	N.S.
5	SA	4.30	4.03	4.35	4.48	2.43	N.S.
6	CC	3.91	3.26	3.67	3.69	5.77	0.0009
7	SMC	4.12	3.51	3.98	4.07	4.93	0.003

* TST teaching style
GAC general attitudes towards the course
TOC type of course
SP'S science periods
SA attitudes towards science
CC course content
SMC motivation towards science due to course

** $\overline{X}_1$ Labrador City
$\overline{X}_2$ St. John's
$\overline{X}_3$ central Newfoundland
$\overline{X}_4$ Springdale

on some of these same items, a significant minority of students expressed negative opinions about various aspects of the course. Some found the course material too hard; while, others found the course material too easy and unchallenging. Some felt that they had learned little science from the course. These negative minority opinions have significance in view of the fact that one premise upon which the course is based is that elementary science is for all students.

Any interpretation of these results must take into consideration the limitations of the instrument used to obtain them. Some unreliability of student responses is suspected to exist and because of the nature of the scaling, there may have been an expectancy attached, i.e., students may have tended to agree with positive statements about the course because they suspected that these were the "correct" responses to make.

An analysis of responses was also carried out in terms of certain independent variables. The sex of the pupil did not affect his feelings towards the course. Girls enjoyed the course to a similar degree as boys. When results were compared in terms of teacher sex, the results were quite different. It was found that on most sub-groups of the Q-sort students who had been taught science by a female teacher responded in a more positive manner than students who had been taught by a male teacher. The effect of class size was also significant in most cases, with students in very small and very large classes having a poorer attitude towards the course than students in middle-size classes. Regional differences were minimal and considered to be of little importance.

Also, an examination of the average scores of the different groups of students on the seven different sub-groups of items in the Q-sort reveals that all of these average scores were greater than three and many had a value of four or more. This is another indication of the generally positive nature of the students' attitudes towards the different aspects of the ESCP Course.

II. TEACHER ATTITUDES TOWARDS THE ESCP COURSE

Teacher attitudes towards the ESCP Course were investigated by means of a questionnaire. From an analysis of responses on the fifty-five different items, it was possible to establish whether or not teachers were mainly positive or negative in their responses. The type of items included also permitted an examination of how teachers felt about different aspects of the course. Did the Teaching Guide provide teachers, who had little or no science background, with enough guidance to teach the course properly? Were the objectives of the course made clear to the teachers? Did the course make impossible demands on the teachers in terms of preparation time and other related demands? Several items sought the opinions of teachers about science in general. The over-all responses on these items helped with the interpretation of items related to the course itself. For example, the answer to a question about liking for science would reflect on the response to an item that asked whether or not the teacher enjoyed teaching the course.

The questionnaire items were classified into the following nine sub-groups on the basis of different aspects of teaching the course:

1. Teaching guide.
2. Apparatus.
3. Teaching methodology.
4. Classroom problems.
5. Evaluation.

6. Apparent student problems.

7. Teacher attitudes about the course.

8. Teacher attitudes about elementary science.

9. Student attitudes about the course as perceived by teachers.

The Likert-type questionnaire used in the study required teachers to respond to different statements about various aspects of the course according to their amount of agreement or disagreement. The five units on the different scales for the various items which teachers could check were: strongly disagree, disagree, neutral (or undecided), agree, and strongly agree. A value from one to five was assigned the different scale units from strongly disagree, which had a value of one, to strongly agree, which had a value of five.

Percentage Summary of Responses Over All Teachers

The percentage of responses of teachers over all five units of the different items was computed in order to summarize the results. A suitable computer program was available to perform this analysis. This program gave the total number of teachers responding to a particular item, the number who omitted it, the response percentage, and the adjusted percentage based on the number responding. Table XXII, pages 83-87, gives the item, the adjusted percentage on the five units of the scale, and the number of teachers omitting a particular item.

An analysis of Table XXII shows that on most items the majority of teachers responded favourably. Sixty-three per cent of the teachers disagreed with the statement that the course consists largely of "fun and games" activities but little is really learned; twenty-one per cent were undecided about this statement; and, seventeen per cent agreed with the statement. Seventy-five per cent of the teachers agreed that students

TABLE XXII

PERCENTAGE SUMMARY OF RESPONSES ON TEACHER QUESTIONNAIRE

Number	Item	Number Omitted	Adjusted Percentages 1*	2*	3*	4*	5*
1.	The introduction to the Teaching Guide was most helpful in relating the aims and purposes of the course.	1	3	9	18	53	17
2.	The instructions for the various activities were very clear in identifying the performance to be expected of students at the end of the activity.	1	20	30	17	25	8
3.	The behavioral objectives for each activity proved to be most helpful.	4	1	21	28	43	7
4.	The purpose of the different activities were very clear.	5	9	27	16	38	9
5.	The overall quality of the apparatus was very poor.	0	10	44	18	23	5
6.	The teacher should be given more detailed instructions regarding how the lesson should be taught.	0	1	13	7	32	47
7.	Instructions for assembling apparatus were very clear.	2	9	29	18	35	9
8.	Understanding how the various items of apparatus work was very simple.	3	2	31	18	43	7
9.	The apparatus drawings in the Teaching Guide were very clear.	2	5	19	20	48	9
10.	Explainations of the apparatus drawings were quite clear.	1	5	28	19	43	5
11.	For all the activities taught during the year the checklist described in the Teaching Guide on page 21 was used to evaluate students.	6	7	35	31	25	3
12.	Students always kept records of what they did in their notebooks.	2	6	29	9	39	17

TABLE XXII (continued)

Number	Item	Number Omitted	Adjusted Percentages 1*	2*	3*	4*	5*
13.	The process aspect of the activities was always emphasized to the students.	5	0	13	18	56	13
14.	The course consists largely of "fun and games" activities but little is really learned.	3	21	42	21	12	5
15.	The teaching of science should not begin until at least grade seven.	0	59	31	5	2	4
16.	The students had a great deal of difficulty in manipulating apparatus.	0	23	37	17	20	2
17.	This course required radical changes in my teaching style.	0	21	44	16	15	3
18.	The students seemed to find the course very exciting.	2	2	7	16	48	27
19.	There always seemed to be a problem of too much noise during the science period.	0	10	35	16	27	12
20.	The students learned a lot about the processes of science from the course.	2	4	28	32	28	7
21.	I would like to teach more elementary science in the future.	2	10	16	26	39	9
22.	The teacher should be able to answer fully all questions asked by the students.	1	21	50	7	17	6
23.	In teaching the course, there always seemed to be classroom organizational problems.	0	12	29	13	34	12
24.	My preparation for teaching this course was quite adequate.	0	12	40	20	25	3
25.	The behavioral objectives at the beginning of each lesson were useful as guides to evaluation of students.	3	1	17	19	61	3

TABLE XXII (continued)

Number	Item	Number Omitted	Adjusted Percentages 1*	2*	3*	4*	5*
26.	The students always asked a large number of questions during the various activities.	2	4	33	14	40	9
27.	I would like to do a university course in the teaching of science in the elementary grades.	1	3	8	25	48	17
28.	A specialist teacher is needed in the elementary grades to teach science.	0	15	39	15	16	13
29.	I would prefer to teach science rather than some other course.	1	26	38	19	12	5
30.	A large number of mathematics problems were experienced by the students in the course.	3	25	44	20	10	2
31.	Classroom storage of equipment created a serious problem.	0	15	50	4	16	14
32.	Some form of inservice training is essential before this course can be taught adequately.	1	4	7	8	51	31
33.	The main function of the teacher in this course is to guide student activity.	1	0	9	7	58	26
34.	Classes are really too large to permit a proper job to be done in teaching this course.	0	9	31	6	22	33
35.	No attempt was made to evaluate my students during the year.	2	17	48	7	23	6
36.	Instructions for assembling apparatus were very unclear.	2	5	46	12	32	5
37.	The quality of the apparatus supplied in the kit was good.	0	6	17	24	43	10
38.	The students had a great deal of difficulty with the activities on quantifying (or other activities	5	2	39	32	21	5

TABLE XXII (continued)

Number	Item	Number Omitted	Adjusted Percentages 1*	2*	3*	4*	5*
	in which quantifying was used.						
39.	I enjoyed teaching this course very much.	1	16	28	21	27	8
40.	I feel that science is a very difficult subject.	1	16	59	12	13	1
41.	Science is appropriate only for the very best students.	0	33	58	5	4	1
42.	The importance of science in our society requires that science be taught as one of the basic subjects.	1	0	6	18	58	17
43.	The students learned a lot from this course.	1	2	24	36	30	8
44.	Preparation for science classes was very time consuming.	3	3	28	8	49	13
45.	I experienced difficulty teaching some of the processes of science.	13	2	45	9	40	4
46.	The sequence of activities presented in the Teaching Guide is appropriate.	7	0	14	23	62	1
47.	The course should include more activities in order to place greater emphasis on certain scientific processes.	10	1	31	32	27	10
48.	Students seemed to have greater difficulty learning certain processes of science.	11	2	41	27	29	2
49.	All processes of science mentioned in the guide were defined adequately.	10	2	42	21	30	5
				Yes		No	
50.	The size of the print in the Teaching Guide was large enough.	2		66		34	

TABLE XXII (continued)

Number	Item	Number Omitted	Adjusted Percentages 1*	2*	3*	4*	5*
				Yes		No	
51.	The lay-out of the Teaching Guide was suitable	4		66		34	
52.	I intend to teach science next year.	10		75		25	
53.	This is my first year teaching elementary science.	2		56		44	
54.	I developed and used my own process tests for evaluation purposes.	4		26		74	
55.	Student notebooks were used for evaluation purposes.	2		65		35	

* 1 strongly disagree
2 disagree
3 neutral (or undecided)
4 agree
5 strongly agree

found the course very exciting; sixteen per cent were undecided about this statement; and, nine per cent disagreed with the statement. This is consistent with responses from the students themselves.

Seventy per cent of the teachers felt that the introduction to the Teaching Guide was helpful in relating the aims and purposes of the course; eighteen per cent were undecided about this statement; and, twelve per cent disagreed with this statement. But fifty per cent of the teachers claimed that the instructions for the various activities were very unclear in identifying the performance to be expected of students at the end of the activity; seventeen per cent were undecided about this statement; and, thirty-three per cent disagreed with the statement. Also, a full thirty-six per cent of the teachers disagreed with the statement that the purposes of the different activities were very clear; sixteen per cent were undecided about this statement; and, forty-seven per cent agreed. Even though these negative responses towards the various aspects of the Teaching Guide were not in the majority, many of the teachers desired more detailed descriptions about the different lessons. Seventy-nine per cent felt that they should be given more detailed instructions regarding how the lessons should be taught; only seven per cent were undecided about the statement; and, fourteen per cent disagreed with the statement. From an analysis of items such as these, it is evident that many teachers would prefer a more detailed Teaching Guide.

Even though the majority of teachers expressed the opinion that they had no major difficulties regarding the apparatus supplied in the kits, some negative reactions were encountered. Twenty-eight per cent agreed that the quality of the apparatus was poor; eighteen per cent were undecided; and, fifty-four per cent disagreed with this statement. Thirty-three per cent of the teachers disagreed with the statement that understanding how the various items of apparatus work was very simple; eighteen per cent were undecided about this statement; and, fifty per cent agreed with the statement. Twenty-two per cent agreed that the students had a great deal of difficulty in manipulating apparatus; seventeen per cent were undecided about the statement; and, sixty per cent disagreed with this statement.

Most teachers appeared to have few problems with teaching the course itself. Eighty-four per cent agreed that the main function of the teacher in this course is to guide student activity; seven per cent were undecided about this statement; and, only nine per cent disagreed with this statement. Sixty-nine per cent indicated that the process aspect of the activities was always emphasized to the students; eighteen per cent were undecided about this statement; and, thirteen per cent disagreed with this statement. But forty-four per cent agreed that they experienced difficulty teaching some of the processes of science; nine per cent were undecided; and, forty-seven per cent disagreed with this statement. Sixty-five per cent of the teachers disagreed with the statement that the course required radical changes in their teaching style; sixteen per cent were undecided about this statement; and, eighteen per cent agreed.

Classroom problems were experienced by some teachers. Thirty-nine per cent of the teachers said that there always seemed to be a problem of too much noise during the science periods; even though forty-five per cent disagreed with this statement and sixteen per cent were undecided, the number of teachers experiencing this problem would indicate that it is fairly widespread. Similarly, many teachers agreed that they experienced classroom organizational problems. Most claimed that classes were too large to permit a proper job to be done in teaching the course.

Many teachers felt unprepared to teach this course. A full fifty-two per cent disagreed with the statement that their preparation for teaching the course was quite adequate; twenty per cent were undecided about this statement; and, only twenty-eight per cent agreed with it. Twenty-nine per cent agreed that a specialist teacher is needed in the elementary grades to teach science; fifteen per cent were undecided; and, fifty-four per cent disagreed with this statement. Eighty-two per cent of the teachers agreed that some form of inservice training is essential before this course can be taught adequately; eight per cent were undecided about this statement; and, only eleven per cent disagreed with the statement.

Many teachers failed to evaluate their students in the course. Twenty-nine per cent agreed that they made no attempt to evaluate their students; seven per cent were neutral on this statement; and, seventy-five per cent disagreed with this statement. Forty-two per cent failed to use the checklist procedure recommended in the Teaching Guide for the evaluation of students; thirty-one per cent were neutral and this probably means that they failed to use it as well; only twenty-eight per cent said they used this technique of evaluation. Thirty-five per cent of the teachers said that student notebooks were not used for evaluation.

Most teachers saw no major problems experienced by the students while doing the course.

Interpretation of results on the teacher questionnaire must be made with the realization that a certain amount of unreliability may accompany responses. Furthermore, because the scale units used may have had an expectancy attached to them, they may have tended to agree more with positive statements than they really felt like agreeing.

Analysis of Teacher Attitudes in Relation to Certain Independent Variables

In order to examine teacher responses in relation to certain independent variables, the values of one to five given the different units of each scale was used to get a mean response score for each teacher on the nine different sub-groups of items in the questionnaire. To do this, the responses on the negative items had to be converted to a positive mode. A suitable computer program was available to make these necessary computations. Thus the higher the mean score on a particular sub-group of items, the more positive the teacher's attitude would be towards it.

Table XXIII shows the effect of teacher sex on responses to the different variables in the questionnaire. There were no significant differences on all variables except those of teacher attitudes towards the course and the Teaching Guide. On these two variables, males responded more positively than females. It is notable that even though female teachers responded more negatively to items on attitudes towards the course, it was shown previously that students with female teachers liked the ESCP Course better than students with male teachers. The different attitudes of male and female teachers were not reflected in student attitudes.

No significant differences in responses were found between teachers of different age groups, except for that of the Teaching Guide. In this instance, as Table XXIV, page 93, indicates, older teachers liked the Teaching Guide better and were less critical of it than younger teachers. Because these same teachers responded similarly on all other variables, this particular difference is less impressive. This, however, suggests a trend which although not significant, is indicative of some consistency.

Similarly, as Table XXV, page 94, and Table XXVI, page 95, manifest

TABLE XXIII

EFFECT OF TEACHER'S SEX ON RESPONSES TO DIFFERENT VARIABLES ON THE TEACHER QUESTIONNAIRE

Variable	Code* Name	Male $\bar{X}$	Female $\bar{X}$	t Value	Probability
1	TG	3.32	2.95	2.96	0.004
2	APP	3.49	3.17	1.88	N.S.
3	TM	3.35	3.42	-0.60	N.S.
4	CP'S	3.23	2.86	1.89	N.S.
5	EVAL	3.40	3.20	1.28	N.S.
6	ASP	3.29	3.45	-1.07	N.S.
7	TAC	3.24	2.75	3.48	0.0008
8	TAES	3.63	3.59	0.38	N.S.
9	ASAC	3.73	3.45	1.61	N.S.

*
TG teaching guide
APP apparatus
TM teaching methodology
CP'S classroom problems
EVAL evaluation
ASP apparent student problems
TAC teacher attitudes towards the course
TAES teacher attitudes about elementary science
ASAC apparent student attitudes towards the course

TABLE XXIV

EFFECT OF AGE ON RESPONSES TO DIFFERENT VARIABLES OF THE TEACHER QUESTIONNAIRE

Variable	Code* Name	Age Means** $\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$	F Ratio	Probability
1	TG	2.30	3.03	3.61	3.89	0.02
2	APP	3.26	3.28	3.29	0.01	N.S.
3	TM	3.40	3.38	3.48	0.11	N.S.
4	CP'S	2.96	2.92	3.25	0.45	N.S.
5	EVAL	3.20	3.25	3.63	1.21	N.S.
6	APS	3.39	3.36	3.69	0.81	N.S.
7	TAC	2.75	2.96	2.30	2.76	N.S.
8	TAES	3.59	3.59	3.71	0.17	N.S.
9	ASAC	3.66	3.40	3.75	1.37	N.S.

* TG teaching guide
APP apparatus
TM teaching methodology
CP'S classroom problems
EVAL evaluation
ASP apparent student problems
TAC teacher attitudes towards the course
TAES teacher attitudes about elementary science
ASAC apparent student attitudes towards the course

** $\overline{X}_1$ twenty to twenty-five years
$\overline{X}_2$ twenty-six to thirty-five years
$\overline{X}_3$ more than thirty-five years

TABLE XXV

EFFECT OF TEACHING EXPERIENCE ON RESPONSES TO DIFFERENT VARIABLES OF THE TEACHER QUESTIONNAIRE

Variable	Code* Name	Group Means**			F Ratio	Probability
		$\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$		
1	TG	2.87	3.06	3.19	2.15	N.S.
2	APP	3.15	3.32	3.30	0.38	N.S.
3	TM	3.43	3.40	3.39	0.03	N.S.
4	CP'S	2.92	3.08	2.91	0.35	N.S.
5	EVAL	3.19	3.32	3.28	0.22	N.S.
6	ASP	3.33	3.43	3.42	0.19	N.S.
7	TAC	2.64	2.93	3.06	2.80	N.S.
8	TAES	3.50	3.64	3.62	0.53	N.S.
9	ASAC	3.74	3.61	3.34	1.86	N.S.

* TG teaching guide
APP apparatus
TM teaching methodology
CP'S classroom problems
EVAL evaluation
ASP apparent student problems
TAC teacher attitudes towards the course
TAES teacher attitudes about elementary science
ASAC apparent student attitudes towards the course

** $\overline{X}_1$ three years or less
$\overline{X}_2$ four to seven years
$\overline{X}_3$ eight or more years

TABLE XXVI

EFFECT OF TEACHING CERTIFICATION ON RESPONSES TO DIFFERENT VARIABLES OF THE TEACHER QUESTIONNAIRE

Variable	Code* Name	Group Means**					F Ratio	Probability
		$\bar{x}_1$	$\bar{x}_2$	$\bar{x}_3$	$\bar{x}_4$	$\bar{x}_5$		
1	TG	3.31	3.18	3.06	2.89	3.00	1.43	N.S.
2	APP	3.33	3.45	3.41	3.14	3.17	0.65	N.S.
3	TM	3.32	3.39	3.35	3.59	3.23	1.66	N.S.
4	CP'S	2.88	3.23	2.90	2.91	2.87	0.53	N.S.
5	EVAL	3.31	3.43	3.08	3.15	3.33	0.73	N.S.
6	ASP	3.60	3.48	3.35	3.34	3.29	0.55	N.S.
7	TAC	3.17	2.92	2.91	2.72	2.96	1.07	N.S.
8	TAES	3.75	3.66	3.40	3.60	3.55	0.88	N.S.
9	ASAC	3.23	3.20	3.58	3.76	3.69	2.10	N.S.

* TG teaching guide
APP apparatus
TM teaching methodology
CP'S classroom problems
EVAL evaluation
ASP apparent student problems
TAC teacher attitudes towards the course
TAES teacher attitudes about elementary science
ASAC apparent student attitudes towards the course

** $\bar{x}_1$ grade one or less
$\bar{x}_2$ grade two
$\bar{x}_3$ grade three
$\bar{x}_4$ grade four
$\bar{x}_5$ grade five or more

teaching experience and teaching certification did not affect the attitudes and positions taken by teachers. According to these results, the less experienced and the less qualified teachers experienced similar problems and taught the course the same as teachers with more experience and higher qualifications.

Whether or not teachers had taken a science education course was another independent variable considered in analyzing responses on the teacher questionnaire. As indicated in Table XXVII, this variable did not affect responses significantly on most sub-groups of items. There was a significant difference in responses related to teaching methodology only. As expected, teachers who had taken a science education course were more positive in their responses to this particular variable than teachers who had not taken such a course. Teachers who had taken such a course would be more aware of the newer approaches to science teaching. It is important to note that responses on other sub-groups of items, including attitudes towards elementary science, were not significantly different for these two groups of teachers.

No differences were found between teachers who had taken science courses and those who had not taken science courses. As Table XXVIII, page 98, illustrates, there were no significant differences in responses on any of the nine variables. This is probably because none of the teachers had taken many science courses and having taken only one or two would not be enough to cause any major differences in responses.

As Table XXIX, page 99, shows, the size of the science class was related to the teachers responses on six of the nine variables in a significant manner. Teachers with very small classes of ten to twenty-three students and those with large classes of thirty-four to forty-five were not as positive

TABLE XXVII

EFFECT OF HAVING DONE A SCIENCE EDUCATION COURSE

ON RESPONSES TO DIFFERENT VARIABLES ON THE

TEACHER QUESTIONNAIRE

Variable	Code* Name	Group Means** $\overline{X}_1$	$\overline{X}_2$	t Value	Probability
I	TG	2.97	3.14	-1.32	N.S.
2	APP	3.26	3.28	-0.13	N.S.
3	TM	3.55	3.30	2.22	0.03
4	CP'S	3.05	2.92	0.69	N.S.
5	EVAL	3.33	3.21	0.80	N.S.
6	ASP	3.33	3.46	-0.91	N.S.
7	TAC	2.95	2.91	0.23	N.S.
8	TAES	3.73	3.54	1.68	N.S.
9	ASAC	3.58	3.56	0.09	N.S.

*
TG teaching guide
APP apparatus
TM teaching methodology
CP'S classroom problems
EVAL evaluation
ASP apparent student problems
TAC teacher attitudes towards the course
TAES teacher attitudes about elementary science
ASAC apparent student attitudes towards the course

** $\overline{X}_1$ teachers having done a science education course

$\overline{X}_2$ teachers having no science education course

TABLE XXVIII

EFFECT OF HAVING DONE SCIENCE COURSES ON RESPONSES TO DIFFERENT VARIABLES OF THE TEACHER QUESTIONNAIRE

Variable	Code* Name	Group Means** $\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$	F Ratio	Probability
1	TG	3.19	2.93	3.03	1.27	N.S.
2	APP	3.45	3.22	3.19	0.76	N.S.
3	TM	3.34	3.38	3.50	0.72	N.S.
4	CP'S	3.02	2.78	3.22	1.89	N.S.
5	EVAL	3.27	3.05	3.48	2.80	N.S.
6	ASP	3.26	3.45	3.31	0.69	N.S.
7	TAC	3.00	2.73	3.01	1.73	N.S.
8	TAES	3.61	3.51	3.70	0.94	N.S.
9	ASAC	3.57	3.54	3.60	0.04	N.S.

*
- TG teaching guide
- APP apparatus
- TM teaching methodology
- CP'S classroom problems
- EVAL evaluation
- ASP apparent student problems
- TAC teacher attitudes towards the course
- TAES teacher attitudes about elementary science
- ASAC apparent student attitudes towards the course

**
- $\overline{X}_1$ no science courses
- $\overline{X}_2$ one science course
- $\overline{X}_3$ two or more science courses

TABLE XXIX

EFFECT OF CLASS SIZE ON RESPONSES TO DIFFERENT VARIABLES OF THE TEACHER QUESTIONNAIRE

Variable	Code* Name	Group Means** $\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$	F Ratio	Probability
1	TG	2.85	3.28	3.03	3.83	0.03
2	APP	3.05	3.38	3.43	1.72	N.S.
3	TM	3.42	3.47	3.41	0.14	N.S.
4	CP'S	3.43	2.93	2.44	9.32	0.0002
5	EVAL	3.28	3.51	3.00	3.70	0.03
6	ASP	3.10	3.58	3.62	5.38	0.006
7	TAC	2.63	3.11	2.87	3.94	0.02
8	TAES	3.36	3.83	3.60	6.11	0.03
9	ASAC	3.46	3.80	3.46	1.78	N.S.

* TG teaching guide
APP apparatus
TM teaching methodology
CP'S classroom problems
EVAL evaluation
ASP apparent student problems
TAC teacher attitudes towards the course
TAES teacher attitudes about elementary science
ASAC apparent student attitudes towards the course

** $\overline{X}_1$ class sizes from ten to twenty-three
$\overline{X}_2$ class sizes from twenty-four to thirty-three
$\overline{X}_3$ class sizes from thirty-four to forty-five

as teachers whose class size ranged from twenty-four to thirty-three students. These differences applied to responses towards the Teaching Guide, evaluation, teacher attitudes towards the course, and attitudes towards elementary science. Teachers in the larger classes experienced more classroom problems than those in smaller classes. This was certainly to be expected because of more student activity in larger classes, as well as students being forced to share the apparatus among themselves. Strangely enough, teachers with smaller classes felt that students experienced more problems with the course. Teachers in smaller classes may have observed their students more closely than those in larger classes, where large numbers would prevent this. Hence, those in smaller classes may have perceived more student problems associated with the course. Class size did not affect teacher attitudes towards the apparatus, teaching methodology, and assumed student attitudes towards the course.

A one-way analysis of variance on group means based on school enrollment showed, as Table XXX shows, that there were more positive responses towards the Teaching Guide, classroom problems, and teacher attitudes towards the course by teachers in smaller schools. Once again, this probably reflects the greater difficulty of teaching under more crowded circumstances. Teachers from schools of medium enrollment responded more positively to items related to apparent student attitudes as perceived by their teachers than teachers from small and large schools.

Summary

An analysis of teacher responses on the questionnaire revealed that the majority were positive in their attitudes towards the ESCP Course, even though it was apparent that many teachers experienced some problems while teaching the course. These related especially to the Teaching Guide

TABLE XXX

EFFECT OF SCHOOL ENROLLMENT ON RESPONSES TO DIFFERENT

VARIABLES OF THE TEACHER QUESTIONNAIRE

Variable	Code* Name	Group Means** $\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$	$\overline{X}_4$	F Ratio	Probability
1	TG	3.30	3.48	2.89	2.94	5.66	0.001
2	APP	3.54	3.59	3.06	3.17	2.39	N.S.
3	TM	3.20	3.40	3.53	3.36	1.28	N.S.
4	CP'S	3.42	3.35	2.98	2.67	3.63	0.02
5	EVAL	3.38	3.51	3.27	3.10	1.43	N.S.
6	ASP	3.29	3.25	3.30	3.56	1.33	N.S.
7	TAC	3.23	3.19	2.72	2.78	3.47	0.02
8	TAES	3.66	3.55	3.55	3.61	0.16	N.S.
9	ASAC	3.27	4.03	3.76	3.19	6.18	0.0007

* TG teaching guide
APP apparatus
TM teaching methodology
CP'S classroom problems
EVAL evaluation
ASP apparent student problems
TAC teacher attitudes towards the course
TAES teacher attitudes about elementary science
ASAC apparent student attitudes towards the course

** $\overline{X}_1$ school enrollment of 100-199
$\overline{X}_2$ school enrollment of 200-299
$\overline{X}_3$ school enrollment of 300-499
$\overline{X}_4$ school enrollment of more than 500

and classroom problems.

When responses were examined in relation to the independent variables of sex, age, teaching experience, teaching certification, number of science education courses, and number of science courses, results show that no significant group differences were evident on most of the sub-groups of items in the questionnaire. The independent variables of class size and school enrollment did affect teacher responses on most variables in the questionnaire.

Also, an examination of the average scores of the different groups of teachers on the nine sub-groups of items in the questionnaire reveals that most of these average scores are three or greater than three. This indicates that on most of the variables in the questionnaire the majority of teachers responded positively, but there was a significant number of teachers who had negative attitudes towards the course as well. When these sub-group scores of the teachers are casually compared with those of the students surveyed, the comparison suggests that generally students had more positive attitudes towards the ESCP Course than did teachers.

CHAPTER SIX

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

I. SUMMARY

The advocacy by science educators for a greater emphasis on the processes of science and for the rejection of the more traditional approach to science teaching has resulted in the development of science courses which are either partially or entirely process oriented. The philosophy taken in these courses is that because of the "fluid" and changeable nature of scientific knowledge and because of the greater rapidity at which "scientific revolutions" are occuring, students should be taught mainly the scientific skills which the scientist uses to question nature and solve problems. The nature of science itself would suggest that teaching only the content of any science at a particular time in its history could produce a citizenry which cannot cope with or understand new scientific advances or the necessity for science to continue as a dynamic enterprise. The reality of such situations has become much more believable in more recent years because of the ever-increasing turnover of scientific knowledge.

Yet in spite of, or due to, the rapid development of more process-oriented science curricula, evaluation of these courses has lagged. One reason for this is the lack of adequate process-oriented instruments which could be used in such an evaluation. Another reason for this lack is the disregard for evaluation exhibited by many developers of these courses. Often evaluation is only on a very subjective basis.

The Elementary Science Curriculum Project (ESCP) is a process-oriented science course which had its beginnings in 1969. The purpose of this study was to conduct a preliminary evaluation of the course. No systematic evaluation had been done previous to the study. Although the course is designed for grades one through to six, this study examined course objectives in grades five and six only. The study considered evaluation from three points of view. The first aspect of the study compared the attainment of process objectives of students who did the course with students who did not do the course. Could students, who were exposed to the ESCP Course, perform on the process tests, which were developed to test the learning of the processes of science stressed in the course, better than students not taking the course. Secondly, student attitudes towards the course were examined, and thirdly, teacher attitudes towards the course were examined.

Two classes of grade five students and two classes of grade six students from a Newfoundland school were used for the experimental aspect of the study. One class from each grade was used as an experimental group and the other class from each grade served as a control group. Experimental groups were taught the ESCP Course as outlined in the ESCP Teaching Guide and the control groups were given an alternate science course which did not stress scientific processes. This course was given to the control groups to control for the Hawethorne effect. This part of the study was conducted during the period January, 1972 to June, 1972.

Both groups were administered pretest and postest, which were developed for the study and which were process-oriented and based on the process instruments developed by the AAAS for their course: Science--A Process Approach. The process instrument developed for each grade was used for both pretest and postest purposes. S.T.E.P. Science Test, Form 4A, was also administered to all groups at the beginning of the study. Results on the pretests, the S.T.E.P. Science Test, and on the Lorge-Thorndike Intelligence Tests, Forms 2A and 3A, along with socio-economic ranking and sex served as control variables to aid in the interpretation of the postest analysis. Multiple linear regression was used to analyze this data.

Student attitudes were elicited using a Q-sort instrument consisting of forty positive or negative statements about the course. The Q-sort was administered to eight classes of grades five or six students chosen on the basis of a stratified sample from the population. Teacher attitudes were evoked by means of a questionnaire. Teachers were required to respond to fifty-five statements about the course. The questionnaire was in the form of a Likert scale. The questionnaire was sent to all teachers teaching the ESCP Course at the time of this study.

A descriptive analysis was carried out on results from both student and teacher responses. Using the computer services at Memorial University, a percentage summary of responses was obtained. Also, all negative responses were transformed into a positive mode and the mean score for each individual on different sub-groups of items from each instrument was found. These mean scores were then analyzed in relation to certain independent variables.

II. CONCLUSIONS

It is convenient to group the contents of this section under three headings since the discussion deals with the results from the experimental setting, student attitudes towards the ESCP Course, and teacher attitudes towards the ESCP Course.

A. Results From the Experimental Setting

Grade five. When multiple linear regression was used to analyze results of the experimental and control groups on the postest, a significant difference was found between these two groups in grade five.[1] These findings indicate that students exposed to a process-oriented science course learn the processes of science better than students in a course which does not emphasize process.

The conclusions based on these results have to be made cautiously, because of the limitations of this study in terms of the analysis technique used and because the teacher variable was uncontrolled. A small amount of evidence was accumulated which might suggest that the grade five results for the experimental class may be atypical, because of some uncontrolled factor, or factors, like the teacher variable.

Furthermore, scores on the process tests for experimental and control groups in both grades were low in terms of the total possible scores on these instruments used. This might suggest that even though the processes of science are being learned, they are not being learned as quickly as the goals of the ESCP Course would imply. But such a conclusion would have to be made based on the particular process tests used. If the items on the AAAS Competency Measures for these grade levels are valid and if the ESCP Course is structured around the same scientific processes as the AAAS Course, then the tests used in the study should reflect the validity of the AAAS Items. But because the AAAS Items were developed to test

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[1]Refer to Table X, page 53.

the process knowledge of science students who had been exposed to such a course from grade one up to grades five or six, this could be one reason why students in the study found these items as difficult as they did. It must be realized that students in the study were only exposed to the ESCP Course for half the school year and that they had no previous training in the processes of science prior to the study. It is postulated that a longer time exposed to the course would increase the student's proficiency in process skills, especially if the student has been exposed to such a course from grade one up to grades five or six.

Grade six. No significant difference was found in performance on the postest between treatment groups in grade six.[2] Students who were exposed to the ESCP Course performed only marginally better on the postest. Yet, the experimental group showed a greater increase on postest scores over scores on the pretest when compared with the control group.[3] Because all grade six students found the process test difficult, for possible reasons already discussed, this greater increase shown by the experimental group on the postest over the pretest can be partially explained by a regression effect. Since students in the experimental group scored lower on the average on the pretest than did students in the control group, this greater increase on the postest over the pretest by the experimental group could be due partly to a regression effect upward. But this greater increase certainly cannot be totally explained in terms of a regression effect and it is speculated that treatment contributed to this increase as

[2] Refer to Table XIII, page 57.

[3] Refer to Table XIV, page 59.

well. When this increase in performance by the experimental group and the fact that they performed better than the control group on the postest is examined in the presence of differences in intelligence and achievement between these two groups, these results become much more significant. Essentially, it can be postulated that due to exposure to the ESCP Course a more backward group of students performed better than a smarter group of students on the process test.

Another result which makes the grade six findings difficult to explain is the very low correlations of the postest with STEP Science and intelligence.[4] If these results had been true for the pretest, it could have been concluded that the process instrument used in this grade was useless as a discriminator among students of process achievement and that all results on the test were essentially due to random effects. However, the pretest did correlate well with STEP Science and since the same process test was used for pretest and postest purposes, this argument cannot hold.

Considering these findings and the fact that the Lorge-Thorndike Intelligence Tests correlated highly with STEP Science, which is a science achievement test, the very low correlations between the postest and these other variables are difficult to explain. Since scores on the pretest did correlate well with those on the other tests, this suggests that scores on the intelligence and science achievement tests should be good predictors of scores on the postest. It is odd that this predictive power did not hold true for the postest. Some uncontrolled factor, or factors, affected performance on the postest in grade six so that results on the postest were no longer related to intelligence and science achievement. It is postulated

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[4]Refer to Table XII, page 56.

that some aspect of the administration of the postest, which differed from that of the pretest administration, interfered with the students' performance. This exact change cannot be ascertained.

A study done by Ash and Bursey in the Springdale school at the grade six level may help explain some of the difficulties encountered in the analysis of the data. They carried out some testing on these students using the Canadian Tests of Basic Skills (CTBS). A wide variation of results was found between experimental and control groups; the control group scored higher than the experimental group. Furthermore, based on correlations between CTBS and the Lorge-Thorndike Intelligence Tests, it was concluded by Ash and Bursey that this intelligence test "was an effective predictor of academic achievement for only the upper one half to one third of children tested."[5] They found that in the experimental group the relationship of ability test scores and achievement test scores was random. One possible cause suggested for this was test unreliability, since the scores were at the lower end of the scales on these tests.[6] Thus, according to this study by Ash and Bursey, reliability estimates quoted earlier for the Lorge-Thorndike Tests may not be valid for the experimental group. If the Lorge-Thorndike Intelligence Tests is not a good predictor of achievement on the CTBS, it might not be a good predictor of achievement on the postest used in the study. For the same reason, the STEP Science Test may not be a good predictor of postest achievement as well. Thus these

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[5] Don Ash and Morley Bursey, "Report of Testing Carried on in the Springdale Integrated Schools, November 15-19, 1971, and of Compilation of District Norms for the Academic Promise Test" (St. John's: Department of Educational Psychology, Guidance and Counselling, Memorial University of Newfoundland, 1971), p. 5.

[6] *Ibid.*

findings help explain, at least partly, the reason for the very low squared multiple correlation obtained from the multiple regression equation. The predictors used in the equation had very low predictive power for the criterion for subjects in the experimental group. However, this still does not explain why correlations between the pretest and the other variables were fairly high.

In view of these complications and the possible inability of the instruments used as predictors of postest achievement to discriminate properly between groups because of differences in the reliability and possible other uncontrolled factors, valid conclusions based on this data about the effectiveness, or otherwise, of the ESCP Course at teaching the processes of science at the grade six level cannot be made. But knowing the poorer quality of students in the experimental group, greater significance can be given to the pretest-postest gain shown by the experimental group. Despite the backwardness of these students, their scores on the process test increased after exposure to the course, whereas, the control group with much higher I.Q. only showed marginal improvements. Also, the experimental group performed better than the control group on this test.

B. *Student Attitudes Towards the ESCP Course*

A perusal of results on the student Q-sort instrument shows that responses were mainly positive.[7] Most students indicated that they found the course interesting and challenging. The majority of students, when asked, said that they prefered this type of course, which is activity oriented, to the more

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[7]Refer to Table XVII, pages 67-69.

traditional type. Yet, there were some who disliked certain aspects of the teaching style used in the course. These students felt that a lot of things to work with often served to make learning difficult; and, some students would have prefered more discussion and lecturing by the teacher.

The majority of students felt that the course presented the basic ideas of science and many indicated that the course taught them how scientists think. Yet, a minority of students felt that the course taught them little about science.

Based on the results obtained on the Q-sort used in the study, it is concluded that the majority of students have a positive attitude towards the ESCP Course. Nevertheless, on many items of the Q-sort there were students who responded negatively. Since a basic premise upon which this course is based is that elementary science is for all students, the negative attitudes of these minority students are considered to be inportant in a final evaluation of student attitudes towards the course.

In the interpretation of these responses on the Q-sort, the limitations of the instrument used must be taken into consideration. It is suspected that there is a certain amount of unreliability in the responses to some of the items in this instrument and, moreover, since students were asked to agree or disagree with the statements included in the Q-sort, these items may have an expectancy attached to them so that students would probably tend to respond more positively to such items than they would actually feel like responding.

Using the values of one to five which were assigned the five different units of the scale associated with each statement and after the negative responses had been converted to a positive mode, a mean score for each student on different sub-groups of items in the Q-sort was computed. It was then possible to analyze these mean scores in relation to the independent variables of pupil sex, teacher sex, class size, and geographical region.

The sex of the student did not affect responses on the Q-sort instrument.[8] These results indicate quite clearly that the course was just as appealing to girls as it was to boys. This is a very desirable situation since science should appeal to both sexes.

Significant differences were found between students who had males as teachers and those who had females as teachers.[9] Students having female science teachers were more positive in their general attitudes towards the course; they found the course content more appealing; and, they were motivated more towards science due to the course than were students having male teachers. Female teachers created better attitudes towards the course than did male teachers. How female teachers did this cannot be determined from the evidence. It can be speculated that female teachers may have taught the course differently, or their personalities were different, or student expectancies differed from those who had male teachers, and this is what caused the better student attitudes.

Distinct differences in responses were found between students from different classes of various sizes.[10] Students from very small classes and very large classes were more negative in their responses than were students from middle-size classes of twenty-five to thirty-five students. It can be concluded that in the students' opinion, a class size of approximately thirty students is about optimum for teaching this course. The

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[8] Refer to Table XVIII, page 74.

[9] Refer to Table XIX, page 75.

[10] Refer to Table XX, page 77.

poorer attitudes of students in the very large classes can be explained in terms of the lack of equipment to allow all students to participate properly in the various activities. The various kits were only developed to accommodate thirty students. Also, in the very large classes more classroom organizational problems would be experienced and each individual student could not be given the same amount of individual attention by the teacher as would be possible in smaller classes. The poorer attitudes of students from very small classes could be due to the lack of motivation which seems to be a feature of smaller classes. Unlike in larger classes where large numbers of students create more group participation, in smaller classes this feeling of group membership would be reduced.

Little regional variation was found in student responses.[11] It can be concluded that the location of students did not affect their attitudes towards the ESCP Course.

C. Teacher Attitudes Towards the ESCP Course

Attitudes of teachers towards various aspects of the course were mainly favourable.[12] Yet in spite of this, results indicate clearly that a significant number of elementary teachers experienced problems while teaching the course. Most of these problems were connected with the Teaching Guide. Teachers desired a more detailed Teaching Guide. They wished to have more detailed information regarding the purpose of the various activities, how they should be taught, and more background information on the activities. The third edition of the Teaching Guide, which is being published in the summer of 1972, will help eliminate many of these

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[11] Refer to Table XXI, page 79.

[12] Refer to Table XXII, pages 83-87.

difficulties. On the basis of these results and others, this new edition will provide teachers with more detailed instructions in these problem areas.

Classroom problems were experienced by a goodly number of teachers. Many teachers felt that classes were too large to permit an adequate job to be done in teaching the course. This problem of too large a pupil-teacher ratio has been in existence for a long time and there seems to be little possibility of it changing in the near future. Teachers may have felt more threatened by these larger classes in this course than they would be in teaching the more traditional courses. Because the course is activity-oriented and students discuss their findings, work together on problems, etc., classes can become quite noisy at times and may appear to teachers new to this situation to be quite confusing. Many teachers said that they experienced classroom organizational problems and too much noise in the classroom.

Similarly, on other items relating to other aspects of the course, even though the majority of students were positive in their attitudes, there were some who expressed negative attitudes.

The interpretation of results on the teacher questionnaire must be done with the realization that there may be some unreliability associated with responding to the type of items included. Because teachers were required to agree or disagree with the statements in the questionnaire, they may have tended to respond more positively than they actually felt like responding.

The sex of the teacher did not affect responses on most sub-groups of items on the questionnaire.[13] There was a difference in responses to

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[13]Refer to Table XXIII, page 92.

items related to teacher attitudes towards the course and the Teaching Guide. Males were more positive on both these sub-groups of items. Generally, male and female teachers had similar attitudes towards the course.

Similarly, teachers of different age groups did not differ greatly in their attitudes towards the course. The only difference was that older teachers liked the Teaching Guide better and were less critical of it than were younger teachers.[14] There were no major differences of opinion between teachers of the different age groups.

Teaching experience[15] and teaching certification[16] were two other independent variables which did not affect teacher attitudes towards the course. The less experienced and the less qualified teachers experienced similar problems and taught the course in a similar manner as teachers who were more experienced and more qualified. This was probably due to the fact that this course demands a new and different approach to teaching, since it is activity-oriented. Therefore, more experience in teaching the more traditional courses would be of little benefit to the teacher. Similarly, even though some teachers were well qualified, they may never have been trained to teach such a course.

Also, it is interesting to note that teachers who had taken a science education course responded quite similarly to teachers with no such course.[17] The only differences which were significant were related

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[14]Refer to Table XXIV, page 93.

[15]Refer to Table XXV, page 94.

[16]Refer to Table XXVI, page 95.

[17]Refer to Table XXVII, page 97.

to teaching methodology. Teachers who had taken a science education course responded more positively to this variable. This is certainly to be expected because they would be more aware of the newer approaches to science teaching and therefore, they would not have to experience as drastic a change in their teaching style. But significantly enough the attitudes of these teachers who had taken a science education course were very much like those who had not taken such a course. Attitudes towards teaching a science course were unaffected by what was taught these teachers in the science education courses. Most teachers who said that they had taken a science education course indicated that they had only taken one course. If they had taken several of these courses instead of just one, the responses may have been different.

In a similar fashion, teachers who indicated that they had taken one or more science courses responded comparably with teachers who had taken no science courses.[18] One reason for this is that none of the teachers were science majors and the vast majority had taken only one science course. Thus, as expected, teacher competency and teacher attitudes were not affected by such a limited science background. It would be interesting to compare responses of science majors with non-science majors. It is speculated that differences would be evident. Unfortunately, very few elementary teachers have elected to major in science and this makes valid comparisons of this nature difficult.

From the findings of this study, it can be concluded that the size of the class in which the teachers taught did affect their attitudes towards

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[18] Refer to Table XXVIII, page 98.

the teaching of the ESCP Course.[19] Teachers with very small classes and teachers with very large classes were not as positive in their responses as teachers in middle-size classes ranging from twenty-four to thirty-three students. Teachers in larger classes experienced problems relating to classroom organization which were of greater magnitude than teachers in smaller classes experienced. This is to be expected because of the greater amount of activity in these larger classes and the necessity for more students to share the same equipment. Probably due to the fact that teachers in very small classes could better observe each individual student, they perceived that their students experienced more classroom problems in the course than those in larger classes. Nevertheless, as the students themselves indicated, these problems were not too serious, or at least this is what the students indicated.

Teachers from schools of small enrollment were more positive in their responses than teachers in larger schools.[20] Teachers in larger schools would experience more classroom organizational problems, if it can be assumed that classes would be correspondingly larger, and hence, their attitudes towards the course would be more negative than teachers in smaller schools, where the class size would be smaller. Also, differences could be related to the fact that different types of teachers teach in different size schools. For example, the more qualified teachers may tend to congregate in the larger schools and they may tend to be more critical of the course.

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[19]Refer to Table XXIX, page 99.

[20]Refer to Table XXX, page 101.

III. *IMPLICATIONS*

For Further Course Development

Teaching guide. One very obvious implication of this study is the need expressed by the teachers for a more structured Teaching Guide. As teachers indicated in the questionnaire results, they desired more information regarding how the various activities should be taught and more detailed information describing the content of the different lessons. Although some guidelines have been included already in the Second Edition of the Teaching Guide for a subjective evaluation of students taking the course, guidelines should be included to direct the teacher in preparing her own process tests, or such tests should be included in the guide for each grade. This would provide the teacher with a direct measure of process performance by the students. These needs may have already been taken care of since a Third Edition of the ESCP Teaching Guide has been prepared and will be published in the summer of 1972. This revision includes much more detailed instructions on how the teacher should teach the various activities and what they are all about. It is recommended that evaluation be done in the future to determine if this revision of the Teaching Guide has eliminated some of these difficulties which teachers experienced with the Second Edition.

Inservice training. All teachers surveyed in this study saw the need for more inservice training regarding the aims and purposes of the course and the particular teaching methodology required to teach the course. Most elementary science teachers in Newfoundland schools, as this study showed, have a very limited science background and many would prefer to teach courses in which they are more interested and compotent. Also, other courses are less time consuming because of the necessity in science to prepare equipment before each lesson is taught. These teachers need guidance as well as assurance for proper teaching of this course. Such inservice training is needed especially during the introductory phase when the course is first being introduced into the school.

Course acceptance. The evaluative evidence presented in this study is the first results which indicate that students in the ESCP Course learn the processes of science better than students not taking the course. Although the evidence is only comparative in nature and subject to further examination because of the limitations of the design of the study and the analysis of the data used, it can help in deciding whether or not the course should be adopted by the Department of Education and introduced into Newfoundland schools on an island-wide basis. The grade five results especially, indicate that students in this course perform much better on process tests than students not taking the course and, furthermore, it is speculated that a longer time exposed to the course--for example, from grade one up to grades five or six, would result in students being proficient in the processes of science. Certainly, further evaluative studies are needed in order to produce a clearer picture of the potential impact of this course at teaching the processes of science. Also, the majority of students surveyed accepted and responded favourably to the course. Even though teachers experienced some problems, there were no major problems which cannot be eleviated. With some changes in the Teaching Guide and more inservice training, teachers can teach this course with confidence.

For Further Research

(a) This study is a preliminary evaluation of the ESCP Course. In examining the process achievement of students in the course, only the grade five and grade six levels of the course were considered. One obvious implication is that similar studies are needed at the grades one to four levels in the course as well.

(b) A longitudinal evaluation of students in this course over a period of years would indicate just how effective the course is at teaching scientific processes. Students who have taken the course from grade one to grade six could be compared with students who have taken the course for one or two years and with students who have not taken the course at all. This would provide information on course effectiveness as a function of the amount of exposure to the course.

(c) It is recommended that future studies relating to evaluation of the ESCP Course be run for the entire school year. The course provides enough activities for it to be taught for the entire school year and this is the pattern taken by all teachers teaching the course, therefore, a study carried out for this period would yield results which would be representative of the amount of advancement that most students would make in the course during one year. Also, problems of cramming and of not allowing students to progress at their own rate could be avoided.

(d) Further studies relating to course evaluation should control the teacher variable more than it was possible in this study. The best procedure for doing this would be a province-wide study using the classroom as the sampling unit, rather than the student. The study could be run for the entire school year with a pretest being given at the beginning of the school year and a postest being given at the end of the school year.

(e) A definite need illustrated by this study is for well-developed, general process instruments which are valid, reliable, and standardized. Such instruments should be developed for a particular grade or age group and based on the limitations set by the level of the student's development. For example, in the lower grades especially, ways should be found to avoid having the performance of the student on these tests depend on the ability to read. Such process instruments are especially needed to test the more complex scientific processes.

(f) An examination should be made of the actual achievement of process objectives. Achievement of these objectives could be examined by comparing performance of students with determined standards.

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APPENDICES

APPENDIX A

Grade Five

NOTE: Before answering each question in this test, read the problem and the instructions carefully. If you have any reading problems, ask the instructor for help.

1. Suppose you are given two balls and you are told one is hollow and one is solid, but you cannot tell which is which by merely looking at them. If you wanted to decide which of the two balls was solid and which was hollow, what procedure would you use -- the one shown in Illustration 1, the one shown in Illustration 2, or the one shown in Illustration 3?

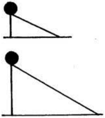


Illustration 1

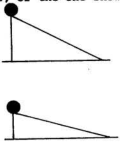


Illustration 2

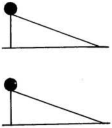


Illustration 3

ANSWER: ______________________________

____

2. Look at Illustrations 4 and 5. The balls in Illustrations 4 and 5 were both released at the same time from the top of the ramp. One of the balls is solid and one is hollow. The ball in Illustration 4, however, reaches the bottom of the ramp first. Which of the two balls is hollow?

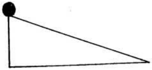


Illustration 4

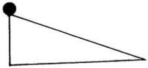


Illustration 5

ANSWER: ______________________________

____

3. The children in a class were asked to memorize the names of all the prime ministers of Canada. They were given 20 minutes to memorize the names. Below is a list of different conditions that exist while the pupils are trying to memorize the names. (We call these conditions variables). Put a check (✓) next to the four variables listed below which would have something to do with memorizing the names.

(a)____ Some children read the names out loud.

(b)____ It is almost time for the class to be dismissed.

(c)____ This is the smallest class in the school.

(d)____ The children in the class have younger brothers and sisters.

(e)____ Some of the children can already name some prime ministers.

(f)____ Every pupil who memorizes the names in 20 minutes will receive a candy bar.

(g)____ The teacher can name most of the prime ministers.

4. An hypothesis is a general statement or assumption which can be used for reasoning out a problem. Of the two statements which follow, the second statement is an example of a hypothesis:

1. John received a very low grade on the spelling test today because he watched TV until 11:30 p.m. last night.

2. Children must have nine hours sleep before a test in order to get a high score.

Read the two statements below and put a check (✓) before the one you think is a hypothesis:

1.____ The tires on this sting ray bicycle wear out fast because the wheels are small.

2.____ Small tires wear out faster than large tires.

5. Here is a hypothesis:

Metals are good conductors of electricity and nonmetals are poor conductors of electricity.

Here are two observations: A diamond is a nonmetal. A diamond is a good conductor of electricity.

These observations ______________________ the hypothesis.
support, do not support

6. Color blindness, which is actually red-green blindness, occurs in some people. It is thought to be passed on from generation to generation. Assume that among 10,000 people selected by drawing names from the population of a city, color blindness is found in 43 males and five females.

Using the data from this group, write a statement of a hypothesis relating to the question: what is the relative frequency of color blindness in males and females?

____

____

Using the data from this group, write a statement of a hypothesis regarding the frequency of color blindness in the population.

____

____

7. Look at the pictures of a pound of butter and a can of tomato juice shown in Illustration 6.

Illustration 6

Illustration 7 shows lengthwise and cross sections of one of the objects in Illustration 6. These are sections of which object? Print the letter of the object in the following space:________

Illustration 7

8. Illustration 8 shows pictures of an Indian tepee and a pyramid.

Illustration 8

Illustration 9 shows lengthwise and cross sections of one of the objects in Illustration 8. Print the letter of that object in the following space:________

Illustration 9

9. Illustration 10 shows a solid object -- a cone -- sliced through with an horizontal cut, as shown by the dotted line. The cut is parallel to the base of the cone.

Illustration 10

What is the shape of the slice? ______________________________

10. A group of five pupils was asked to demonstrate a procedure for determining the mass and volume of the components of a mixture of coarse sand and water. They were given the

following items to work with:

- a mixture of coarse sand and water (about 20 pints)
- an equal arm balance
- ounce masses to balance the mixture and the components
- a graduated cylinder
- two pieces of paper toweling
- a bowl or pan

Figure 1 shows six things that the pupils might do in the investigation. Check the parts of Figure 1 that demonstrate steps that the pupils should take in order to analyze the mixture.

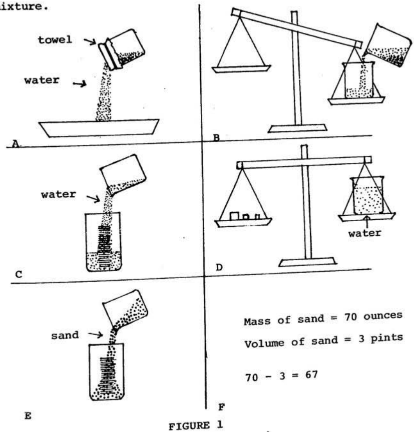


FIGURE 1

11. The five pupils mentioned in question 10 recorded their data in Table 1.

TABLE 1

	Mass in ounces	Volume in pints
water	29	4
sand	68	3
mixture	100	6.5

Complete the statement of an inference to explain why the sum of the masses of the components is less than the mass of the mixture.

____

____

____

12.

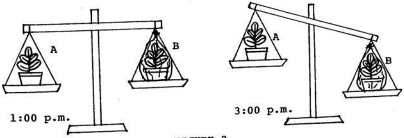


FIGURE 2

Figure 2 shows two potted plants, labeled A and B. Plant B was completely enclosed in a large, airtight plastic bag. At 1:00 p.m. the two plants were placed one at each end of an equal-arm balance, which was then level. (Plant A balanced plant B). But by 3:00 p.m., the balance was no longer level.

State an inference to explain why the plant that was not in the plastic bag, Plant A, weighed less than the plant inside the plastic bag, Plant B, after two hours.

____

____

____

13. Three powders of unknown materials labeled Powder A, B, and C are tested by the following procedure: A pinch of Powder A is put into each of three different jars containing different colorless liquids and labeled Liquid 1, 2, and 3. Next, a pinch of Powder B is put into a second set of jars labeled Liquid 1,2, and 3. Finally, small amounts of Powder C are put into a third set of jars labeled Liquid 1, 2, and 3. The results are shown in Illustration 11.

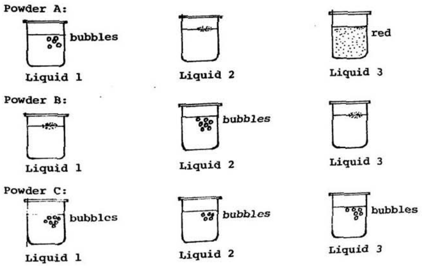


Illustration 11

Make a record of these observations in Table 2:

TABLE 2

Liquid / Powder	Liquid 1	Liquid 2	Liquid 3
Powder A			
Powder B			
Powder C			

Complete these two statements so that they are observations that show that Powder A and Powder B are different.

Powder A ______________ in Liquid __________

Powder B ______________ in Liquid __________

14. Look at the plan of a house shown *in Illustration 12*, on next page. Notice the mouse hole in one room and the food in another room. One night a mouse who hadn't been in the house before came out of the hole to look for food. Every night afterwards he found food in the same place. Without the mouse's knowing it, we put dust on the floor so that we would know where he went when he came out of the hole. Now look at the four patterns. The first shows where the mouse went on the first night; the second shows where the mouse went on the second night; and so on for the third and fourth nights. What do you think the patterns show that would make us think that the mouse has learned where food is in the house? Write your answer in the space provided:

____

____

____

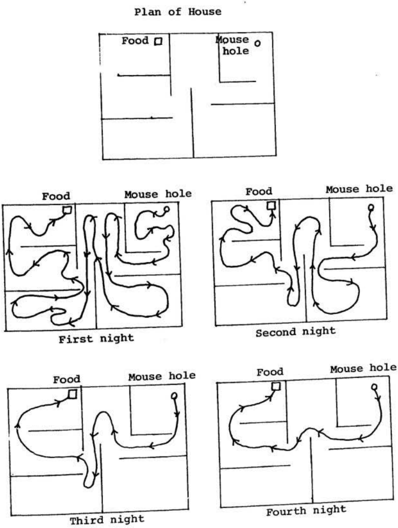


Illustration 12

15. If you were looking through a tube at a brick wall across the street and you wanted to get more bricks in your view, would you move closer or farther from the wall?

ANSWER: ______________________________

Here are some data on the number of bricks seen at various distances. Construct a line graph on the graph paper below to represent these data.

TABLE 3

Distance from Wall	Number of Bricks seen
10 feet	4
15 feet	9
25 feet	25
30 feet	36
40 feet	64

From the graph you constructed in Problem 15, determine where a person would need to stand to see about 16 bricks.

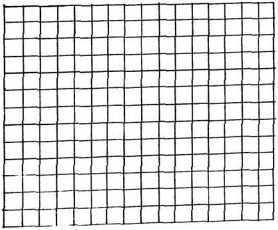
ANSWER: ______________________________

16. Two children dropped a ball from different heights and noted how high the ball bounced each time. They used feet as their unit of measurement. Table 4 gives their results.

TABLE 4

Drop Height	Bounce Height
2 feet	1 foot
4 feet	2 feet
6 feet	3 feet

On the graph paper below construct a bar graph (histogram) showing the relationship between the height from which the ball is dropped and the height to which it bounces.



17. From Table 4, or the graph you constructed in Problem 16, predict what the bounce height would be for drop heights from three feet (ANSWER:____________) and five feet (ANSWER:________).

18. Two jars of the same size and shape were half-filled with water. Four ice cubes were added to one jar, and eight to the other. The experimenter then observed that the eight ice cubes took sixty minutes to melt, and the four ice cubes took twenty minutes to melt. See Table 5.

TABLE 5

Number of Ice Cubes	Melting Time (minutes)
4	20
8	60

Predict how long it will take six ice cubes to melt under the same conditions.

ANSWER:__________________

Predict how long it will take two ice cubes to melt under the same conditions.

ANSWER:__________________

19. Look at Figure 3 below. When you look through one type of microscope you can see a measure showing these lines. The distance between each of the marks is a "yem".

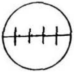


FIGURE 3

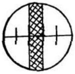


FIGURE 4

How wide is the field of vision of the microscope in yems?

ANSWER:__________________

Look at Figure 4. The shaded area is a wire viewed through a microscope. What part of the total field of vision is the width of the wire?

ANSWER: ________________________

20. *Examine Figure 5 below.*

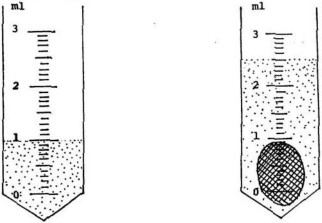


FIGURE 5

Water fills a cylinder to the level *shown on* the left in Figure 5. An object is placed in the cylinder and the water rises to the level shown on the right. *Find the* volume of the object.

ANSWER: __________ ml.

21.

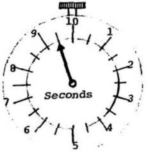


FIGURE 6

The stopwatch shown on the left in Figure 6 is set at the world record time for running the length of a football field. What is the record time?

ANSWER: ________ seconds.

22. Some observations made with a spring are shown in Illustration 14 below. Each block shown in the illustration weighs one pound. Using the graph paper on the next page, calibrate the spring so that you can use the stretch of the spring to measure forces.

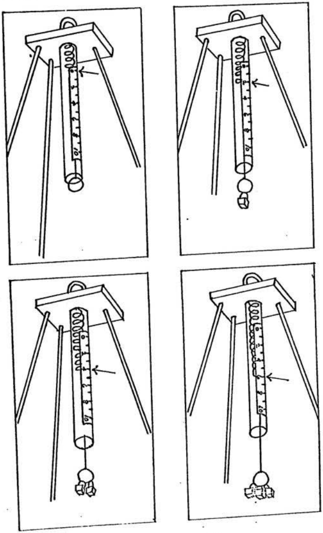
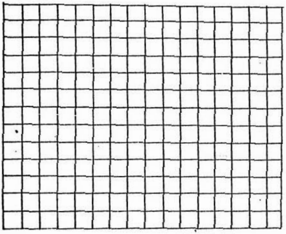


Illustration 14

23.



24. Illustration 15 below shows the spring you have just calibrated being stretched by hand. How much force is being exerted on the spring? Make a small arrow on your graph at the top of this page showing this amount and write this amount of force below the arrow.

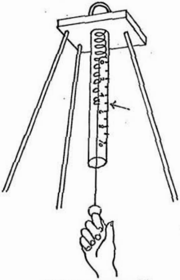


Illustration 15

Grade Six

NOTE: Students should read the problem and instructions *carefully before* attempting each question. If you have any reading problems, consult the instructor.

1. Robert has a dog that he calls Napoleon. The dog has *lived and played* with children under many conditions. (We call these conditions variables). Name a variable that may affect Napoleon's behavior with children.

____

____

2. Jane Green said the amount of exercise Napoleon gets will affect his growth. Jane lives on a farm where she can have several dogs and there will be *lots of space* for the dogs to run. Below is a number of statements giving steps that might be taken in an investigation of the question: Will a dog that gets daily exercise for one month beginning on the day he is two months old grow more than a dog that gets no exercise during this month? *Put a check mark* (✓) beside statements that describe things Jane should do.

(a)____ Jane compares the growth of two different breeds of dogs.

(b)____ Jane compares a male and a female puppy.

(c)____ Jane compares two puppies from the same litter.

(d)____ *One dog* is fed dog biscuits and the other hamburger.

(e)____ The dogs are fed the same food.

(f)____ The dogs are kept in identical pens.

(g)____ Jane decides to consider gain in mass and length from tip of nose to end of tail as indications of growth.

(h)____ Jane weighs and *measures* the lengths of both dogs when they are two months old.

(i)____ One dog runs with Jane in the woods from 4:00 to 5:00 o'clock each day.

(j)____ Jane pets the dog that doesn't get to *run* every morning and night.

(k)____ Jane asks her mother to give the dog that isn't running a treat while the other dog is in the woods.

(1)____ Jane measures how tall each dog is.

3. Suppose our class made the following hypothesis for testing:

The quality of the vision of a batter in a baseball game will have greater effect on his batting average than his general physical condition.

List four variables in the statement of the hypothesis or in a test of the hypothesis.

____

____

____

____

____

4. Suppose you had two pieces of cloth of the same size and shape but of different materials. How would you find out what material absorbs water faster? Which of the following would you do? Check the ones you would need to do:

(a)____ Put the same length of each strip of cloth in water.

(b)____ See how high the water goes up each piece of cloth.

(c)____ Observe both pieces with a magnifying glass.

(d)____ Fold both pieces in the same way.

5. From the list given check which variable the experimenter will change,or manipulate, in an experiment to determine which cloth absorbs water faster.

(a)____ Length of time in water.

(b)____ Temperature of water.

(c)____ Kinds of cloth.

6. In most experiments some variables must be held constant.

From the list below check off the variables that must be held constant in order to determine which cloth absorbs water faster.

(a)____ Kinds of cloth.

(b)____ Length of time in water.

(c)____ Height that water goes up material.

(d)____ Amount of cloth in water.

7.

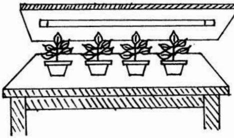


Illustration 1

Illustration 1 above shows a group of seedlings that have been growing for several days under artificial light. Suppose you wanted to do an experiment in which you try to change the position of the stem in relation to the surface of the soil. What variable would you change or manipulate?

____

List at least two variables you would want to keep constant while you changed the variable you mentioned above.

____

____

8. A teaspoon of salt was dissolved in a beaker **partially** filled with water. The mixture was placed in a small freezer in which the temperature could be controlled. The freezer also had a glass front through which a person could see. It was observed that it took 55 minutes for the mixture to freeze. Two teaspoons of salt were then dissolved in

another beaker of water. This time it took 40 minutes for the mixture to freeze in the freezer. A third beaker containing water was mixed with three teaspoons of salt. This time it took 75 minutes for the mixture to freeze.

Name three variables that might account for the differences observed.

1.____

2.____

3.____

9. A student found that a beaker containing a salt and water mixture froze in different lengths of time when exposed to the temperatures shown in Table 1.

TABLE 1

Freezer Temperature	Time Required for Mixture to Freeze
30° F	75 min.
15° F	60 min.
-5° F	45 min.
-20° F	35 min.

Describe the effect of changing the temperature of the freezer on the freezing time.

____

____

10. A student was asked to examine two shoeboxes, one marked A and the other marked B, as shown in Figure 1.

FIGURE 1

He pulled on both strings of box A at the same time. He found that he had to use force to pull on the two strings and that after pulling each string out an additional inch from its original position, both strings stopped (he could not pull the strings any further).

Construct a *hypothesis* (*a reasonable explaination* based on the facts) in the space below to explain what you think is happening inside boxes of this type. You may use drawings as well as sentences in your description of the hypothesis.

____

____

____

____

On the basis of your hypothesis, make an inference that you could test *with the shoebox.*

____

____

____

Describe a test of your inference by describing the necessary steps of the test.

____

____

____

____

The student also examined box B by pulling both strings at the same time. He found that more force was *required* to pull the strings out to their stopping position than was required with box A.

Construct a single hypothesis that will explain what is going on inside both boxes.

____

____

____

11.

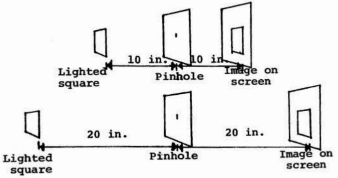


Illustration 3

Look at the two diagrams in Illustration 3. With the lighted square, the pinhole, and the screen spaced at the distances shown in the two diagrams, the size of the image is the same as the size of the object.

Construct a hypothesis based on these data.

____

____

____

12.

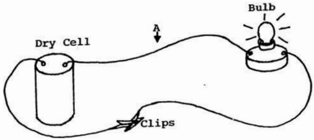


Illustration 4

Look at Illustration 4 on the previous page. The two clips are fastened tightly together. The bulb is on. What would happen to the bulb if the clips were seperated? Make a check (✓) mark:

Bulb turns off ________

Bulb stays on ________

What would happen if you cut through the wire at point A? Make a check mark.

Bulb turns off ________

Bulb stays on ________

13.

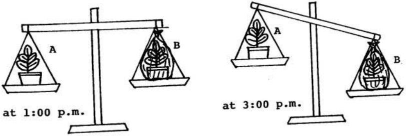


Illustration 5

Illustration 5 shows two potted plants, labeled A and B. Plant B was completely enclosed in a large, airtight plastic bag. At 1:00 p.m. the two plants were placed one at each end of an equal-arm balance, which was then level. (Plant A balanced Plant B). But by 3:00 p.m., the balance was no longer level.

State an inference to explain why the plant that was not in the plastic bag, Plant A, weighed less than the plant inside the plastic bag, Plant B, after two hours.

____

____

____

14. Look at Illustrations 6 and 7 below. Check whether Illustrations 6 and 7 are balanced or not balanced.

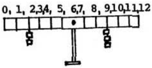


Illustration 6

Balanced ____

Not balanced ____

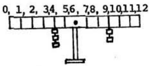


Illustration 7

Balanced ____

Not balanced ____

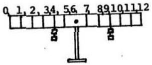


Illustration 8

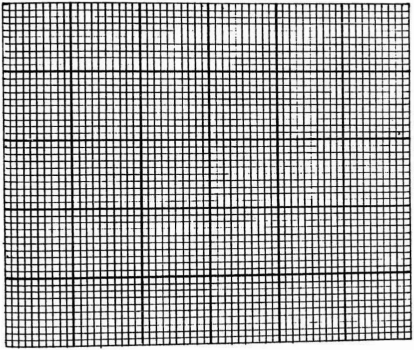
Where would you hang a single weight in Illustration 8 in order to balance the system? Draw in the single weight in its proper position in Illustration 8.

15. If you were looking through a tube at a brick wall across the street, as you moved further from the wall you would see more and more bricks. Here are some data on the number of bricks seen at various distances.

TABLE 2

Distance from Wall	Number of Bricks Seen
10 feet	4
15 feet	9
25 feet	25
30 feet	36
40 feet	64

Using the graph paper on top of the next page, construct a line graph to represent the data.



Where would a person need to stand to see about 16 bricks?

ANSWER: ______________ feet.

16.

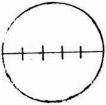


Illustration 9

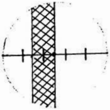


Illustration 10

Look at Illustration 9. When you look through one kind of microscope you can see a measure showing these lines. The distance between each of the marks is a "yem". How wide is the field of vision of the microscope in yems?

ANSWER: ______________

Look at Illustration 10 on the previous page. The shaded area is a wire viewed through a microscope. What part of the field of vision is the width of the wire?

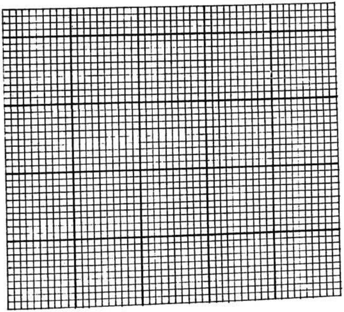
ANSWER: ____________________

17. You have conducted a test on the time it takes for a sugar tablet to dissolve in water at different temperatures. You have found the data shown in Table 3 below.

TABLE 3

Initial Temperature of water (in degrees Fahrenheit)	Dissolving Time
20	29.0 sec.
45	15.5 sec.

Construct below a graph of these data.



Now consider the points you have plotted. Make an inference about the relationship between the two variables:

____

____

____

Use your graph to make predictions about the dissolving time of a sugar tablet at water temperatures of 85°F and 130°F.

ANSWER: at 85°F __________; at 130°F __________

18. The data in Table 4 below were collected by using washer weights placed on a plunger of a large syringe or pump filled with air.

TABLE 4

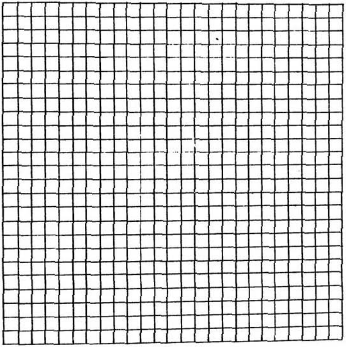
Force (washers)	Volume (ml)
0	40
4	33
8	29
12	25
16	22
20	20
24	18
30	16

Plot these data on the graph paper at the top of the next page.

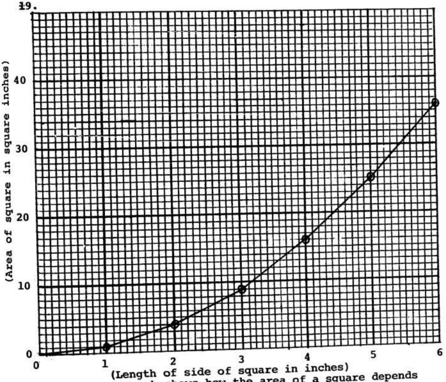
Look at your graph or table. When the force applied to the air changes from ten to 20 washers, the volume of the air changes from what to what?

ANSWER: ____

Look at your graph. Mark an X on the place where the volume is changing most rapidly with change in force.



19.



The above graph shows how the area of a square depends on the length of the sides of the square.

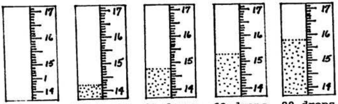
(a) What is the area of a square whose sides are 5 inches?
ANSWER: ________

(b) What is the area of a square whose sides are 3.6 inches?
ANSWER: ________

(c) If a square has an area of 21 square inches, what is the length of its side?
ANSWER: ________

20. Illustration 11 on the next page shows by five pictures how water level rose in a cylinder as twenty more drops were

added from a medecine dropper each time. Read the height of the water in each cylinder and record the pairs of data in Table 5 below.



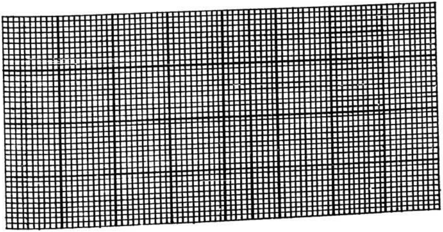
0 drops 20 drops 40 drops 60 drops 80 drops

Illustration 11

TABLE 5

Number of Drops	Height of Water (cm)
0	13.7

Plot these data on the graph below.



21. Suppose now you emptied the cylinder, mentioned in the previous question, of water and dried it. You then put 35 drops of water into it. Use the graph you drew to predict what the level of the water would be. Write your answer below.

ANSWER: __________ cm.

Now write in your own words what you would do to test your prediction.

____

____

____

22.

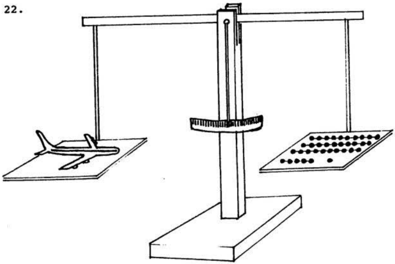


Illustration 12

A small plastic airplane is just balanced by the number of chains shown on the righthand pan of the equal arm balance. If ten beads make one chain, the weight of the airplane is the same as the weight of how many chains?

ANSWER:_________ chains.

23.

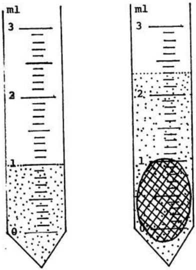


Illustration 13

Water fills a cylinder to the level shown on the left above. An object is placed in the cylinder and the water rises to the level shown on the right above. Find the volume of the object.

ANSWER: __________ ml.

24. Some observations made with a spring are shown in Illustration 14 below. Each block shown in the illustration weighs one pound. Using the graph paper on the next page, calibrate the spring so that you can use the stretch of the spring to measure forces.

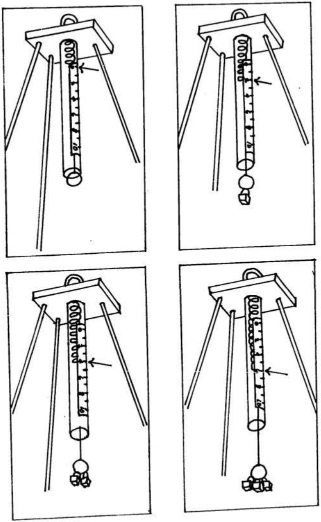
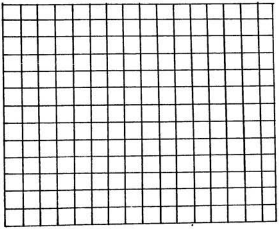


Illustration 14



25. Illustration 15 below shows the spring you have just calibrated being stretched by hand. How much force is being exerted on the spring? Make a small arrow on your graph at the top of this page showing this amount and write this amount of force below the arrow.

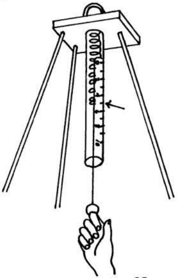


Illustration 15

APPENDIX B

Copy of Form Letter Sent to Elementary

Science Teachers

ELEMENTARY SCIENCE CURRICULUM PROJECT

Dear Teacher:

The third edition of the teacher's guide for the Elementary Science Curriculum Project (ESCP) will be written this coming summer. As a teacher who has taught the course, none is any more aware of the problems and limitations of the course than you are. If this science course is going to succeed in our Newfoundland schools, it is essential that this edition incorporate your useful suggestions and ideas. We need your criticisms of the teacher's guide and the accompanying apparatus in order to make changes which will improve this course. We would like you to carefully fill out the enclosed questionnaire according to the instructions and return it to your principal who will return it to us. This may require an hour or so of your time and energy but I am sure you can appreciate its importance for the future of the ESCP program.

I would like to thank you in advance for your cooperation.

Yours very truly,

Robert K. Crocker
Project Director

RKC/nmw