THE EFFECTS OF A PHYSICAL SCIENCE COURSE USING THE PROCESS APPROACH IN DEVELOPING ATTITUDES AND COMPETENCIES OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS AT CEBU NORMAL COLLEGE, CEBU CITY, PHILIPPINES

Thesis for the Degree of Ph. D.

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LILY KINTANAR SABULAO

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ABSTRACT

THE EFFECTS OF A PHYSICAL SCIENCE COURSE USING THE PROCESS APPROACH IN DEVELOPING ATTITUDES AND COMPETENCIES OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS AT CEBU NORMAL COLLEGE, CEBU CITY, PHILIPPINES

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Lily Kintanar Sabulao

The purpose of this study was to determine the effects of an experimental curriculum combining a physical science course using the process approach and elementary science methods course in developing the attitudes and competencies of prospective elementary school teachers at the Cebu Normal College, Cebu City, Philippines. Relationships which existed between intelligence, process, attitude toward teacher-pupil relationship, and content in physical science were examined, along with differences existing between IQ levels and treatment groups for outcomes in content, process, and attitude.

The population consisted of 90 prospective elementary teachers in their junior year regularly enrolled in the course, Physical Science, school year 1971-1972. Eighty-five of the subjects were females and five were males.

The instruments used to measure attitude, process, content, and intelligence were: the Minnesota Teacher Attitude Inventory, Science Process Test for Elementary Teachers, A Content-Understanding Test and SRA Verbal Intelligence tests. All data to which statistical tests were applied were secured from scores made by subjects on the instruments. These data were analyzed by the t-tests, correlation techniques, and two-way analysis of variance. The 0.05 level of confidence was held for the rejection of the hypotheses tested.

The design was a longitudinal study without a control group. The instruction of the science content of the course was organized around physical science concepts developed in the area, Matter and Energy. Most of the activities were taken from the Elementary Science Curriculum Guides 1-6, constructed in 1967 by the Bureau of Public Schools, Philippines, with the adoption of the process approach in the elementary science curriculum. The elementary science methods part of the course included an orientation of the use of the curriculum guides using the process approach. A peer-group teaching experience was included to give students opportunities to teach a concept and a process skill. The experimental curriculum also included lectures and independent study questions that were off-shoot of laboratory experiences and discussions. The teaching procedure for the treatment groups was a weekly two-hour lecture and weekly four-hour laboratory: two-hour modular laboratory and two-hour recitation laboratory. The individual and group laboratory aimed to develop the basic and integrated processes of the process approach.

The pertinent findings of this study were:

1. There was a significant improvement between pre- and post-test measures in content and process at the end of the study. This indicates that treatment improved significantly the process and content competencies of the subjects.

2. There did not appear a significant improvement in the pre-post tests in students' attitude towards teacher-pupil relationship. Results showed significant improvement of attitude occurring in the High IQ group only. Since IQ was not related at all to attitude as shown in the study, this could be attributed to some variables not accounted for in this study.

3. A significant increased positive correlation between process and content was found after treatment. This infers that as students became more competent in the processes during the course, they became more competent in the science content.

4. Intelligence and process became significantly correlated in the course of the study. This indicates that the high IQ subjects of the study developed better process competency than the low IQ subjects.

5. Relationship of intelligence and content was not found substantial at the end of the study. Findings pointed to treatment contributing inversely to the IQ groups, that the High IQ subjects did not gain as much as the low IQ group.

6. There were no significant correlations between intelligence and attitude. This infers that IQ is not an index of students' positive attitude towards teacher-pupil relationship.

7. A significant difference existed among the IQ levels in the three post-test criterion measures. A post hoc comparison revealed a highly significant difference between the High and Low IQ groups. This indicates that of the three IQ groups, the student with the high IQ has the better chances of improving her science competencies in process and content than the student with the low IQ.

8. There were no significant differences between the treatment groups in the process and content competencies at the post-test. This was expected as learning experiences were made as consistent as possible to the three class sections in spite of different schedules and subjects not organized according to IQ. However, a significant difference existed between two treatment groups in their attitude towards teacher-pupil relationship.

9. There were no significant interaction effects between IQ groups and class sections in process and content. This indicates

that there were no significant mean differences between the gains of the three class sections in process and content due to IQ distribution in the class sections.

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Lily Kintanar Sabulao

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CHAPTER I

THE INTRODUCTION

World events and national needs have served to accelerate interest in science. The tremendous achievements of developed countries like those of the United States and Russia in the fields of industry, defense, and space travel have pointed to the stark realization that progress and economic stability depend to a large extent on a country's advancement in science and technology.

Considering the school as a potent basic agency in the promotion of science consciousness among the people and in the production of scientists and technologists, educators have assumed the task of improving the school system, particularly that educational aspect of science education.

The purposes of education stem directly from the values and ideals of the society which maintains it. To a great extent the objectives of science education have changed with the changing needs of society. The purpose of education is ultimately to help children and young people acquire the understandings, attitudes, and skills which would make them happy and useful citizens of a democratic society.

Science education has a significant role to play in the realization of this overall purpose of education.

In the Philippines, science and technology has lagged far behind. The country has been tagged as one of the underdeveloped countries of the world, in spite of America's influence in her culture. There is a felt need for science consciousness and scientific know-how in agriculture and industry, for more food production, better health and safety and for wiser consumption. Since this is a basic problem of a developing country as a whole, the greatest responsibility lies in the hands of science educators, people who are concerned with science education.

Elementary Science Education in the Philippines

Science in the elementary school in the Philippines has long been taught since 1901 at one time or another under varying names and characteristics. In the primary curriculum of 1901, Physiology and Nature Study were listed as subjects in Grades one, two, and three. Considered difficult, the curriculum was revised giving way to a 40-minute course called Science Studies in Grades five, six, and seven. Again the curriculum met revisions when in 1907 and 1909 Nature Study, Plant Life, and Physiology and Hygiene were taught in Grades four, five, six, and seven respectively, with the same time allotment of forty minutes. In 1913 only Grade seven had some science, Physiology, Hygiene, and Sanitation. Then for almost twenty years nothing was heard about science in the elementary school until 1934 when a subject with the nomenclature, Elementary Science, was given in Grade three and another, Gardening and Elementary Science, in Grade four.[1]

In 1940, other subjects like Pre-Military Training and Filipino Language came in. Naturally, since the length of a school day could not be lengthened, some subjects had to go. Science was removed from Grades three and four and was offered in Grades five and six. From that time on until 1956, Elementary Science as a curricular subject was taught to Grades five and six children only.[2]

From 1957 to 1969, the Revised Philippine Educational Program included science together with health in the whole elementary curriculum from Grades one to six. Under this program, Health and Science was given 40 minutes in Grades one and two, 40 minutes in three and four, and 50 minutes in five and six.

Lately, since 1970, another revision has taken effect. Science is taught as a separate subject. Health is integrated with Physical

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[1] Josefina A. Vicente and A. Juele, "What is the Elementary Science Curriculum?," Effective Approaches to Science Teaching (Manila: Manlapaz Publishing Co., Inc., 1963), p. 17.

[2] Ibid., p. 18.

Education. A time allotment of 40 minutes is given to science in the lower grades and 50 minutes in the upper grades.

General Objectives of Education and of Science Education in the Philippines

The general objectives of education in the Philippines is provided for in its Constitution, Article XIV, Section 5, which states: "All schools shall aim to develop moral character, personal discipline, civic conscience, and vocational efficiency, and to teach the duties of citizenship."[3]

These objectives have gone through a number of revisions. One major change in these objectives was made when Congress of the Philippines, feeling the need for better education in the country, created the Board of National Education. As the highest educational policy-making body, its first job was to re-examine the whole list of objectives of education. Believing in the importance of science in this modern age, the committee adopted science and arts as the fifth category which cites:

> Arts and sciences are to be treated in the elementary grades in the simplest fashion, and should inculcate scientific attitudes in the young children. To eradicate or minimize superstitions and false beliefs, the children should be taught the roles of science on our life.

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[3] *Ibid.*, p. 9.

> Higher education should aim to prepare leaders in the arts, sciences and in the professions, and to conserve and extend the frontiers of human knowledge. The training of leaders is to encourage among those who have the natural gifts for higher education. To accomplish this it is suggested that the government should begin to implement the constitutional provisions regarding the promotion of arts, letters, and sciences throughout the system of scholarship.[4]

The Bureau of Public Schools in the Philippines adopted the following objectives for elementary science:

> 1. To help children cultivate scientific ways of thinking commonly referred to as scientific attitudes.
> 2. To help children develop a sound method of procedure, commonly called scientific method of solving problems.
> 3. To help pupils gain functional understanding of facts, concepts, and principles.
> 4. To help pupils realize the need and develop the desire to conserve our natural and human resources.
> 5. To help children gain understandings, attitudes, and habits that will improve and maintain good personal and community health and safety.
> 6. To assist children in the development of desirable social behavior.
> 7. To assist children in the development of appreciation and a wide range of interests and hobbies.
> 8. To provide opportunities for the development of instrumental and manipulative skills such as:
>   a. to read science content with understanding
>   b. to make observations of events
>   c. to perform various science activities like experiments, demonstrations, and projects.[5]

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[4] _Ibid._, p. 10.

[5] _Ibid._, pp. 15-16.

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Teacher-Training in the Philippines

The training of teachers in the Philippines is undertaken jointly by the public institutions represented by the normal schools under the Bureau of Public Schools and the College of Education, University of the Philippines, and by private normal schools and colleges of education. The normal schools under the Bureau of Public Schools and the private normal colleges of education train elementary school teachers; while the colleges of education provide for the training of teachers for the secondary schools. Each of the private teacher training institutions is established either as a separate college or as one of the colleges in a university. The normal schools under the Bureau of Public Schools, like the Cebu Normal College of which the writer is a faculty member, serves surrounding regions such as Agusan, Bohol, Surigao, Misamis, and Negros Oriental.[6]

The Preparation of Elementary Teachers

The training of elementary school teachers used to cover a period of two years but with the revised curriculum, it takes four years to complete the training course. A Bachelor of Science in Elementary Education curriculum (B.S.E.Ed.) offers courses in English,

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[6] Antonio Isidro, "The Teacher and His Profession," The Philippine Educational System (Manila, Philippines: Bookman, Inc., 1949), pp. 261-263.

National Language, Social Studies, Natural Sciences, Psychology and Education including the Philippine School System, Elementary School Methods, Handicrafts, Practice Teaching, Health and Physical Education and Military Teaching.[7]

The selection and admission of students in the government normal schools are governed by strict rules and regulations. Admission is based on the results of a competitive examination given once a year to applicants. The applicant is given an interview for a personality test. Applicants with physical handicaps such as deafness, conspicuous physical or facial defects, and speech defects like stuttering and lisping are not accepted. Any graduate of a public or private secondary school is eligible for admission on the following conditions: a) he must fall within the upper 50 per cent of the class; b) he must not have failed in any year or subject in his secondary school work; and c) he must be at least 16 years of age.[8]

Science in the Teacher-Training Curriculum

In recent years the elementary teachers' pre-service curriculum in the Philippines has been marked with several and quite frequent

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[7] *Ibid.*, p. 263.

[8] *Ibid.*, p. 264.

modifications in an attempt to meet changing needs and demands. However there has been much success in strengthening the science curricula. From 1952 to 1957 the four-year curriculum in the regional teacher-training colleges required six units of science, three of which were in the biological fields and the other three in the physical fields for graduation. Chemistry was offered as one of the electives. A year later, another change increased the units of the Physical Science and Biological Science to four units each respectively. In 1960 the required units for graduation in science was reduced again to six. Basic Science 1 covered units in The Earth and Living Things while Basic Science 2 treated The Universe, Matter, and Energy.[9] In 1968 with the introduction of the process approach in elementary school science, the subject The Teaching of Elementary Science was offered as an elective while Biological Science (Science 1) and Physical Science (Science 2) were required. Since 1969 to date, the aforementioned elementary science methods course is integrated with the subject, Teaching the Elementary School Subjects.

In 1970 the curriculum was again revised. This time Physical Science (Natural Science 1) became a 5-unit laboratory subject. Earth

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[9]Liceria B. Soriano, "The Role of Science in the Community School Concept of Philippine Education," Science Teaching in Philippine Schools (Manila, Philippines: M. M. Castro Publishing Company, 1960), pp. 31-35.

and Space (Natural Science 2) is a required 3-unit course and offered for the first time. Biological Science (Natural Science 3) completes a total of 11 units of science required for graduation.

<u>The New Science Curriculum for Elementary Schools in the Philippines</u>

The many changes in the development of science educational programs in the United States in the last decade brought about a great impact in revolutionizing the science curriculum of the elementary schools in the Philippines. In 1966 the Curriculum Division, Bureau of Public Schools, Philippines, planned out a curriculum workshop to develop science guides for elementary science. The elementary science curriculum was then developed and written in 1966 and 1967 by a group of Filipino science educators and the United States Peace Corps of the Philippines.

A study of the new guides for use in the elementary grades revealed the processes stressed in each grade which progresses from one grade to the other. In other words, grade one has simpler processes; grade two getting complex and the intermediate grades emphasize both simple and complex processes.

The new elementary science curriculum emphasizes science as a process whereby the child learns to understand his environment and simultaneously develops scientific skills through personal experience with materials and phenomena.

As seen in Table 1, the skills emphasized in each grade level vary. For Grade three they are observation, interpretation, comparison, and classification. In Grade four, the skills developed in the previous grade are utilized and the skill of measurement is developed. The skills emphasized in Grades three and four are strengthened in Grade five while making inference, hypothesis and communication are developed and stressed. In Grade six, all the skills developed in the early grades are developed further and the skills of predicting controlling variables and experimenting are developed and stressed as a means of learning about science. The science content that the child learns is organized around basic concepts which serve as unifying threads in a more realistic science instructional program. The content is organized around three broad topics, namely: Living Things; Matter, Energy, and Motion; Earth and Space. The activities of these topics are those that contribute to the development of the aforementioned scientific skills. Main objectives of the science curriculum point to the development of process acquisition and attitudinal changes.

TABLE 1

PROCESSES STRESSED IN THE ELEMENTARY GRADES IN THE PHILIPPINES[10]

The Processes	Grades					
	1	2	3	4	5	6
1. Observation	X	X	X	X	X	X
2. Communication	X	X	X	X	X	X
3. Description	X	X	X	X	X	X
4. Comparison	X	X	X	X	X	X
5. Classification	X	X	X	X	X	X
6. Inference			X	X	X	X
7. Measurement				X	X	X
8. Hypothesis Building					X	X
9. Prediction						X
10. Control of Variables						X
11. Experimentation						X

[10] Jose Rizal Sanchez, "Action Research on Science--A Process Approach," The Philippine Journal of Science Teachers, IV (September, 1960), 26.

Action Research Conducted by the Writer in 1969

In 1969 the writer became interested in the process readiness of her students, who were then prospective elementary school teachers in their junior year. Specifically the investigator wanted to find out if her students were equipped with the basic process skills to prepare them to teach science as a process. An action research study was then planned by the writer. This study was based on the premise that one cannot teach what one does not know.

The problem of the study was then, "How well equipped are our students in the basic processes preparatory to the teaching of elementary science as a process?" Upon identification of the problem an action research was then conducted. The subjects of the study were 86 juniors registered in a course, Physical Science (Science 2).

Basic processes mentioned in this study are those important investigative skills emphasized in the lower primary grades such as observing, describing, comparing, classifying, and formulating concepts. The action research aimed to equip our prospective elementary teachers with the basic skills so that they would be better prepared in teaching elementary science using the process approach. It is a common complaint among laboratory school instructors that our student teachers are not ready to teach science when they are assigned in the Laboratory School.

To determine the weaknesses of the students in the aforementioned basic processes, a process readiness test adopted by the United States Peace Corps in in-service training was administered by the writer as pre- and post-tests. The tests given were for observation involving one-stage and multi-stage binary classification system. Describing and formulating concepts were also involved in the measures.

The results of the pre-tests revealed a picture of the students who seemed fairly good on simple observing skills but seemed inadequate in the complicated ones. The lowest percentage made by the students in the tests were in communicating and formulating concepts. This researcher went further to investigate if students with high Grade Point Average (GPA) obtained high process readiness scores. It was surprising to note that about one half of the students with high GPA ranked lower than either Medium or Low GPA students in the Process Readiness Tests. In communicating skill and formulating concept measures, fourteen students got a 0 score.

Results of the overall pre-tests showed apparently that even high achieving students were deficient in the process skills. This result was surprising as the writer expected high process readiness scores from the top students of her class.

As a result of these revealed deficiencies, the writer embarked on an action program. A sufficient number of process activities such as: observing a suffocating candle; observing mystery bags and boxes, observing a birthday candle; classifying objects such as rocks, leaves, buttons, seeds, and students were taken as process competency exercises. Comparing materials such as water and alcohol and kinds of paper, kinds of white powders was also part of the process competency program. This program went on for a period of four months.

At the end of the study, the post-tests were given, the same set of tests given at the beginning of the program. A comparison of the results of the pre- and post-tests is seen in Table 2.

TABLE 2

PRE- AND POST-TESTS MEANS OF PROCESS CRITERIA MEASURE OF ACTION RESEARCH

Test I		Test II		Test III	
Observation involving One-stage Classification		Observation involving Multi-stage Classification		Communicating Skills involving describing and formulating concepts	
Pre-Test $\bar{X}$	Post-Test $\bar{X}$	Pre-Test $\bar{X}$	Post-Test $\bar{X}$	Pre-Test $\bar{X}$	Post-Test $\bar{X}$
80.03	85.46	67.30	76.24	37.28	58.62

It can be seen in Table 2 that students after the treatment showed improvement in the process skills. In Test I, there is an increase of five points; in Test II, nine points; and in Test III, a gain of twenty-one points in the mean score.

This action research revealed that after weeks of students' undergoing process activities to develop their process competency, results were encouraging. Data showed that 60 per cent or fifty-two of eighty-six subjects of the study improved their process scores. Twenty-five students or 28 per cent either got the same or lower scores than the pre-tests.

The overall study gave a picture of students of science changed. Prospective elementary school teachers acquired to some extent the basic process skills necessary in the teaching of science as a process. Although there was no control group in the study, the change seemed to be attributed to the series of process exercises given to the students regularly for a period of four months. The writer found the course work limited as process activities were incorporated with the content of the course, Physical Science (Science 2), although it was a 6-hour a week course.

Rationale for Problem

The process approach in the teaching of elementary science was implemented in 1968 in the Cebu Normal College with the distribution of the newly developed curriculum guides (Grades one to six) by the

Bureau of Public Schools for the Cebu Normal Laboratory School. The writer teaches Physical Science (Science 2) to prospective elementary school teachers in the junior year of this college. The Cebu Normal College is a government teacher-training institution serving prospective elementary school teachers in Visayas and Mindanao regions. With the new approach introduced in the public schools, in-service training programs for teachers were held throughout the country. The Cebu Normal College was one of the sites of these in-service programs which were sponsored by the Bureau of Public Schools and financed by the National Science Development Board in the summer of 1967.

The training of prospective elementary school teachers in the Cebu Normal College in the use of the new science curriculum guides has been found wanting as a separate science methods course is not offered in the curriculum. Rather it is integrated in a general methods course, Teaching the Elementary School Subjects as previously mentioned. Since most of the instructors who have taught this course are not aware of the "new" science, the new trends in the teaching of science are sadly neglected, more so with the effective use of the newly developed elementary science curriculum guides developed by the Bureau of Public Schools. As a result of this study, a recommendation for the inclusion of a science methods course in the elementary teacher curriculum was made. This was needed because science courses taken by our students did not give them a feel of the new science as most of these courses are taught traditionally, where the lecture method is commonly used. Even if so-called "experiments" were done, most of them are really demonstrations, the cookbook style, which is not the essence of the new science--a process approach.

A prospective elementary school teacher in science should broadly understand science, its basic methods, and process if he is to teach this kind of science to children. The results of the pre-tests of the pilot study gave us a negative picture of our student teachers who were not ready to teach science as a process. In answer to the needs of our prospective elementary school teachers, an old axiom might be repeated: Teachers teach as they were taught.

Statement of Problem

Feeling the great need of having prospective elementary school teachers who are studying in the Cebu Normal College learn the new science, the writer conducted a study the results of which would be the basis for the proposed revision of the science curricula of teacher-training institutions in the Philippines.

The problem of the study conducted by the writer was investigating the effects of a Physical Science course using the process approach in developing attitudes and competencies both in process and content to prospective elementary school teachers. A main objective of the study was to determine whether a process-oriented Physical Science course would produce changes in the students' attitudes and competencies in both science and content after the treatment. Changes were measured in post-tests on attitudes (MTAI, Minnesota Teacher Attitude Inventory) and competencies in content (A Content-Understanding Test) and process (Science Process Test for Elementary School Teachers). Also, the investigator was interested to know in this study if the students' process competency is correlated with content, attitude, and intelligence.

Brief Overview of Design and Hypotheses of the Study

Students registered in the Physical Science course (Science 2), 1971-1972, were subjects of the study. They were given intelligence tests at the start of the study to determine their three IQ levels: High, Medium, Low. Upon the writer's arrival early September, 1971, students could not be organized according to IQ but on their subjects of concentration.

The design is a longitudinal study without a control group. An experimental curriculum was constructed by the writer to determine whether a process-centered course would produce changes in attitudes and competencies both in process and in content of prospective elementary school teachers. Changes were measured in pre- and post-tests on attitudes and competencies in process and content. The design of the study was as follows:

Pre				Post		
Op_1	Oc_1	Oa_1	X_{exp}	Op_2	Oc_2	Oa_2

All data to which statistical tests were applied were secured from scores made by prospective elementary school teachers on the instruments. These data were analyzed through the t-test, correlation techniques, and the two-way analysis of variance. Level of significance for rejection was set at 0.05.

Hypotheses Relevant to the Study

The following hypotheses were formulated relative to the above problems:

Ho_1: There will be no mean improvement between the pre- and post-tests for ability to perform process skills as measured by an examination, Science Process Test for Elementary School Teachers.[11]

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[11] Delbert W. Mueller, "Science Process Test for Elementary School Teachers, A Guide for Curriculum Evaluation: A Descriptive Study of the Implementation of the Earth Science Curriculum Project for the Carman School District, Flint, Michigan, 1970-1971 (unpublished Ph.D. dissertation, Michigan State University, 1972).

Ho_2: There will be no mean improvement between pre- and post-tests for knowledge and understanding of physical science concepts as measured by an examination, A Content-Understanding Test.[12]

Ho_3: There will be no mean improvement between pre- and post-tests of prospective elementary school teachers as measured by the Minnesota Teachers Attitude Inventory.[13]

Ho_4: There will be no significant correlation between content and process on the pre- and post-tests.

Ho_5: There will be no significant correlation between intelligence and process on the pre- and post-tests.

Ho_6: There will be no significant correlation between intelligence and content on the pre- and post-tests.

Ho_7: There will be no significant correlation between intelligence and attitude on the pre- and post-tests.

Ho_8: There will be no significant correlation between process and attitude on the pre- and post-tests.

Ho_9: There will be no significant correlation between content and attitudes on the pre- and post-tests.

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[12] Paul F. Brandwein, Sylvia V. Nievert, and Mary H. Williams, Science Teaching Tests, the World of Matter and Energy (New York: Harcourt, Brace and World, Inc., 1964).

[13] Walter W. Cook, Carol Leeds, and Robert Callis, Minnesota Teacher Attitude Inventory (New York: Psychological Corporation, 1951).

Ho_{10}: There will be no significant differences between the three IQ levels of subjects in the post-test process measure.

Ho_{11}: There will be no significant differences between the three classes of subjects in the post-test process measure.

Ho_{12}: There will be no interaction between classes and IQ levels in the post-test process measure.

Ho_{13}: There will be no significant differences between the three IQ levels in the post-test content competency measure.

Ho_{14}: There will be no significant differences between the three classes of subjects in the post-test content competency measure.

Ho_{15}: There will be no interaction between IQ levels and classes in the post-test content competency measure.

Ho_{16}: There will be no significant differences between the three IQ levels in the post-test attitude measure.

Ho_{17}: There will be no significant differences between the three classes of subjects in the post-test attitude measure.

Ho_{18}: There will be no interaction between the IQ levels and the classes in the post-test attitude measure.

Limitations of the Study

Some limitations of the study are the following:

1. This investigation is a longitudinal study without a control group.

2. The subjects treated in the study deal with only one group of students, those studying in the Cebu Normal College, not with other groups of students in other institutions.

3. This study covers only a physical science course.

4. Sex differences are not covered in the study because male students enrolled in the physical science course were very few. The number in the study involved 85 females and 5 males.

5. Classes were not organized according to IQ as the investigator resumed teaching September 1971, two months after the start of classes. Organization of these classes according to IQ was beyond her control. As previously mentioned, classes were already organized according to students' subjects of concentration.

Definition of Terms Pertinent to the Study

Physical Science Course: A course purposely constructed for this study to incorporate methods and content of teaching science in the elementary schools in the curriculum of the Cebu Normal College, Cebu City, Philippines. Science methods are incorporated in this course with the end in view of having students enrolled in the course acquire science skills in the new science and be able to teach science as a process. The content of the course is organized around the broad areas of Matter, Energy, and Motion which are partly found in the curriculum guides in elementary science of the Bureau of Public Schools, Philippines. Concepts developed around these broad areas aim to develop the basic and integrated process skills of observing, comparing, classifying, inferring, measuring, formulating hypotheses, predicting, controlling variables, and experimenting which are the processes emphasized and taught in the elementary grades.

Process Approach: An approach to learning science involving science activities common to scientists in all scientific disciplines when they are practicing science. The new elementary science curriculum in the Philippines, which emphasizes science as a process, is derived from the Science--A Process Approach (AAAS). In this approach, the child learns to develop scientific skills through personal experiences. It utilizes the process skills of observing, describing, classifying, measuring, inferring, formulating hypotheses, communicating skills, predicting, controlling variables, and experimenting.

Attitudes: This term "attitudes" as used in literature on science education, has multiple meanings, and it is important to know precisely which meaning this writer is using in order to understand and evaluate this research. The study presented here directs attention to attitudinal change in the prospective elementary school teacher who experiences a curricular innovation which focuses on the processes of science. Attitudes have been selected for study since they reflect perceptions maintained by individuals. These perceptions structure their behavior. They represent a key criterion for change or improvement.

Competencies: This term as used in the study refers to acquiring of process skills and understanding of content in science. The function of this course was to introduce the prospective elementary school teacher to an understanding of science, both as subject matter and as processes of scientific inquiry.

Prospective Elementary School Teachers: This refers to junior students registered in the course, Physical Science (Science 2) of the Cebu Normal College, Cebu City, Philippines, 1971-1972.

Independent Study: This involves questions examined in depth by students which are in line with peer-peer discussions and peer-peer instructor interaction in lecture and laboratory sessions.

Lectures: As used in the study, refers to the lecture-discussion method. The teacher selects topics for lecture related to process-oriented laboratory activities, thus enriching generalizations and concepts learned in the laboratory.

Modular Laboratory: Students undergo a series of exercises to develop individual competencies in the processes. Each exercise is called a laboratory module.

Peer-Group Teaching: This refers to a method whereby students take turns demonstrating a concept or a process to different groups of the class.

Concept Learning: This refers to learning of content and understanding of physical science. In this investigation concepts were organized around the broad areas of Matter, Energy, and Motion.

High, Medium, Low: The High comprised the top one-third of the subjects; the Medium, the middle one-third; the Low, the bottom one-third. These three categories refer to the IQ levels of the subjects.

Assumptions of the Study

1. That teachers teach as they were taught.

2. That teachers will be teaching the Philippine version of the AAAS Science--A Process Approach.

3. That teachers' behaviors can be modified.

4. That attitudes are measurable.

Overview

In Chapter II the relevant research was reviewed with the objective of providing the reader with a background with regard to findings of other researchers who have looked at the topic of the effects of innovative programs in science on the learner. Chapter III provides the reader with a conceptual perceptive of the sample used in the study, the instruments, the design, the experimental curriculum, and the analysis procedure.

CHAPTER II

REVIEW OF LITERATURE

Since the purpose of this study is to examine the effects of a physical science course using the process approach in developing attitudes and competencies both in process and products on prospective elementary school teachers, pertinent literature was reviewed, particularly those studies related to the experimental study. A more detailed review of the research conducted in this area is presented herein.

Rationale of the New Experimental Programs in Elementary School Science

With the impact of the new innovative programs in elementary science during the last decade, emphasis in science teaching has shifted from a product to a process approach. Reasons behind this change from content-oriented teacher-dominated traditional approach to process-oriented student-centered progressive approach in science teaching will be discussed in the following situations.

Children today live in a world of new things. There are new discoveries, new medicines, new ways of doing things, new kinds of jobs. Life today is radically different from that of the past. It is a fact that change is the accent of the times. One should ask whether the science curriculum is keeping pace with the world of our present day children. There is also the question of what the goals of science teaching should be for a rapidly changing society that produces new knowledge faster than it can be either communicated or consumed.

Recent developments in curriculum design recognize the most important objective of science education, that is the acquiring of "specific competencies in students which will make it possible for them to solve problems, to make discoveries, and more generally to think critically about science from their very years onward."[1] Hurd sees a significant trend reflected in all programs, a shift from teaching the specific facts and theories that are the products of scientific investigation to the investigation itself.[2]

The changes that science education has undergone in the past years can be traced to teachers' growing professionalism in the fifties and the upheaval of the American public when Russia launched into space the first man-made satellite, Sputnik I, into orbit in 1957.

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[1]Robert M. Gagné, "Psychological Issues in Science--A Process Approach," The Psychological Bases of Science--A Process Approach (AAAS Miscellaneous Publication 65-8, 1965), p. 7.

[2]Paul De Hart Hurd and James J. Gallagher, New Directions in Elementary Science Teaching (Belmont, California: Wadsworth Publishing Company, 1969), p. 128.

The groundwork for the trends in striving for academic excellence was already laid down by organized educators of the country long before the flag-waving Sputnik concern of the public. Brehm, in a descriptive study of "The Pursuit of Excellence Theme in American Education, 1940-1963," traced the present changes of the curriculum as partly due to the "professionalism movement among teachers in the late 1950's and the greater recognition accorded them that led to their heightened concerns for the content of the subject matter they were specified to teach."[3]

The Sputnik event saw the initiation of a large number of science programs to meet changing needs of both elementary and high schools. Change was the order of the day and the curriculum was revised with the end in view of improving the teaching of science.

Psychological Bases and Learning Theories of the Innovative Elementary Science Programs

Learning is at the very center of educational process. Adequate knowledge of the process of learning is important to the teacher, if she aspires to make her teaching effective. Some principles of learning used in teaching led to a greater and more positive result in

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[3]Shirley Alice Brehm, "The Pursuit of Excellence Theme in American Education, 1940-1963" (unpublished Ph.D. dissertation, Michigan State University, 1964), p. 191.

the classroom. The teacher's first concern then is to know the child's intellectual development at a particular grade level in order to attain this end.

Kuslan and Stone hailed the new interest which psychologists were showing in classroom learning and teaching, which would make it possible to base teaching on a sound theoretical foundation.[4] Our bases of the innovative elementary science programs are attributed to the educational theories of three outstanding psychologists of our times: Jean Piaget, Robert Gagné, and Jerome Bruner. An analysis of their theories and implications to education are treated here.

Analysis of Piaget's Theories of Learning

From his early work with children in Paris and through his continuing work at the Institute of Genetic Epistemology in Geneva, Switzerland, with which he has been associated for the past forty years, Jean Piaget developed his theories of intellectual development.

Piaget theorizes that the child goes through four stages of development:

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[4]Louis I. Kuslan and A. Harris Stone, Teaching Children Science: An Inquiry Approach (Belmont, California: Wadsworth Publishing Company, Inc., 1968), pp. 100-102.

1. Sensori-Motor. This stage concerns the infant's early development. During this stage the child is object-oriented and if he cannot see the physical object, he does not realize that the object cannot exist. In this stage the child moves from apparently uncoordinated reflex responses to successively more complex responses. He develops an initial sense of the persistence of permanent objects whether or not that something is an animate creature. Piaget states that a child leaves this stage between two and two-and-a-half years old.

2. Pre-Operational. In this stage, we have the beginning of language, and the permanency of objects. A child realizes an object exists without being physically present. Also in this stage, if one pours liquid from one glass to another of a different shape, the pre-operational child will think that there is more liquid in one glass than the other. The child perceives only one relationship at a time, actions are not reversible and are dominated by perception. All results are possible; things are what they seem, not what they are. The child leaves this stage when he is about seven years old.

3. Concrete Operations. During this stage the child can consider two or three dimensions simultaneously instead of one successively. In the liquid experiment, he realizes that the lack of height of the liquid is compensated for by the width of the second container. However, these are called concrete operations because they operate on concrete objects and not yet on verbally expressed hypotheses. The stage of concrete operations is a prolonged stage during which a child becomes able to perceive stable and reversible relationships in concrete situations. He will often test his ideas with concrete materials iterating an operation many times before he is sure of it. He leaves this stage between the ages of eleven and twelve.

4. Formal Operations. In this stage the child can now reason on hypotheses, and not only on objects. The child attains new structures which are more complicated and more mobile than those of the concrete operations. At the level of concrete operations, the operations apply within an immediate neighborhood. The child attains the facilities to become capable of logical

> thought, based on symbolic and abstract symbols. The stages are reversible, a child (or an adult) may operate in a particular stage most of the time but may relapse into an earlier mode of behavior in play, or regress during confusion or stress. On the other hand, the creative and powerful thinkers in our society develop a much higher formal operation than that reached by the average adult.
>
> These stages have to appear in order but their time of appearance varies with the particular child and the particular society. It is noted that these stages are not abrupt changes, but rather the child progresses gradually from one stage to another. Piaget further believes that the factors that attribute to the growth from one stage to the next are maturation, experience, social transmission, and equilibrium.[5]

The heart of Piaget's theory as it pertains to how learning takes place is the concept of "mental equilibrium." Briefly stated, the thought processes approach a type of stable equilibrium as learning occurs. This is explained through Piaget's "assimilation-accommodation model." As new information is encountered, something jars the learner so that a temporary "disequilibrium" condition is set up. As this new information is assimilated and the cognitive structure is changed in accommodation to it, equilibrium is restored once more. Disequilibrium is an essential condition of learning.[6]

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[5]Robert McGinty and Melvin Poage, An Analysis of Piaget's Work with a Comparison to the Works of Bruner and Gagné, Michigan State University, n.d., pp. 10-12. (Mimeographed.)

[6]Ronald D. Anderson, Alfred De Vito, Odvard Egil Dyrli, Maurice Kellogg, Leonard Kochendorfer, and James Weigand, Developing Children's Thinking Through Science (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970), p. 135.

Piaget's Theories and Their Implications to Education

While Piaget has not been concerned with schools, one can derive from his theories as a number of general principles which may guide educational procedures. Some of these principles that can be adapted in the classroom are given by Girsberg and Opper:

1. The child's language and thought are different from the adults. The teacher must realize this and must therefore observe children closely to discover these unique perspectives.

2. Children need to manipulate things in order to learn. Formal verbal instruction is generally ineffective, especially for young children. The child must physically act on his environment. Such activity constitutes a major portion of genuine knowledge; the mere passive reception of facts or concepts is only a minor part of real understanding.

3. Children are most interested and learn best when experience is moderately novel. When a new event is both familiar enough so that it may be assimilated without distortion into current cognitive structure, and novel enough so that it produces some degree of conflict, then interest and learning are promoted. Since at an age level, children's cognitive structures differ, all children will not find the same new event interesting, nor will they learn from it. This implies that successful group instruction is almost impossible. Children should work individually with freedom, at tasks of their own choosing. Piaget finds too that an important aspect of learning is self-regulation. Before he enters schools, and without adult instruction, the child learns in many ways.

4. The child's thoughts progresses through a series of stages, each of which contains distinctive strenghs and weaknesses. Teachers should respect both of these. Children should not be forced to bear materials for which they are not ready. They should be allowed to

apply their intuitive understandings to subjects covered in school. In order to accomplish this, the teacher must once again display high sensitivity. He must perceive each child's inadequacies and strengths.

5. Children should talk in school, should argue and debate. Social interaction, particularly when it is centered about relevant physical experience, promotes intellectual growth. It should be clear that these views are at variance with many of the assumptions of traditional education. According to Piaget's evidence and theory, students at a given age level do not and cannot learn essentially the same material; they learn only in a minor way through verbal explanation or written exposition (concrete experience must come first); they can and do exert control over their own learning; and they should talk to one another.[7]

By way of summary, the "Piagetian child is an active, exploring creature, not a passive receiver of external stimuli. But he is also thorough and from the adult point of view, somewhat repetitious."[8]

Bruner's Theories of Learning

Jerome S. Bruner has been called the "prophet of the discovery-learning, favoring minimal teacher guidance and maximal opportunity for exploration and trial and error on the part of the student."[9] With

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[7] Herbert Girsberg and Sylvia Opper, Piaget's Theory of Intellectual Development (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969), pp. 230-231.

[8] Edward A. Chittenden, "Piaget and Elementary Science," Science and Children, VIII (December, 1970), 15.

[9] Lee S. Shulman, "Perspective on the Psychology of Learning and the Teaching of Mathematics," Elementary Education in the Seventies, Joyce, Oana, Houston, ed. (New York City: Holt, Rinehart and Winston, 1970), p. 63.

Bruner the emphasis is not on the product of learning but on the processes, which is the essence of most programs in the elementary schools.

Bruner usually begins by concentrating on the manipulation of concrete materials by children. He believes that human beings pass through three stages of representation in their cognitive growth. These stages are explained as follows:

> 1. Enactive representation. This stage appears after the child is about six months old. In this stage, the identification of objects does not depend so much on the nature of the objects, but more by the actions envoked by the objects. At this stage, he is unable to differentiate clearly between percept and response.
>
> 2. Ekonic representation. This stage is entered after the age of one. Here the child is able to represent the world to himself by an image that is relatively independent of action. In the beginning of this stage, there remains a strong component of manipulation as a necessary aid to imagery. There is now a sharp separation between the child and the world around him. When he matches something in his mind to something he is encountering he does so by pointing to some particular correspondence between the two.
>
> 3. Symbolic representation. When the child can be beyond this level by direct correspondence, he moves to symbolic representation. Symbolic activity stems from some primitive or photo-symbolic system that is specific to man. This system becomes specialized in such domains of human life as language, in tool using, and in the organization of experience itself. Some of the basic properties of a symbolic system are: categorization, hierarchy, prediction, causation, and modification. Bruner calls these representations modes.[10]

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[10]McGinty and Poage, An Analysis of Piaget's Work with a Comparison to the Works of Bruner and Gagné, pp. 75-77.

Jerome Bruner believes that any subject can be taught effectively in some intellectually honest form to any child at any stage of development.[11]

He went to note:

> Research on the intellectual development of the child highlights the fact that at each stage of development, the child has a characteristic way of viewing the world and explaining it to himself.[12]

The experience of Bruner suggests that the readiness of the child for learning is not a simple unfolding process but is dependent upon the way the child has been taught and upon the design of the curriculum.[13]

Bruner states that learning by discovery,

> frees the child from the immediate control of such extrinsic motives as high marks, desire for parental approval, and a need to conform to the expectations of authority figures. His position is that to the degree that one is able to approach learning as a task of discovering something rather than learning about it, to that degree will there be a tendency for the child to carry out his learning activities with the outcomes of self-reward, or more properly by reward that is discovery itself.[14]

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[11] Jerome S. Bruner, The Process of Learning (Cambridge, Massachusetts: Harvard University Press, 1960), p. 33.

[12] Ibid., p. 34.

[13] Hurd and Gallagher, New Directions in Elementary Science Teaching, p. 79.

[14] Barry A. Kaufman, "Psychological Implications of Discovery Learning in Science," Science Education, LV (January-March, 1971), 79.

Bruner's Theories and Their Implications to Education

Bruner is probably best known for his position on discovery-learning. He cites the reasons for the advantages of this approach in the teaching of science:

> 1. Discovery-learning increases intellectual potency. The student acquires information in such a way that it is readily available in problem-solving.
>
> 2. Discovery-learning increases intrinsic motivation. It strengthens the student's tendency to carry out his learning activities with the autonomy of self-reward or the reward of discovery itself.
>
> 3. Discovery-learning teaches the student the techniques of discovery. Solving problems through discovery develops a style of problem-solving or inquiry that serves for any task, or almost any task, one may encounter. The student improves his technique of inquiry by engaging in inquiry.
>
> 4. Discovery-learning results in better retention of what is learned because the student has organized his own information and knows where to find the information when he needs it. Discovery is defined not as a product discovered, but as a process of working, and the so-called method of discovery has as its principal virtue and encouragement of such process of working.[15]

Gagné's Theories of Learning

Robert M. Gagné is by comparison to Piaget and Bruner a newcomer to the field of educational learning theory. Gagne is primarily concerned with the process of learning as in the case of Bruner.

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[15]McGinty and Poage, An Analysis of Piaget's Work with Comparison to the Works of Bruner and Gagné, pp. 79-80.

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Gagné has described eight types of learning that are distinguishable from one another in terms of the conditions required to bring them about. These eight types of learning begin with the simple types and end with the complex, thus forming a hierarchy of types of learning. A brief description of these eight types is given as follows:

1. Signal learning. In this type of learning one learns a conditioned response to a given stimulus. An example given is a dog salivating at the sound of a bell. This is called classical conditioning.

2. Stimulus-Response learning. In this type of learning one moves the skeletal muscles in response to some stimuli. An example of this is a dog raising its paw when it hears the word "shake hands." This is also called operant conditioning.

3. Chaining. This type of learning involves connecting in a sequence two or more previously learned stimulus-response units. An example of this is a child calling someone by his name.

4. Verbal association. This type of learning might be a subclass of chaining where the links are verbal. An example is the translation of an English word into a French word.

5. Discrimination learning. In this type of learning one learns to distinguish between previously learned chains. An example of this is being able to distinguish the various models of cars.

6. Concept learning. In this type of learning one can classify stimulus situations in terms of abstract properties such as color, shape, size, etc. This type of learning is very limited in animals, but is very common in humans. Language is the vehicle employed in this type of learning.

7. Rule learning. A rule is a chain of two or more concepts. The simplest type of rule is of the form, "If A then B." In rule learning, one acquires the idea involved in such propositions, and not just the memorization of the rule.

8. Problem-solving. In this highest order of learning, one learns to combine previously learned rules into a new higher-order rule, and thus solving problems. This is commonly called thinking.[16]

Gagné's Theories of Learning and Their Implications to Education

Gagné defined problem-solving as it relates to elementary science education. He identifies a hierarchy of capabilities that are learned as the child explores the world of science, seeing them as essential to the child's success whether or not they are directly taught. In exploring the relationship of problem-solving to discovery, Gagné suggests that problem-solving as a method demands the discovery

[16] Robert M. Gagné, The Conditions of Learning (New York: Holt, Rinehart and Winston, 1970), pp. 94-276.

of principles by the pupils. Problem-solving is the only final step in a sequence of learning that extends back through many prerequisite learning that must have preceded it in time. Inherent in most of the interpretations of inquiry as a mode of search is that children's thinking is not predetermined by the teacher nor is it structured to achieve results which only the teacher may have in mind.[17] An inquiry approach to science instruction implies that there are significant problems to be solved and that freedom to examine, manipulate, and explore is an essential characteristic of children's problem-solving experiences. Whether or not and to what degree the teacher may or should structure the learning experiences is a question naturally raised by the emphasis upon creative thinking.

The instructional theory of Gagné begins with a task or objective stated in behavioral terms. This task is analyzed to reveal its knowledge structure. In so doing, the subordinate or prerequisite knowledge necessary for students to master this task can be defined. Iterating this procedure one builds a very complex pyamid of prerequisites to the task.

Gagné's model contains the different levels identified as shown below.

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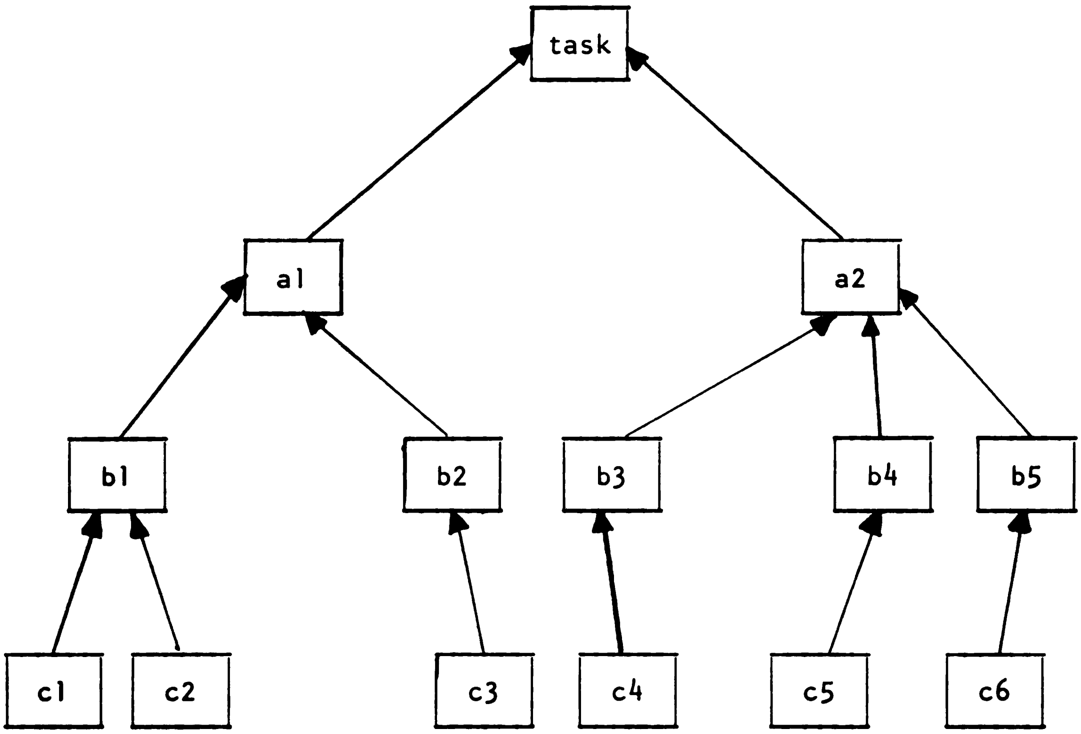
[17] Gagné, The Conditions of Learning, p. 235.



The task is the top level and is a problem-solving capability; the second level contains the rules, a1 and a2 or principles needed. The third level contains the specific concepts, b1, b2, b3, b4, and b5; the fourth level contains the necessary discriminations, c1, c2, c3, c4, c5; the fifth level, verbal associations or chains; and the bottom level facts or simple associations. Not every level is necessarily represented in a particular task hierarchy and every task has several such hierarchies.[18] This learning hierarchy is the basis of the process approach.

[18] Ibid., pp. 237-276.

In theory, Gagné does not care how a student learns, it may be by discovery, by guided teaching, by drill, or by review. In practice when he implements his instructional theory he uses programmed materials. In order for a child to be guided through a sequence of instruction one must program either the materials or the teacher. Gagné chooses to use programmed materials because they have one great advantage; they can be made virtually teacher proof. He believes programmed materials guide the child's learning a new task while encouraging "discovery." Shulman attributed the position of guided-discovery to Gagné.[19]

Gagné and the Process Approach

Robert M. Gagné gives his rationale in support of the process approach in the teaching of science. He believes that Science--A Process Approach represents an attempt to establish the "specific competencies in students which will make it possible for them to solve problems, to make discoveries, and more generally to think critically about science from their very early years ahead."[20]

He further expounds:

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[19] Lee S. Shulman, "Perspective on the Psychology of Learning and the Teaching of Mathematics," p. 129.

[20] Robert M. Gagné, "Psychological Issues in Science--A Process Approach," pp. 7-8.

> When process is emphasized, it does not mean content is absent. Content is there but children are not asked to learn and remember particular facts or principles about these objects and phenomena. Rather they are expected to learn these phenomena with process skills. What is taught to children should resemble what scientists do, the processes, that they carry out in their scientific activities. These skills which Science--A Process Approach is designed to establish begin in a highly specific and concrete form and in increasing generality of these skills by a planned progression of exercise.[21]

Psychological Basis of the ESS Approach

The ESS program is based psychologically on the child's innate nature.

> ESS approach allows children to follow their own inclinations as they explore materials. The thinking behind this is that children learn more when they are doing what they want to do instead of what someone else wants them to do. Furthermore, such self-directed learning has more meaning for them.[22]

The psychological basis of the ESS program is due to:

> using concrete things and children's active involvement in learning supported by Piaget's ideas on intellectual development. The notion that children should have the early phases of learning has been stressed by Bruner, Hunt, Berlyne, Dewey, and John Holt. Moreover Susan Isaacs, an outstanding leader

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[21] Ibid., p. 8.

[22] Robert E. Rogers and Alan M. Voelker, "Programs for Improving Science Instruction in the Elementary School, Part I," Science and Children, VII (January-February, 1970), 36.

> in child growth and development in England, and Robert Sears, an American psychologist, have emphasized that children derive the greatest pleasure from those things (either animate or inanimate objects) that respond to their manipulations.[23]

Piaget and the SCIS Program

The SCIS program is based upon Piaget's learning theory of cognitive development. Piaget places major emphasis on the role of activity in intellectual development especially in the years of early life.[24] Based on this premise, the SCIS program emphasizes student activity. This activity is expressed in the forms of child-to-child interaction, child-to-object interaction, and teacher-child interaction.[25]

With Piaget's theories of learning as guidelines, the role of the teacher is central in teaching the SCIS program. The classroom is converted into a laboratory, guiding students to make observations and forming inferences based on evidence, and not presenting information in a lecture fashion from a textbook. The teacher's art of

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[23] Ibid., p. 36.

[24] Ginsburg and Opper, Piaget's Theory of Intellectual Development, p. 221.

[25] Robert Karplus and Herbert Thier, A New Look at Elementary School Science (Chicago: Rand McNally and Co., 1967), pp. 12-14.

questioning is the major vehicle for guiding the child's activity in the SCIS program.

Summary of the Innovative Approaches

Piaget, Bruner, and Gagné cannot be compared on common grounds. Each one has his own theory of learning that has influenced greatly teaching practices of today. A great Piagetian learning theory that one can apply in the classroom is the use of concrete materials which Bruner and Gagné also agree especially for discovery learning through the manipulation of objects. While Bruner and Piaget are interested in the process of learning, Gagné stresses the final product.

For Gagné, the crucial question is, "What do you want the child to know?" For Bruner, it seems to be, "How do you want the child to know?" For Gagné, it is guided discovery; for Bruner, it is learning by discovery.

Many educators find themselves to agree with Piaget's stages of cognitive growth in learning. A teacher then should realize that children have a wide cognitive power, but should be aware that they have their limits. Piaget's investigations of conservation and reversal have helped teachers understand how a child learns science.

The works of Bruner, especially in relation to discovery learning has had a great effect on science education. The continual use of discovery learning in the classroom, in commercial texts and in the science program attests to this impact.

Gagné's guided discovery and learning hierarchies is the basis of today's programmed instruction and computer-assisted programs. In this approach, the student is led in a step-by-step fashion through given tasks until he reaches the top.

The learning theories of Piaget, Bruner, and Gagné have helped teachers gain insight into the learning process. With these theories they have attempted to explain conditions for successful learning. A variety of approaches based on their learning theories would come up meaningful to curriculum construction and educational practice.

Improving Teacher Education and Elementary Science

Since the new elementary science requires different competencies, teacher education will need to be different. The processes of scientific inquiry should be an integral part of the pre-service instruction. It is only reasonable to expect that, if elementary school teachers are to emphasize in their teaching such skills as observing, measuring, formulating hypotheses, and using numbers, the meaning and significance of these must be a part of their own college education. The teacher will also need to know how these skills are related to the basic concepts of science.

The style of teaching that the new programs call for requires teachers to have a greater understanding of the learning process as it is related to teaching science. Teachers need to know the objectives of science education, her role in teaching science in the innovative programs and realize the impact of the innovative curricula on children's learning in science and in other disciplines as social studies and mathematics.

Objectives of Elementary Science Education

Science education objectives have changed with the times. Before the twentieth century, science has been at one time or another, a hit-and-miss affair. At one time it was regarded as the study of nature, another time object study; then of technology, then the processes of investigations.[26]

A review of the development of science objectives that changed with the times and influenced by society is hereby given:

> Before 1860, religion was the dominant factor and society demanded the inculcation of moral values; the science curriculum of that time filled this need. When faculty psychology demanded mental discipline, the science curriculum offered it. When society needed a reaction against rapid industrialization the science curricula

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[26] Ronald D. Anderson, et al., Developing Children's Thinking Through Science, pp. 17-20.

> stressed emotional and esthetic goals. The depression of the 1930's called upon the schools to teach practical knowledge. The science curricula shifted to teaching socially useful skills.[27]

It was not until 1932 when the first landmark for elementary science education appeared, the publication of the Thirty-First Yearbook by the National Society for the Study of Education. It established the teaching of science in the schools and recommended a continuous (K-12) science program. The prime objectives of science teaching were to develop an understanding of major generalizations of science and scientific attitudes.[28]

The Forty-Sixth Yearbook published in 1946 stressed that the learning of science education be functional, that there should be functional understanding of facts, principles, and concepts. The development of functional skills, attitudes appreciation, and interest was stressed.[29]

In 1960 the Fifty-Ninth Yearbook on science objectives was published. It expressed its awareness of the increasing dependence

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[27] Ibid., pp. 21-22.

[28] Guy M. Whipple, ed., A Program for Teaching Science, Thirty-First Yearbook, National Society for the Study of Education (University of Chicago Press, 1932), p. x.

[29] Henry B. Nelson, ed., Science Education in American Schools, National Society for the Study of Education, Forty-Sixth Yearbook (University of Chicago Press, 1947), p. 1.

of society on science, especially the concern of society over the shortage of manpower and the launching of Russia's first man-made Sputnik into space. The Fifty-Ninth Yearbook added problem-solving and critical thinking to its list of objectives, and it stressed the importance of teaching science as a process of inquiry.[30]

As a result of this great upheaval of societal needs and concerns, a large number of science programs were initiated for the purpose of improving the teaching and learning of science. It is imperative, then, that all those concerned with such programs understand clearly the role of science in the elementary school.

Victor gives us six broad goals for the elementary science program:

> 1. Help our children understand and interpret their environment.
>
> A good science program will be directed to learning concepts and their relationships, not memorizing these concepts or facts. The science program should be organized so that there is time and opportunity for the children to reinforce and strengthen their understanding of these concepts.
>
> 2. Help our children learn the key operations of science and scientists.
>
> Children are natural problem raisers and problem solvers. A good science program will give an insight into the different methods that scientists use to solve their problems. Children can use these methods to

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[30]Henry B. Nelson, ed., Rethinking Science Education, Fifty-Ninth Yearbook (University of Chicago Press, 1960), p. 37.

solve their problems, and in the process, develop greater insight and the ability to think more critically and more abstractly.

3. Help our children to think critically and creatively.

The science program can help children think both critically and creatively. This kind of thinking will help children develop the habit of questioning things, of making careful and accurate observations, of withholding judgment until sufficient evidence has been collected, and of showing a willingness to be tolerant of and receptive to new ideas.

4. Help our children grow according to their individual abilities, interests and needs.

The science program can offer a wide range of learning activities for the children, thus making it possible for the school to provide for the varied interests, abilities, and needs of children. A good science program lends itself well to individual learning, and therefore it is able to help each child grow in science to the utmost of his ability and capacity.

5. Help our children live successfully in a changing world.

The science program can help children understand that nothing is fixed and that our universe itself is based upon change. Children should come to realize that change is an inevitable part of their lives. Studying and learning about change in science--how and why change happens and the whys and means of coping with change--more intelligently and successfully to the equally rapid sequence of events and changes they may expect to encounter in their future.

6. Correlate science with the rest of curriculum.

Learning can be more effective when all phses of the curriculum is integrated. Correlating science with mathematics, has been a project with the Minnesota Mathematics and Science Teaching Project (MinneMAST). This could be done with the other subjects in the

elementary curriculum; arts, social studies, reading, and the language arts.[31]

The innovative programs in science are the AAAS, Science--A Process Approach, SCIS (Science Curriculum Improvement Study), and the ESS (Elementary Science Study). These programs devote primary attention to the process of science and secondary attention to the product of science. All of these programs are activity-oriented and less of teacher domination in the classroom. Although these programs are similar in some aspects, there are differences in the emphasis on concepts, phenomena, and processes that make up the science course.

1. Elementary Science Study (ESS). This program stresses the child's involvement with the phenomenon and is confident that he will thereby gain practice with the processes and achieve understanding of valuable concepts even though these are not made explicit.

2. Science Curriculum Improvement Study (SCIS). This program stresses the concepts and process learnings with emphasis on the children's experimentation, discussion, and analysis.

3. AAAS, Science--A Process Approach. This program stresses the child's practice with the processes and uses the phenomena only as vehicles and concepts as tools. An added difference is that the

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[31]Edward Victor, Science for the Elementary School (New York: The MacMillan Company/Collier-MacMillan Limited, 1970), pp. 7-11.

AAAS program attempts to appraise the children's progress more systematically and in greater detail than do the others.[32]

Basic premises of the AAAS Science--A Process Approach are:

> 1. The scientists' behaviors in pursuing science constitute a highly complex set of intellectual abilities which are however, analyzable into simpler activities.
>
> 2. Scientists' behaviors (processes) are as most scientists agree, highly generalizable across scientific disciplines. This refers to the transfers of training to other disciplines.
>
> 3. These intellectual processes of scientists may be learned. Implication seems to be that intellectual activities of scientists can be learned by almost children, regardless of ability, as they progress from kindergarten through Grade six.[33]

The psychological bases of the AAAS program are principally Gagnian and evidence are behavioral objectives, action words, and the hierarchy. The program is characterized by laboratory activities.

The Teacher's Role in Teaching Science Using the Innovative Programs

The role of the teacher in the experimental science programs is very important. It could mean progress in education or defeat by way of the traditional approach. Lacking insight into the philosophy

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[32] Karplus and Thier, A New Look at Elementary School Science, p. 87.

[33] John Newport, "Are Content and Processes Salable Items?," School Science and Mathematics, LXX (April, 1970), 2.

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behind these programs could make a one-way traffic. Effective teaching means the meeting of the minds, that of the teacher and the child. Sears and Kessen say:

> Teaching is an exchange between people. This simple human fact is both problem and promise for education in science as it is for all education. The child can understand, only what he has been prepared to understand, the teacher can teach only what he knows, and the meeting of the prepared child with skillful is an unforgettable encounter for both.[34]

Hurd believes that the style of teaching in the new programs call for teachers to have a greater understanding of the learning process as it is related to science. Teachers need to understand child development and how to work with individual pupils as well as with children in groups. To be successful in teaching the new science, teachers should be skilled in listening to children and diagnosing learning difficulties, and then, through proper questioning, be able to guide the pupils toward the goals of instruction.[35]

With the changes in the style of teaching, the teacher expects changes in the child too.

> The kind of teacher that expects these changes should see teaching as an interaction. This is where the action that affects pupils outcomes. Establishing a

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[34]Paul B. Sears and William Kessen, "Statement of Purposes and Objectives of Science Education in School," A Psychological Bases of Science--A Process Approach (AAAS Publication, n.d.), p. 3.

[35]Hurd, New Directions in Elementary Science Teaching, p. 128.

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relationship between teacher behavior and teacher efforts is the key to the solution of the problem.[36]

The improvement of learning is the ultimate goal. Teaching-learning processes that are involved toward this goal relate to:

> Children and youth who become more knowing, more understanding, more skillful, more creative, healthier, and more moral in their behaviors as a result of their school experiences. Greatly responsible for the enhancement of the processes conducive to learning is the teacher who is directly engaged in conducting the main business of the school, that of helping children to learn.[37]

In the new science programs, science is viewed as a big question mark. Too often science is viewed as a set of answers. It is understandable that if science is viewed by teachers as a body of facts or a set of answers, it will be taught as such, often through textbook readings. Kondo and Demkovitch say:

> Perhaps viewing science as a big question mark is more congruent with current trends in science education in the elementary school, in which the child's active involvement in his own learning is stressed. When science is viewed in these terms, the questions and subsequent quests for the answers, and not the answer per se became the focus of attention. Questions concerning natural phenomena precede answers. In this approach, the answers, and quests for answers, became more meaningful to children. Rather than having children "experiment" by doing additional demonstrations of application of facts

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[36]Donald Musela, "Improving Teacher Evaluation," The Journal of Teacher Education, XXI (Spring, 1970), 17.

[37]Louis J. Rubin, ed., Life Schools in School and Society, Association for Supervision and Curriculum Development, NEA, 1969, 8.

> presented in books or by the teacher. Children can experiment to find out. The science period becomes a time to question and to investigate phenomena, not a time to learn answers to questions which have not even been posed.[38]

Examining the impact of inquiry teaching and materials upon children as revealed in several recent research studies, Renner and Stafford reported the rapid development of children taught by inquiry. In this aspect, "the teacher must provide such experiences for them and permit the interaction between the children and their environment to take place."[39]

Lewis and Potter reported that children are more stimulated by:

> the teacher who is as curious about science as they are, and who can find ways for them to solve their own problems than they are by teacher who knows and tells all the answers. Children don't want or need a teacher who is just a textbook. What a teacher says and does and the way she acts make a deep impression on children. A teacher quickly wins the respect of children when he lets them know that he is willing to tackle with them science problems to which he does not know the answers. The solution of the problem then becomes a cooperative venture.[40]

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[38]Allan K. Kando and Joan Demkovitch, "Science is a Great Big Question Mark," Science and Children, VIII (November, 1970), 14-15.

[39]John W. Renner and Donald G. Stafford, "Inquiry, Children, and Teacher," The Science Teacher, VII (April, 1970), 56.

[40]June Lewis and Irene C. Potter, The Teaching of Science in the Elementary School (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1965), p. 9.

Karplus considers the concept of the teacher's role as important when one considers any group of learners, but becomes particularly critical when one thinks about the learning patterns of elementary school children. He states,

> Especially in the early years of elementary school children, the child is functionally illiterate in regard to the printed word . . . . The presence in the classroom of an adult leader (the teacher) capable of listening to, analyzing, and guiding his communication, which can by design be based on actual experience, leads to the further development of understanding on the part of the children.[41]

Karplus cites the classroom as the laboratory where children can make discoveries and gain experience with natural phenomena.

> The teacher is the leader whose job is not primarily to tell children about science or to listen to them while they read about science, but rather to observe children while they are involved with science. Pupils are encouraged to experiment to find answers to their questions.[42]

Speaking of the role of the teacher in the new program Butts and Montague had this to say,

> Our role as teachers is that of skillfully structuring situations in which students are called upon to perform tasks. After assessing which of these they can do or which are absent then we as teachers structure the situation in which students are guided to perform.[43]

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[41] Robert Karplus and Herbert Thier, A New Look at Elementary Science, p. 81.

[42] Ibid., p. 93.

[43] David Butts and Earl J. Montague, "Who's Responsible for Learning?," Science and Children, VII (May, 1970), 17.

It is evident that the authors of this statement express the responsibility for learning belonging to the student, but the teacher is there to see that he accomplishes this end. "As the student operates, the influence of the teacher is constantly felt as additional guidance, assessing or structuring of new situation is needed in order to confront the student with the need to improve his performance in specific behavioral tasks."[44] This is the role of the teacher in Science--A Process Approach.

The role of the teacher using the new science programs is definitely changed. The findings of a research of the changed behaviors of teachers teaching the "new" science curriculum, Science--A Process Approach, revealed the

> teachers teaching Science--A Process Approach were found to differ significantly from teachers not teaching a recently developed science curriculum. The curriculum organization of Science--A Process Approach emphasizes children doing activities. These "doing" behavior were found to occur significantly more often in these classrooms.[45]

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[44]Ibid., 18.

[45]Gene E. Hall, "Teacher-Pupil Behaviors Exhibited by Two Groups of Second Grade Teachers Using Science--A Process Approach," Science Education, LIV (October-December, 1970), 333.

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Summary on Teacher's Role in the New Innovative Programs in Science

The "new" science calls for a new teacher's role. The thrust of education is from a narrow emphasis on accumulation of factual and substantive knowledge to a broad scope which includes conceptual understanding, knowledge of processes, development of self-learning skills, and growth of scientific attitudes. The conduct of investigative, laboratory-oriented classes represent a departure from conventional expository methods of teaching. These changes the teacher in science should realize.

Impact of Innovative Curricula on Children's Learning in Science and in Other Disciplines: Social Studies and Mathematics

With the impact of the innovative curricula, we expect changes in children's behaviors in learning science and other disciplines.

Hurd comments that the "new" elementary school programs

> provide children with the opportunity to engage in learning activities that are closely aligned with science as a discipline. Children make their own interpretations from what they have observed. They speculate on the best way to interpret the data and test their ideas in contact with those found by other pupils. In these ways, children experience the kind of activity that typifies the work of a scientist, not in the specialized context of the researcher, but in terms of ideas and materials at their own level of development. The children, not the teacher,

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is a guide to learning, more than a "teller" of science.[46]

Findings of recent researches as a result of the new innovative programs on other disciplines hypothesize that "an inquiry-centered experience in science education prepares a teacher to teach all subjects in an inquiry point of view."[47]

In the Social Studies, Taba commented that

> like the new mathematics and the new science, the new developments in this subject tend to emphasize inductive learning, discovery learning, and active inquiry. The idea is to encourage students to discover generalizations from the analysis of original unprecedented data, to build one concept and generalization upon another, to compare, contrast, and evaluate and eventually to develop an understanding of the fundamental structure of the subject or subjects.[48]

Like the "new science," social studies encourage teachers asking open-ended questions especially "those that invite discovery and search, divergent answers, exploration and hypothesizing that are the essence of the 'new' science program."[49]

Mathematics was the first discipline to undergo major revision in the sixties, the decade of curriculum reforms. Acceleration

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[46] Hurd, New Directions in Elementary Science Teaching, p. 3.

[47] Renner and Stafford, "Inquiry, Children, and Teacher," 57.

[48] Hilda Taba, "Techniques of In-Service Training," Elementary Education in the Seventies, Joyce, Oana, Houston, eds. (Holt, Rinehart and Winston, 1970), p. 5.

[49] Ibid., p. 127.

of change occurred as a result of a potential threat to the national image and national defense. Topics in the curriculum were generally introduced earlier than they were previously. Content of the elementary program was broadened to include aspects of mathematics other than arithmetic. Like science and social studies, the teaching-learning modes were the directed-discovery techniques.[50]

The teaching of mathematics, like science and social studies, are "to give students an opportunity to think for themselves, the opportunity to appreciate the order and pattern which is the essence of mathematics, not only in the man-made world but in the natural world as well as the needed skills.[51]

Linkage of science and mathematics was attempted in a number of projects. The Minnesota Mathematics and Science Teaching Program (MinneMAST) was one of these projects.

> The project proceeds on the assumption that the school curriculum in science and mathematics should be considered as a unity. This curriculum provides children with the attitudes, skills, and knowledge that are favorable to further school work in science and mathematics.

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[50]William Joyce, Robert Oana, and W. Robert Houston, Elementary Education in the Seventies (New York City: Holt, Rinehart, and Winston, 1970), p. 5.

[51]Edith Biggs, "Mathematics Laboratories and Teachers' Centres the Mathematic Revolution in Britain," Elementary Education in the Seventies, p. 66.

Other objectives include the following:

1. Presenting science and mathematics as a part of a continuing human endeavor and as changing, creative disciplines;

2. Providing children with the skills, processes, and techniques of science and mathematics that will permit them to be rationale and effective individuals in society; and

3. Helping children to make sense of the universe and man's place in it.[52]

Cultural Forces Prompting Innovations in the Curriculum

It is an accepted fact that cultural forces of a country direct innovations in curriculum-making. Society is one of the forces that influence the goals of education, the curriculum of the school. The curriculum of a school reflects the needs of society at one time or another.

The United States. The present elementary curriculum found in American schools today has undergone an evolution.

> The current curriculum patterns used in the elementary school did not emerge from a scholastic vacuum or out the clear blue. Rather, they are contemporary phases of curriculum evolution. From almost a singleness of character depicting narrowness in scope, purpose, emphasis, and methodology--in yesterday's curriculum,

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[52]Hurd, New Directions in Elementary Science Teaching, p. 88.

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> there has appeared an array of curriculum patterns and instructional changes.[53]

Within a given society, the factors that exert influence on curricula are variable and numerous. However, the "more potent of these factors are three sources of directiveness--content, society, learner."[54]

Anderson agrees with the author of the previous statement when he mentions of the basic sources that influence the changing curriculum: the nature of the discipline, the nature of the learner, and the nature of society and culture.[55]

Schools are institutions established by society for a particular purpose. Thus it is not surprising that "society is the main determiner of the answer that will be given to the function of the goals of education. The importance of society goes beyond this, however, and in the area of science, for example, it is of prime determiner of what aspects will be included in the curriculum and of how this content will be organized."[56]

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[53]William L. Walker, "The Developing Elementary School Curriculum," Contemporary Education, XLII (April, 1971), p. 244.

[54]Ibid.

[55]Anderson, et al., Developing Children's Thinking Through Science, p. 145.

[56]Ibid., p. 147.

As mentioned earlier in this chapter, the everchanging goals of science education from the past to the present--from religious to utilitarianism, to the disciplines, then to the processes--can be traced to society's changing needs. At the same time, one can see the ever dependence of society on science and technology, and this dependence has been, and is, increasing at a rapid rate."[57]

That society has influenced the curricular changes can be illustrated when Russia sent into orbit its first man-made satellite, Sputnik I.

> Since Sputnik, much of the science curricula of this nation has been changed. The success of the Soviets in space vehicles created in many Americans the need to revise and revamp the physical science and mathematics curriculum. This surge to reform these disciplines has spilled over to many of the sciences and other disciplines.[58]

Kuslan and Stone viewed the changing curricula as due to a rapidly changing society stimulated by advances in science. They give a rationale of the rapid changes of the curriculum:

> Schools exist to help young people know about and participate in the life of their time. In the past when cultural change and progress in science were slow, instruction in science could lag fifty years or more with little consequence for the individual or the nation. At the turn of this, however,

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[57]Ibid.

[58]John Paul Eddy, "Some Thoughts on Curriculum Reforms in American Schools," Contemporary Education, XLVII (May, 1971), 300.

> America began to move from an agrarian society to a scientific technological society. Adjustment made in the science curricula reflected new technological development.[59]

The Philippines. The history of the country produces some rough look at Philippine culture. A quick look of Philippine history would give one a picture of a country dominated by foreign powers at one time or another. The Spaniards dominated the country for over five hundred years leaving the country the Catholic religion and a passion of life. The Americans, with almost half a century influence, left her a Westernized education that developed, as called by the U.S. Peace Corps, the "Coca-Cola culture." The Chinese, followed by the Japanese, left her with the social cancer of corruption and the stigma of the World War II. As of this day, the Philippines is still struggling for a national identity. A foreigner would find it difficult to understand Filipino culture because of its "East-West cultural dualism of Filipino ideology and political orientation."[60]

David L. Szanton, formerly of the Peace Corps, Philippines, has described Filipino culture as one of "cultural fatigue." "Cultural fatigue is the physical and emotional exhaustion that almost

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[59]Kuslan and Stone, Readings on Teaching Children Science, pp. 15-16.

[60]Onofre D. Corpuz, The Philippines (Englewood Cliffs, New Jersey: Prentice-Hall, Incorporated, 1965), pp. 52-53.

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invariably results from the infinite series of minute adjustments for long-term survival in an alien culture."[61]

Szanton proceeds by describing Filipino culture of many influences as:

> derived from decades of American domination, followed by some years in which American cultural influence has been stronger than that of any outside nation . . . conceptualizing Philippine culture as being something like an onion with various layers. The outer layer is American in cultural coloration, especially in urban areas. Underneath this layer is a Spanish Catholic layer acquired during more than three hundred years of Spanish domination. The core of the onion, however, is distinctively Malaysian and non-Western. The PCV, especially when newly arrived has difficulty determining where one layer ends and the next begins.[62]

If Philippine education is basically traditional, one can trace it to its long history of foreign domination. Traditionalism is found in the home where parents dominate the children, dictate to them what to do, and children are receptacles of this culture. Traditionalism is heavily expressed in schools where teachers dominate the classroom and students find it best to be seen and not to be heard. The writer then can say that the traditional curricula reflects very well the Filipino traditional way of life.

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[61] David L. Szanton, <u>Cultural Confrontation in the Philippines</u> (unpublished paper, n.d.), p. 10.

[62] <u>Ibid</u>.

Formal education started when the Americans took over the country after the Spanish-American War in 1898. Education was primarily on the three r's. Since then, education in the Philippines was patterned after the United States until she became independent in 1946. So for quite a while, the school curricula was influenced by American education and not by Philippine culture.

Then the second world war broke out leaving the Philippines a place of great devastation. Everything became disjointed, more so with education. The country had to pick its pieces again. Education became static because of a spiritless society. Brandou has this to say of Philippine situations:

> The national priorities in the Republic of the Philippines are similar to those in other developing nations. The country needs to exploit its own natural resources to either feed its growing population itself or develop skills which can be exchanged for food in the international market place. It must concentrate on ways to reduce the gap between the "haves" and the "have nots" by raising the quality of life for all. Universal education opportunity is accepted as an appropriate mechanism for change; and to increase the rate of change, certain fields have been selected for extra emphasis. Agriculturally-oriented science and technology have been given priority; this school and college science education have become important foundation areas.[63]

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[63] Julian R. Brandou, "Philippines," The Science Teacher, XXXVII (October, 1970), 27.

The present curricula constructed towards this end have their prime objective to improve the living conditions of the Filipino people.

> The drive to uplife the economic condition of the Filipino people has so far produced a unique edition of BSCS green version biology program; adaptations of CHEM Study Chemistry, PSSC physics, and IPS physical science, and trials of ESCP earth science and ISCS science. Elementary school science is also being altered toward the AAAS materials.[64]

These curriculum materials have been produced by the cooperative efforts of Filipino educators and the Peace Corps, Philippines.

> The Philippine approach has taken into consideration the level of national development. Our educators recognize the basic fact that the Philippines, a developing country, will never simply wake up one morning to find itself an industrialized nation. Consequently, they are accepting their responsibility to develop science teachers. Projecting from this basic groundwork, they confidently expect that another generation will have the scientists and technologists necessary to support an industrialized nation.[65]

We have seen in effect how cultural forces are prime movers of curriculum changes, how society directs the schools toward this end. Changes are expected to fit society's needs. To see if the changes are in line with society's goals is the subject of an evaluation.

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[64] Ibid.

[65] Brother J. Damian Teston, FMS, "Innovations in Philippine Science Teaching," The Science Teacher, XXXVII (October, 1970), 32.

Evaluation of Elementary Science Programs as it Relates to Children's Learning

A treatment of the evaluation of the innovative science programs would be to look at the goals or objectives of science teaching as it relates to children's learning. A review of findings or research work along this line reveals encouraging and positive results.

A statement of the goals will guide us to a review of this evaluation. As mentioned earlier in this chapter, the goals of science education as embodied in the Fifty-Ninth Yearbook stressed problem-solving and critical thinking and emphasized the importance of teaching science as a rpocess of inquiry. It also stressed the development of skills, attitudes, appreciation, and interest.[66]

These outcomes have been identified by Hurd and Gallagher:

1. An understanding of science principles
2. Skills for acquiring knowledge
3. Favorable attitudes toward science.[67]

A number of investigations conducted during the past decade have compared the effects of different courses, procedures, and materials on achievement, process skills, and attitudes towards science.

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[66] Nelson B. Henry, ed., "Rethinking Science Education," Fifty-Ninth Yearbook, p. 37.

[67] Hurd and Gallagher, New Directions in Elementary Science Teaching, pp. 12-15.

Evaluation on the effects of the new programs achieving the goals of science is treated along this line.

Effects of Innovative Programs on Children's Competencies in Content and Process Skills

A review of a limited number of studies in the past decade comparing the effects of "traditional" with "modern" science courses on students' competencies in content and skill is hereby treated.

Karplus and Thier conducted a study comparing SCIS (Science Curriculum Improvement Study) students and non-SCIS students on the understanding of science principles. They revealed that after the study, SCIS students gained a greater understanding of relative motion than non-SCIS students.[68]

Neuman attempted to measure intellectual growth of first-grade children utilizing Material Objects unit. He found that the group of SCIS girls scored significantly higher on a post-test. Various comparisons were made as well as with first graders in a conventional program.[69]

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[68] Karplus and Thier in Barbara S. Thomson and Alan M. Voelker, "Programs for Improving Science Instruction in the Elementary School," Part II, SCIS, ERIC, Science and Children, VII (May, 1970), 30.

[69] Donald B. Neuman, "The Influence of Selected Science Experiences in the Attainment of Concrete Operations by First Grade Children" (paper read before 42nd meeting of the National Association for Research in Science Teaching, Pasadena, California, February, 1969).

Stafford conducted a research on the question of accelerating concept skills in the area of conservation. The experimental group showed greater growth in each of the six areas tested: conservation of number, length, liquid amount, solid amount, weight, and area.[70]

Montgomery's study on the effects on BSCS inquiry teaching on achievement and retention in biology revealed the following:

1. The BSCS materials generally improve the retention of biological knowledge;

2. The use of inquiry with traditional materials is at least as effective as the traditional approach with those materials;

3. The inquiry teaching method coupled with the BSCS materials apparently results in the greatest post-test achievement.[71]

Lashier's study compared an experimental group with a control group to test two null hypotheses of four grade levels; whether there was an initial significant difference between two groups and also whether the experimental group exceeded the achievement of the control group after encountering the AAAS program. Findings revealed that in

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[70]Don Stafford, "The Influence of the Science Curriculum Improvement Study First-Grade Program on the Attainment of the Conservations," University of Oklahoma, 1969, Vol. XXX (unpublished dissertation), p. 2862-A.

[71]Jerry L. Montgomery, "Effects of BSCS Inquiry Teaching on Achievement and Retention in Biology" (paper presented in the NSTA nineteenth annual meeting, Washington, D.C., March, 1971).

all four grade levels, there was no initial-significant differences at the 0.05 level between the control and experimental groups as measured by the pre-test sets of competent tasks. After completing the sequence of AAAS exercises, both groups were post-tested with the same instruments. In all four grades, significant achievement differences existed in favor of the experimental group. Significance at kindergarten level was set at 0.05 level. In the first grade, the level of significance was 0.025. In the second grade, a 0.00 "grade level of significance" was obtained. The level of significance for the third grade group was 0.05. The results of the study indicated that the students involved in this AAAS program consistently achieved more of the stated objectives than the students in the control.[72]

Ritz in his study of the effect of 2 instructional programs: Science--A Process Approach and the Frostig program noted that kindergarten children who received Science--A Process instruction followed by visual perceptual training attained significantly higher Perceptual Quotient scores than did the pupils of the other two groups.[73]

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[72]William S. Lashier, Jr., "An Assessment of Science--A Process Approach" (paper presented in the 42nd meeting of National Association for Research in Science Teaching, Pasadena, California, February, 1969).

[73]William C. Ritz, "The Effect of Two Instructional Programs, Science--A Process Approach and the Frostig Program for the Development of Visual Perception, on the Attainment of Reading Readiness, Visual Perceptual, and Science Process Skills in Kindergarten Children" (paper presented in the 42nd meeting of the National Association for Research in Science Teaching, Pasadena, California, February, 1969).

Zietler conducted a study of the effect of a science program of children of age three on their perceptual skills. The program was based upon development characteristics of children as well as the learning of investigative skills. Evaluation was an integral part of the program. On the pre-test, the children observed 8 out of 22 possible properties of objects given to children. On the post-test after the program, 19 properties were observed and named. The differences between the mean scores on the pre-test and post-test was significant at the 0.01 level.[74]

Jungwirth in his investigation of a course in a process-oriented curriculum of BSCS Biology for ninth and tenth grade children in Israel contradicted opponents of process-oriented curricula, who expressed the fear that pupils would acquire less "subject-matter," than pupils in content-centered curricula. From data obtained in his study, BSCS pupils gained significantly more than pupils studying conventional biology.[75]

Rowe made a comparative study of SCIS and non-SCIS children's skills on observation. She conducted the study with eight SCIS and

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[74] W. R. Zietler, "Science Evaluation for Three Year Olds" (paper presented in the NSTA nineteenth annual meeting, Washington, D.C., March, 1971).

[75] Jungwirth, "Content-Learning in a Process-Oriented Curriculum: Some Aspects of BSCS Biology in Israel," Science Education, LV (January, 1971), 94.

eight non-SCIS second graders. After they examined two different systems (i.e., aquarium and an SCIS whirlybird), through observations, the examiner disagreed with all the statements made by both groups of students. Six of the SCIS students argued their point of view but only one from the non-SCIS group even attempted a second experiment to support his argument.[76]

Regarding evaluation of ESS (Elementary Science Study), the feedback gathered from teachers and administrators indicates that children who use ESS materials like science, ask more questions, ask more perceptive questions, are more observant about things outside of school and actively initiate projects.[77] In a summary statement on the effects of using ESS program on children's learning Rogers and Voelker said:

> In the area of the psychomotor domain, ESS's emphasis upon children's manipulating concrete materials, develop motor skill. But ESS's greatest strength is, perhaps, its contribution to the effective development of children. Children derive satisfaction from exploring, in their own individual ways, interesting materials, finding not only answers and solutions but also that they have the ability to learn for themselves. Perhaps, too,

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[76] Mary Budd Rowe, "Science, Science, and Sanctions," Science and Children, VI (March, 1969), 11.

[77] Robert E. Rogers and Alan M. Voelker, "Programs for Improving Science Instruction in the Elementary School," Science and Children, VII (January-February, 1970), 42.

> children who find satisfaction in exploring will in time come to value and commit themselves to it.[78]

Effects of Elementary Science Programs on Attitudes of Students

The term "attitude" as used in researches in science education has multiple meanings, and it is important to know precisely which meaning a given writer is using in order to understand and evaluate his study.

> Majority of studies on "attitudes towards science have been concerned with effect on feeling--like vs. dislike--toward science in general or a particular science. Other investigations have dealt with 'attitude towards scientists' which refers to like vs. dislike or approval vs. disapproval of the activities engaged in by scientists and the kind of people that scientists are. Finally another group of research investigations and writings has been concerned with the more cognitive 'Scientific attitude,' which is another term for adherence to or knowledge of the 'scientific method.'"[79]

The writer is particularly interested in studies that change the learner's attitudes after using an innovative program in program in science. Studies, along this line, are limited, especially among children.

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[78] *Ibid*., 43.

[79] Lewis R. Aiken, Jr. and Dorothy R. Aiken, "Recent Research on Attitudes Concerning Science," *Science Education*, LII (October, 1969), 295.

Charen compared an open-ended inductive approach with a traditional, deductive approach in the teaching of high school chemistry laboratory. He obtained attitude measures by observing 268 students, by discussion with them and their teachers, and by administrating a questionnaire. The students expressed more positive attitudes toward the inductive approach because it reportedly "made them think, feel like real chemists, gave them more freedom in the laboratory, and was more challenging, interesting, enjoyable, and stimulating than the traditional approach."[80]

Another study on changing attitudes of children was done by Lowery. His study involved 335 California fifth-grades, divided into experimental and control groups which were matched for I.Q. at each of three socio-economic levels. The experimental group received instruction in an NSF-sponsored science unit on animal coloration; the control group was taught a comparable science unit on the topic of animals from the California textbook series. Among the results were the significant changes in attitudes toward science in the experimental group, but not in the control group, at each socio-economic level and especially in the upper socio-economic group.[81]

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[80] George Charen, "Laboratory Methods Build Attitudes," Science Education, L (February, 1966), 54-57.

[81] Lowery in Aiken and Aiken, "Recent Research on Attitudes Concerning Science," Science Teacher, LIII (October, 1969), 301.

De Lucca investigated changing attitudes of students in a structured-inquiry approach in an Introductory Geology laboratory course. The control group was taught by the lecture-demonstration-participation method. Results indicated that the experimental course produced favorable students' attitude to geology and science.[82]

Cossman evaluated the effects of a course in science culture on children's attitudes and scientific literary. He found significant positive effects of the experimental course on attitudes, general understanding of the scientific process, and critical thinking but there was no significant change in scores on a science achievement test.[83]

From the foregoing citations of research studies of the effects of the different innovative programs on children's attitudes and competencies in content and in the process skills, the writer believes that there is adequate evidence though limited, that these innovative programs have achieved the goals of science education set according to the needs of a dynamic changing society.

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[82] Frederick P. de Lucca, "Structural Inquiry Methods Materials for an Introductory Geology Course" (paper presented in the NSTA nineteenth annual meeting, Washington, D.C., March, 1971).

[83] Cossman in Aiken and Aiken, "Re,ent Research on Attitudes Concerning Science," Science Teacher, LIII (October, 1969), 302-303.

With the curriculum innovations, parallel programs for teacher education have been developed. The question arises: with what type of teacher can a teacher education program be expected to produce the greatest change in both perception of the innovation and the practice of the innovation. Analysis of related research is hereby presented.

Related Studies of the Present Investigation

With the innovations in the elementary school science curriculum and the changes we expect in children's behavior, we look forward to new teacher-training programs.

Voelker gives his rationale of a revision of the curriculum in teacher-education to meet prospective elementary school teachers' needs. He gives students' reasons as follows:

> College methods courses in general are on the docket. Students enrolled in teacher-preparation programs are requesting, even demanding more relevant and practical experiences . . . . These college students hear their methods instructors commend the techniques of individualized instruction but they do not see these techniques demonstrated. No wonder, then, that they consider much of the teacher-education programs to be trivia. At the same time students are aware that increasing emphasis is being placed on specifying competencies which they are to acquire before being certified for teaching.[84]

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[84] Alan M. Voelker, "A Competencies Approach to Teacher Education," The Science Teacher, XXXVII (September, 1970), 37-38.

Voelker recommends a type of teacher-preparation program in which individualized instruction is practiced in which the student is made aware of these competencies that are expected of him, and in which he is given the opportunity to develop these competencies in real school situations.[85]

The Department of Education of Hunter College introduced a methods course in elementary science education in 1965 which is undergoing continuous evaluation and revision. This course includes methods and materials appropriate for classes from the kindergarten to the sixth grades.[86]

An evaluation of the curriculum of a new course in elementary methods at Hunter College was done by name of feedback data obtained by questionnaires from samplings of newly appointed elementary school teachers, student teachers, and students. All three groups rated the methods course content as to what they thought was most useful for the beginning teacher in science.[87]

In the summer of 1967, the University of Illinois established a new course which combined a science course with an elementary school

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[85] Ibid., 37.

[86] Edward Frankel, "Evaluation of a Curriculum for Elementary Science Education," Science Education, LII (April, 1968), 284.

[87] Ibid., p. 285.

science methods. No formal statistical measurements of success or failure have as yet been attempted of this innovation, although a report is expected about students' changed attitudes and accomplishments.[88]

Purdue University is attempting to individualize their science-methods instruction on the premise that as they "find each child enters a grade level with differing abilities, we also find that each prospective elementary teacher enters a science-methods course with differing abilities.[89]

The Science Education Area at the University of Houston has developed a laboratory-oriented program of self-instructional modules for the pre-service elementary school teachers. The instructional modules were developed around the major elementary science curriculum projects: SAPA, SCIS, ESS, MinneMAST, IDP, and COPES. These modules provide the pre-service elementary teacher

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[88]Sidney Rosen, "Report on a New Single Course Combining Content and Technique in the Science Preparation of Elementary School Teachers" (paper presented in the 42nd meeting of the National Association for Research in Science Teaching, Pasadena, California, February, 1969).

[89]Gerald H. Krockover, "An Individualized Science Methods Approach" (paper presented in the NSTA nineteenth annual meeting, Washington, D.C., March, 1971).

an opportunity to learn science concepts in an active, material-centered situation.[90]

Okey has presented a program for teaching science process skills that is underdevelopment. Intended users of the program are prospective and in-service elementary school teachers of Indiana University, Bloomington. The science process skills referred to in his program are primarily those associated with the curriculum, Science--A Process Approach.[91]

The experimental study the writer was involved in was assumed to be unique in the sense that she was not aware of any study like it. She developed a course incorporating a methods course and a physical science course in the Cebu Normal College, Philippines, hopefully to develop prospective elementary school teachers' attitudes and science competencies in skills and content. An evaluation of changes in students' behaviors was done at the end of the experimental study.

A review of studies alone this line was found to be limited. A similar study was that of Pickering's which was a comparison of

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[90]Jacob W. Blankenship, "Facilitating Change for the Pre-Service Elementary School Teachers" (paper presented in the NSTA nineteenth annual meeting, Washington, D.C., March, 1971).

[91]James R. Okey, "Developing Competence in Process Skills" (paper presented in the NSTA nineteenth annual meeting, Washington, D.C., March, 1971).

inquiry-laboratory, inquiry-demonstration, and lecture techniques in an experimental study of the effects of inquiry experiences on the attitudes and competencies of elementary teachers in the area of science. He found that the inquiry-laboratory group was superior to the inquiry-demonstration and lecture-techniques groups on the criteria of attitude toward science. His conclusions pointed to a significant improvement between the pre- and post-tests for all attitude and competence criteria under investigation.[92]

Bruce in a study to find changes in teachers' attitude and competencies after a 3-week SCIS workshop held at Michigan State University reported in his findings no significant differences in the teachers' attitude toward the teacher-pupil relationship before and during formal involvement in the program.[93]

Part of his findings also revealed no significant difference in the teachers' understanding of the processes of science. Of interest to the writer was his findings of a positive correlation

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[92]Robert S. Pickering, "An Experimental Study of the Effects of Inquiry Experiences on Attitudes and Competencies of Prospective Elementary Teachers in the Area of Science" (unpublished Ph.D. dissertation, Michigan State University, 1970), pp. 154-159.

[93]Larry Rhea Bruce, "A Determination of the Relationships among SCIS Teachers Personality Traits, Attitude toward Teacher-Pupil Relationships, Understanding of Science Process Skills and Questions Types" (unpublished Ph.D. dissertation, Michigan State University, 1969), pp. 99-100.

between the process test and the Minnesota Teacher Attitude test.[94] This was one of the hypotheses tested by the writer.

Olsted in his study of the effect of a science teaching methods on the understanding of science of prospective elementary school teachers concluded that the groups showed significant increase in their understanding of science as measured by the TOUS (Test on Understanding Science). The function of the course was to introduce to prospective elementary school teachers an understanding of science both as subject matter and as processes of scientific inquiry.[95]

On studies regarding changes in attitudes of prospective teachers, Oshima examined the differences between lecture-demonstration method and the individual investigation method in a college course for prospective teachers of elementary school science. Oshima found no significant changes in attitudes in either group, although there were slight positive changes in the experimental group. The experimental group also gained significantly more in confidence in teaching science.[96]

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[94] Ibid., p. 100.

[95] Roger G. Olsted, "The Effect of a Science Teaching Methods on the Understanding of Science," Science Teaching, LIII (January, 1969), 9-10.

[96] Oshima in Aiken and Aiken, "Recent Research in Attitudes Concerning Science," 300.

Diel investigated the effects of an experimental course in physical science for non-science majors on the attitudes of prospective elementary school teachers. The experimental group had non-directed teaching and a pervasive laboratory approach, while the control group had lectures and a fixed laboratory experience. The results revealed no significant difference between the change scores of the two groups on a measure of rigidity ("mind set") or on the prospective teachers' social outlook toward science.[97]

Liddle compared the effects of two modes of small group instruction in an elementary science methods course upon the attitudes held by pre-service elementary teachers related to science and the teaching of science. One treatment was designated as auto-instructional, while the other was designated as lecture-demonstration. The auto-instructional treatment involved manipulation of materials and equipments by the students, which directions were provided for by guide sheets for each session. The lecture-demonstration treatment involved the same topics and objectives but the students were not allowed to manipulate the material and equipment.[98]

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[97] Diel in Aiken and Aiken, op. cit., 300.

[98] Edward Liddle, "A Quasi-Experimental Study of the Effects of Two Modes of Instruction on the Attitudes of the Pre-Service Elementary Teachers in the Area of Science Teaching" (unpublished Ph.D. dissertation, Michigan State University, 1971), abstract page.

Findings revealed greater positive changes in attitudes of the lecture-demonstration treatment group than the auto-instructional treatment group. The findings of this study indicate that instruction in an elementary science methods course can aid the development of more positive attitudes toward science and teaching of science.[99]

Summary

The past two decades have been marked by great changes in the school curriculum. Causes could be traced to the growing professionalism among teachers in the fifties and triggered by the concern of the American public with the launching of the first man-made satellite by the Russians. Here we see how society directed the goals of the school's curriculum to fit its pressing needs. Curriculum changes then became the order of the times. Along with the changes were the learning theories of Piaget, Bruner, and Gagné which were the basis of the new curriculum program in the elementary school. Piaget and Bruner emphasized the processes of learning and Gagné on the product of learning.

In this chapter we see a different role of the teacher as she effects changes in the child's behavior. She is a far cry from the traditional teacher who dominates the classroom activities. Rather the new teacher acts as guide, not a teller of science.

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[99] Ibid.

A review of research studies though limited, revealed the positive results of the use of the innovative programs in science. Significant gains are found in experimental studies using the science curricula as the SCIS, ESS, and AAAS in effecting changes in the child's attitude and science competencies in process and content.

With changes we expect from the child in the new programs, we look forward to changes in teacher-preparation. There is a number of revisions of teacher education curriculum lately that hopefully warrants changes in the prospective elementary school teachers' attitude and competencies set in the patterns of the new science programs. Results of experimental studies on changes of prospective elementary school teachers are not quite so promising especially in changes of attitudes. More studies along this line are expected for more adequate information.

CHAPTER III

PROCEDURES AND METHODOLOGY

Described in this chapter are the population, the instruments, the design, the experimental curriculum, and analysis procedures used in the study.

The Population

The population used in the investigation were prospective elementary school teachers of the Cebu Normal College, Philippines. Subjects of the study were 90 students comprising of three sections of juniors registered in the course, Physical Science (Science 2), of the Cebu Normal College, Philippines, 1971-1972. Eighty-five of the subjects were female and five were male.

The Instruments

Instruments to measure intelligence and changes in attitude and science competencies were:

1. Science Research Associates (SRA) Verbal Intelligence Tests, Forms A and B.

2. Minnesota Teacher Attitude Inventory (MTAI).

3. Science Process Test for Elementary School Teachers.

4. A Content-Understanding Test.

SRA Verbal Intelligence Tests. SRA Verbal, Forms A and B, is a test of general intelligence. It measures the overall ability and flexibility of an individual in adjusting to the many complex situations that arise in everyday living. It takes into account quickness of thought and action, ability to comprehend and follow instructions, and ability to prepare in advance for difficulties that might arise to hinder the accomplishments of an assigned task. Forms A and B can be used at all educational levels from junior high school through college, and at all employee levels from unskilled to company executives.[1]

The SRA intelligence tests, being largely language dependent and not culture free, could have been biased to the subjects. In view of this, the subjects of the study perhaps did not perform as well as their American counterpart. The testing time was limited to 15 minutes and this is unduly short as far as to the Filipino subjects are concerned.

The SRA intelligence test was administered to the subjects by the Guidance Coordinator of the Cebu Normal College shortly before the

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[1]Thelma G. Thurstone and L. L. Thurstone, Verbal Intelligence Tests, Forms A and B (Chicago: Science Research Associates, Inc., 1956), p. 2.

arrival of the writer in September, 1971. Raw scores were converted to Quotient Rank. Results revealed IQ as high as 131 and as low as 60. The mean converted IQ score of the subjects was 83.7. For statistical purposes, subjects were divided into High, Medium, and Low IQ levels to determine significant differences of the three groups in the three criteria measures. Criteria of the three IQ levels was based on the ranking of subjects from highest to lowest. The top one-third composed the High; the middle one-third, the Medium; and the bottom one-third, the Low.

It is hereby mentioned that the writer could not organize these classes according to IQ results as previously planned in her dissertation proposal. Upon her arrival, classes were already organized according to students' major subjects of concentration.

Minnesota Teacher Attitude Inventory (MTAI). The Minnesota Teacher Attitude Inventory is designed to measure those attitudes of a teacher which predict how well he will get along with pupils in impersonal relationships and indirectly how well satisfied he will be with teaching as a vocation. Investigation carried on by the authors of this test indicate the attitude of teachers toward children and schoolwork can be measured with high reliability, and that they are significantly correlated with the teacher-pupil relations found in the teacher's classrooms.[2]

The investigator's objective in giving the MTAI as pre- and post-tests was to determine if significant change occurred in prospective elementary teachers' attitude across time toward children and school work as a result of the experimental curriculum used in the study.

With the MTAI, there are no "right" or "wrong" answers. Rather, there are agreement or disagreement with specific attitude statements. In order to avoid a change in the accepted terminology, the scoring keys have been given the commonly used "right" or "wrong" labels; no implication of correctness or incorrectness of answers is intended. The possible range of scores on the MTAI is from 150 to minus 150. Each response scored "right" has a value of plus one, and each response scored "wrong" has a value of minus one.[3]

The MTAI instrument calls for one's attitude toward teacher-pupil relationship in an American setting. Scores of the instrument reflect to some extent a child-centered permissive attitude which is predominantly an American cultural mode. Since the subjects of the

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[2]Walter W. Cook, Carol Leeds, Robert Callis, _Minnesota Teacher Attitude Inventory Manual_ (New York: Psychological Corporation, 1951), p. 2.

[3]_Ibid_., p. 4.

study belong to a culture where respect for tradition, the family, and authority is the rule, responses could have been affected by this cultural background.

The MTAI is a type of test in which the structure is unfamiliar to the Filipino subjects. The MTAI calls for responses in five categories: strongly agree, agree, uncertain, disagree, strongly disagree. To the subjects, a response is either categorically agreeable or disagreeable to a certain statement. She either agrees or disagrees with a statement in the Inventory. The responses, strongly agree and strongly disagree, are too emphatic and beyond her culture. Belonging to a culture that is not inquiry-oriented, her responses tend to be influenced to a large extent by authority of the book or what the teacher says.

Science Process Test for Elementary School Teachers. The writer used the instrument, Science Process Test for Elementary School Teachers to measure competency in the processes of prospective elementary school teachers. This is adopted from Mueller's instrument to measure processes which he purposely constructed for his research study.[4]

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[4]Delbert W. Mueller, "Science Process Test for Elementary School Teachers, A Guide for Curriculum Evaluation: A Descriptive Study of the Implementation of the Earth Science Curriculum Project for the Carman School District, Flint, Michigan, 1970-1971 (unpublished Ph.D. dissertation, Michigan State University, 1972).

The pre- and post-tests of this instrument tend to measure the basic processes (observing, classifying, measuring, communicating, and inferring) and the integrated processes (formulating hypotheses, defining operationally, controlling variable, interpreting data, and experimenting). The test, consisting of two types, has 35 items and a total of 77 points for all processes evaluated. One type provides written instructions for the students and states the problem to be considered. Each student had her own answer sheet which she marked as she was directed to do. The other type consists of multiple choice items with each having four possible answers to choose from.

A reliability coefficient of .87 and .70 were established for the pre- and post-tests respectively of this instrument in Mueller's study. He used the formula:[5]

$$\frac{MS_R - MS_{RC}}{MS_R} = r$$

MS_R = means square subjects

MS_{RC} = means square interaction between subjects and test items

r = reliability coefficient

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[5]G. J. Hoyt, "Test Reliability Estimated by Analysis of Variance," Psychometric, VII (1941), pp. 153-160, as found in William Mehrens and Robert L. Ebel, Principles of Education and Psychological Measurement (Chicago: Rand McNally and Company, 1967), p. 111.

Content-Understanding Test. To measure competency in the understanding of science covering the areas in Matter and Energy, the writer administered the pre- and post-tests, A Content-Understanding Tests adopted from Science Teaching Tests, the World of Matter and Energy.[6]

The test consists of 80 multiple choice items with each having 4-5 possible answers to choose from. The instrument covers units on Matter and Energy and excluded those on Earth and Space which area was taught by her substitute-instructor before the writer took over the classes.

The Design

The design was a longitudinal study without a control group. An experimental curriculum was constructed by the writer to determine whether a process-centered course would produce changes in attitude and competencies both in process and in content of prospective elementary school teachers. Changes were measured in pre- and post-tests on attitudes and competencies in process and content. The design of the study was as follows:

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[6]Paul F. Brandwein, Sylvia S. Nievert, Harry H. Williams, Science Teaching Tests, the World of Matter and Energy (New York: Harcourt, Brace and World, Inc., 1964), pp. 60-78.

Pre				Post		
Op_1	Oc_1	Oa_1	X exp	Op_2	Oc_2	Oa_2

The Experimental Curriculum

The course, Physical Science (Science 2), was used in this study. This was a year course consisting of two semesters. An experimental curriculum was purposely constructed by the writer for her classes in her study to incorporate content and methods of teaching science in the elementary schools. Science methods is incorporated in this course with the end in view of having students enrolled in the course acquire investigative skills needed in the new science and would be able to teach science as a process. The first semester's work was focused on the building of the process skills developed in the elementary grades 1-6. Process activities were taken from the elementary science curriculum guides, and AAAS Science--A Process Approach.

The content of the physical science course was organized around concepts in the area Matter and Energy, taught in the Elementary Science Curriculum Guides 1-6. This set of curriculum materials was constructed by the Bureau of Public Schools, Philippines. Additional activities to improve science competencies were also adopted from Michigan State University's Physical Science 203 which was constructed by Dr. Richard McCleod and his team of the Michigan State University

Mathematics and Science Teaching Center. Concepts in the units on Matter and Energy aimed to develop the basic and integrated process skills of observing, comparing, classifying, inferring, measuring, formulating, hypotheses, predicting, controlling variables, and experimenting, which are taught in the elementary grades in the Philippines.

This teacher-preparation experimental curriculum included the following components: 1) independent study questions, 2) lectures, 3) recitation laboratory, 4) modular laboratory, 5) peer-group teaching.

Independent Study. The independent study involved questions examined in depth by students as a result of peer-peer discussions in laboratory sessions or peer-peer instructor interaction in lecture and lab sessions. Since fewer topics were considered in the lectures, this type of instructional module was in order.

Lecture. The lecture portion of the course was allotted two hours a week. Topics related to the laboratory activities were selected for lecture. Emphasis was given on concepts learned in the laboratory. Enrichment of the concepts and related concepts was further investigated in the independent study projects of students.

Recitation Laboratory. Two hours a week of recitation laboratory was included in the experimental course. This was mainly laboratory work followed by discussion of findings on a series of problems investigated on Matter and Energy. In this type of laboratory, the class was divided into groups of four or five where students observe, measure, infer, interpret data, predict, control variables and test hypotheses by experimenting. Most of the activities were taken from the Elementary Science Curriculum Guides 1-6 and Physical Science 203 of Michigan State University as mentioned earlier.

Modular Laboratory. Another two hours a week were given to students for individualized laboratory work. Its objective was to develop individual competency in the aforementioned processes. Individual students went through competency exercises toward this end. Peer-group teaching was a part of this modular laboratory.

Peer-Group Teaching. The objective of the peer-group teaching was to have the students get the feel of teaching science as a process. Students in the group took turns demonstrating a concept or a process skill. This was usually followed by a critique session by the whole class, which basis was a set of criteria for peer-group teaching. Subject matter content of the peer-group teaching was taken from the Elementary Science Curriculum Guides 1-6.

The Treatment

This study is concerned with a group of students, comprising four sections (III-A, III-B, III-C, and III-D) of juniors registered in the Physical Science course (Science 2) of the Cebu Normal College, Philippines, 1971-1972. When the writer arrived early September to take over these classes, students were already organized according to their subject areas of concentration. For the purpose of controlling the size of classes, the writer distributed the class section III-D students having the least number (18) to class sections III-A, III-B, and III-C making 32, 33, and 33 students in each class respectively. By the second semester, this number dropped to 30 in each class since the eight students had met the science requirements for graduation and did not continue in this course.

The teaching procedure was two-hour lecture and four-hour laboratory weekly: 2-hour recitation laboratory and 2-hour modular laboratory. Sections III-A and III-C met 3 times a week (M-W-F) with a total of 6 hours a week. Section III-B met twice (T-TH) with the same number of class hours, 6 a week.

The first week of the experimental study was utilized for the administration of the pre-tests instruments. Subsequent instruction in the treatment of the study in the first and second semester was made as consistent as possible throughout the three classes. As mentioned in the early part of this chapter, the course incorporated methods and content of elementary science.

The instruction of the methods part of the course involved: 1) the objectives of science education in the elementary school, 2) the psychological bases of the innovative science programs, 3) basic information of the Philippine science curriculum in the elementary grades as to content and processes involved, 4) instructional techniques in teaching science, 5) preparing instructional materials especially on lesson planning with emphasis on the construction of behavioral objectives, 6) constructing simple aids and devices in line with the new programs, 7) constructing sample evaluating materials particularly the paper-pencil type stressing on the processes developed in the elementary grades.

A peer-group teaching activity was required of each student. Here students took turns in demonstrating a process or a concept to a group. Students of the course also observed classes in the laboratory school to see children learn science through the process approach.

The instruction of the content part of the course was organized around the units on Matter and Energy. Investigations using the process approach were carried on Density, Boiling, Heat, Light, Sound, Magnetism, Electricity, and Simple Machines. Basis of these activities were the Elementary Science Guides 1-6 and MSU's Physical Science 203 as mentioned earlier. Sessions were divided into lecture (2-hour weekly) and laboratory sessions (4-hour weekly) making a total of 6 hours a week.

The Collection of Data

During the first two weeks of the experimental investigation, the pre-test instruments were administered to all subjects. The subjects of this investigation were given these instruments over a period of three successive days. The Minnesota Teacher Attitude Inventory (MTAI) Form A, was administered on the first day, Science Process Test for Elementary School Teachers given the second day, and the Content-Understanding test on the third day of the second week of September.

Data collected on the attitude measure is presented in Table I of the Appendix.

In the case of the instruments for measuring science competency in content-understanding and processes in science, raw scores were utilized for subsequent analysis. All of the data collected are presented in Table I of the Appendix.

During the last two weeks of the experimental study (April, 1972), the same procedures that were followed during the administration of the pre-tests instruments were utilized. The post-test instruments included the same instruments used in the pre-tests. The scoring of these instruments also followed the same procedures as described in the pre-tests. These data are recorded in Table I of the Appendix.

The Analysis of Data

To analyze the data collected during the experimental investigation, the writer selected a number of statistical treatments for the purpose of clarifying some aspects of the study, and to test the hypotheses as stated in Chapter I. All data to which statistical tests were applied were secured from scores of the pre- and post-tests obtained by the subjects on the aforementioned instruments used in the study.

Hypotheses one, two, and three were tested by the test analysis of difference between pre-test and post-test means. The level for the rejection was set at 0.05, determining the significance of the difference at this level.

The procedure to test hypotheses four, five, six, seven, eight, and nine was the correlation technique. A 0.05 level of significance was used to test the relationship between content and process, intelligence and process, intelligence and content, intelligence and attitude, process and attitude, and content and attitude on the pre- and post-tests. The test statistic r was used to give the value that would reject the null hypotheses. The correlation technique was also used to test the significant correlation of the same set of variables in the top one-third and bottom one-third of the subjects on the pre- and post-tests. Statistical treatment to determine the significant difference of the IQ levels and treatment groups was a two-way ANOVA design with three IQ levels (High, Medium, Low) and class (III-A, III-B, III-C) as independent variables in the pre- and post-tests of the three instruments.

As to the criteria of the classification of the three IQ levels subjects were ranked from highest to lowest. Those who got quotient rank equivalents of 87 to 131 composed the High IQ level group; 79 to 86, the Medium IQ level group; and 60 to 78, the Low IQ level group. Table 3 shows the number of subjects found in each class based on this criteria. There were 30 students in each class.

TABLE 3

IQ LEVELS AND TREATMENT CLASSES

IQ Levels*	Classes			Total
	III-A	III-B	III-C	
High	9	9	12	30
Medium	11	11	8	30
Low	10	10	10	30
Total	30	30	30	90

*High (top one-third) with quotient rank equivalent to 87-131.
Medium (middle one-third) with quotient rank equivalent to 79-86.
Low (bottom one-third) with quotient rank equivalent to 60-78.

As shown in the results of the testing used in the study, an overall mean of 83.7 was obtained by the subjects, falling far below the American norm of 99.75. The classification of High, Medium, and Low IQ levels as used by the writer in the study did not come up to the standard norm set by the SRA stanine rank of three IQ levels. The SRA stanine rank classified quotient rank equivalents of 112.5 to 140 as Good; 87.5 to 112, as Average; and 60 to 86.5 as Poor.

Outcomes of the intelligent tests would point to the subjects as mentally poor by American standards. It should be mentioned here that subjects of the study, as well as other applicants for admission to the Cebu Normal College, were screened and passed a battery of tests given by the Bureau of Public Schools as entrance examinations. Before applicants are qualified to take the tests, they should belong within the upper fifty percent of the high school graduating class. In this aspect, the writer feels that the results of the SRA intelligence tests did not do justice to the subjects in terms of IQ.

Furthermore, the use of the SRA Non-Verbal Form could have been given as supplement for cases scoring very low and requiring rechecking. This was not available as materials could not be secured at the time of the study.

Significant differences of row and column effects and their interaction were calculated by the computation of the F-ratios to test hypothesis ten to hypothesis eighteen. Post hoc comparisons using Scheffe's method was used to uncover the groups causing the row and column effects or their interaction if they existed.

Summary

Pre- and post-test instruments were administered to a total sample of 90 students of the Cebu Normal College, Philippines, to determine the effects of a Physical Science course using the process approach in developing attitude and science competency of prospective elementary school teachers, 1971-1972.

To determine improvement of subjects in attitude and competencies after the treatment, a t-test analysis of difference between pre- and post-test means was used. To test the relationship between content and process, intelligence and process, intelligence and content, intelligence and attitude, process and attitude, and content and attitude, the correlation technique was used. Correlation of the same set of variables of the top one-third and bottom one-third of the subjects was also included in the analysis. A two-way analysis of variance was used to determine significant differences of the IQ levels and the treatment groups.

The next chapter gives the analysis of data and results.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS

Data collected are analyzed in this chapter and results are based on this analysis. The hypotheses as stated in Chapter I are statistically treated for their acceptance or rejection in this chapter.

Pre- and Post-Tests Data

The primary purpose of giving the pre- and post-tests of the study was to ascertain the relative effects of treatment on attitudes and competencies of prospective elementary school teachers.

An analysis of significant differences between pre- and post-test means on the scores of the criteria measures was used to test hypotheses one, two, and three. Hypothesis one stated that there will be no mean improvement between pre- and post-tests for ability to perform process skills. Hypothesis two stated there will be no mean improvement between pre- and post-tests for understanding physical science concepts. Hypothesis three stated that there will be no mean improvement between pre- and post-tests on attitudes of prospective elementary teachers. Tables 4, 5, and 6 present data of pre- and post-test mean scores and standard deviations of the three criterion measures on process, content, and attitude. Table 4 shows means and standard deviations on pre- and post-tests. These were statistically treated to test hypotheses one, two, and three.

Table 5 shows a significant difference between pre- and post-tests in students' ability to perform the processes. It further reveals a significant difference between pre- and post-tests on content and understanding of physical science concepts. Test statistics then rejected hypotheses one and two. Hypothesis three was not rejected as there were no significant differences at 0.05 level between pre- and post-tests in students' attitude before and after treatment as shown in Table 4.

Table 6 shows pre-post test gains on students' processes, content, and attitude. It shows significant mean gains in process and content at 0.05 level. However, no significant gains were found in the attitude criteria measure.

Further analysis revealed the significant differences of pre-post test means existing in all three IQ levels (High, Medium, Low) in both process and content competency measures as shown in Table 7. However in the attitude measure, significant difference of pre-post test means occurred only in the High IQ level group, not in the Medium or Low IQ level groups.

TABLE 4

MEANS AND STANDARD DEVIATIONS OF PRE- AND POST-TEST CRITERIA MEASURES

Pre-Tests						Post-Tests					
Process		Content		Attitude		Process		Content		Attitude	
$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
19.4	9.15	29.11	6.05	-30.31	17.17	35.0	9.16	37.9	7.27	-27.0	22.58

TABLE 5

SIGNIFICANT DIFFERENCES OF PRE- AND POST-TEST MEANS IN PROCESS, CONTENT, AND ATTITUDE CRITERIA MEASURES

Tests	Pre-Tests $\overline{X}$	Post-Tests $\overline{X}$
Process	19.4	35.0*
Content	29.11	37.9*
Attitude	-30.31	-27.0

*Significant at .05 level.

TABLE 6

PRE-POST GAINS IN PROCESS, CONTENT, AND ATTITUDE

Process		Content		Attitude	
$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
		Pre-Tests			
19.4		29.11		-30.11	
	9.15		6.05		17.17
		Post-Tests			
35.0		37.9		-27.0	
	9.16		7.27		22.58
		Pre-Post Gains			
15.8*		8.9*		3.3	
	8.60		5.21		19.17

*Significant at 0.05.

TABLE 7

PRE-POST GAINS IN THREE IQ LEVELS IN CRITERIA MEASURES

IQ Levels	Pre-Post Gains					
	Process		Content		Attitude	
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
High	17.9*	10.50	10.6*	6.41	9.0*	19.89
Medium	11.9*	8.74	8.4*	5.10	3.0	18.72
Low	13.6*	6.96	8.1*	4.48	-1.1	16.85

*Significant at 0.05.

Furthermore as shown in Table 7, the mean of the pre-post gains of the Low IQ level group turned out to be higher than the mean of the Medium IQ level group in the Process Competency Measure after the treatment, although found not substantial.

Correlation Data

Another purpose of the study was to determine whether any relationship existed between sets of variables. Specifically it was to find a significant correlation between content and process, intelligence and process, intelligence and content, intelligence and attitude, process and attitude, and content and attitude on the pre- and post-tests. The test statistic r was used to give the values that would either reject or accept the null hypotheses of no correlation. Hypotheses four, five, six, seven, eight, and nine stated no relationship (Ho_4) between content and process; (Ho_5) between intelligence and process; (Ho_6) between intelligence and content; (Ho_7) between intelligence and attitude; (Ho_8) between process and attitude; and (Ho_9) between content and attitude on the pre- and post-tests.

For this phase of the study, standard scores from all the pre- and post-test criteria measures were used to calculate the intercorrelation matrix. This would give significant relationship of the aforementioned variables. Another aspect of the study was to compare the top one-third and bottom one-third of the subjects to determine relationship of the same set of variables. The procedure is based on a statistical treatment suggested by Chao.[1] Table 8 presents intercorrelation coefficients on intelligence process, content, and attitude in both the pre- and post-test measures.

Table 9 shows data used to test significant relationship between content and process, intelligence and process, intelligence and content and attitude on the pre- and post-tests. Analysis of the data revealed that a relationship existed between content and process

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[1] Lincoln L. Chao, "Correlation Analysis," Statistics: Methods and Analyses (New York: McGraw-Hill Book Company, 1969), pp. 348-355.

TABLE 8

INTERCORRELATION COEFFICIENTS BETWEEN ALL PRE- AND POST-TEST CRITERIA MEASURES

	Criteria	Pre-Tests			Post-Tests		
	1*	2	3	4	5	6	7
1*	1.00	.23	.13	.05	.18	.26	.19
2		1.00	.43	-.12	--	--	--
3			1.00	.19	--	--	--
4				1.00	--	--	--
5					1.00	.57	.24
6						1.00	.38
7							1.00

*These numbers refer to the following: 1--intelligence; 2--content pre-test; 3--process pre-test; 4--attitude pre-test; 5--content post-test; 6--process post-test; 7--attitude post-test.

TABLE 9

CORRELATIONS BETWEEN ALL PRE- AND POST-TEST CRITERIA MEASURES

Criteria Measures		Computed r	t-Test
Content and Process	Pre	.43	4.43*
	Post	.57	6.71*
IQ and Process	Pre	.13	1.23
	Post	.26	2.52**
IQ and Content	Pre	.23	2.23**
	Post	.18	1.71
IQ and Attitude	Pre	.05	.47
	Post	.19	1.83
Process and Attitude	Pre	.19	1.83
	Post	.38	3.80*
Content and Attitude	Pre	-.12	1.13
	Post	.24	2.30**

t .05 = 1.99
t .01 = 2.63

*Significant at .01 and .05 levels.
**Significant at .05 level.

in both pre- and post-tests at both 0.05 and 0.01 levels of confidence. Therefore hypothesis four of no significant relationship between content and process was rejected. Further analysis of the intercorrelation matrix showed a significant correlation between intelligence and process in post-tests at 0.05 level. However, the pre-test data revealed no significant correlation. In other words, intelligence at the beginning of the study was not found to be related to process but became so in the post-test. Hypothesis five was then accepted of no correlation between intelligence and process in the pre-tests but this was rejected in the post-tests analysis.

Further analysis of data showed significant relationship at 0.05 between intelligence and content in the pre-tests but found to have no significant correlation at the same level in the post-tests. In other words, significant relationship between intelligence and content was found at the beginning of the study but significant correlation between the set did not occur at the end of the study. Analysis of the post-test data showed that high achievers were not necessarily students with high IQ's. Hypothesis six was then rejected at 0.05 in the pre-tests and accepted at the same level in the post-test scores.

Furthermore, when intelligence scores were compared to attitude scale scores, significant correlation was not evolved in both pre- and post-tests. Therefore, hypothesis seven failed to be rejected, that of no correlation between intelligence and attitude.

More analysis of data of the post-tests showed significant relationship between process and attitude at 0.05 level of confidence, although found wanting at the start of the investigation as shown in the pre-tests. Therefore hypothesis eight failed to be rejected at 0.05 level in the pre-tests and rejected the no correlation between process and attitude in the post-tests. Further analysis showed also a significant relationship between content and attitude in the post-tests at 0.05 but found lacking in the pre-tests. Hypothesis nine failed to be rejected at 0.05 in the pre-tests and rejected at the same level in the post-test scores.

The writer further investigated significant correlation of the same set of variables comparing the top one-third and bottom one-third of the subjects of the study in the pre- and post-test scores. Table 10 shows a strong significant positive relationship between content and process in the bottom one-third in the pre- and post-tests. However, analysis of data revealed a weak positive correlation of content and process in the top one-third in the pre-test but became fairly strong and significant in the post-tests.

Table 10 shows a fairly weak insignificant negative correlation between intelligence and process in the top one-third in both

TABLE 10

CORRELATIONS BETWEEN PRE- AND POST-TEST CRITERIA MEASURES OF TOP ONE-THIRD AND BOTTOM ONE-THIRD

Criteria Measures		Top One-Third		Bottom One-Third	
		r	t-test	r	t-test
Content and Process	Pre	.21	1.14	.38	2.17*
	Post	.47	2.81**	.53	3.29**
IQ and Process	Pre	-.22	1.20	.23	1.25
	Post	-.32	1.76	.11	.59
IQ and Content	Pre	-.12	.64	.18	.97
	Post	-.46	2.69*	.08	.43
IQ and Attitude	Pre	-.04	.21	-.01	.06
	Post	-.20	1.09	-.06	.32
Process and Attitude	Pre	-.43	2.53*	.19	1.02
	Post	.31	1.72	.29	1.81
Content and Attitude	Pre	-.27	1.54	.62	4.19**
	Post	.42	2.64*	.41	2.38*

t .05 = 2.048
t .01 = 2.763

*Significant at 0.05.
**Significant at 0.01.

pre- and post-tests. However, a nonsignificant but weak positive correlation existed in the bottom one-third in both pre- and post-tests. This is contrary to the significant positive correlation finding between intelligence and process at 0.05 when all scores of the three levels (High, Medium, Low) were treated for significance. This could be attributed to the Medium IQ group.

Further study as shown in Table 8 shows no significant correlation between intelligence and content in the Low IQ group in the pre-tests. However a low negative correlation between IQ and content existed in the top one-third in the pre-tests but increased negative correlation became significant at 0.05 in the post-tests. This was found not substantial in the bottom one-third in the post-tests. Furthermore, a negative insignificant correlation between intelligence and attitude was found in both pre- and post-tests of the top and bottom one-third of the subjects.

When relationship of process and attitude was considered, a significant negative correlation was found between this set of variables of the top one-third in the pre-tests at 0.05. However a slight positive correlation occurred after treatment in the same top IQ group despite the fact it was not significant. A significant positive relationship between process and attitude existed in the bottom one-third at the same level in the pre-post-tests. An improved but insignificant relationship between process and attitude was found in both High and Low IQ groups in the post-tests as shown in Table 10.

Furthermore, a significant positive correlation between content and attitude was revealed in the bottom one-third of both pre- and post-tests. On the contrary, an insignificant negative correlation was found to exist in the top one-third in the pre-tests. However, this weak relationship became positively strong and significant in the post-tests.

As in the findings of the overall analysis of all pre- and post-test scores on significant correlation of the aforementioned set of variables, comparison of the top and bottom groups yielded the same parallel results, except that of the correlation of intelligence and process and between process and attitude. Whereas correlation of intelligence and process was found to be significant in the overall treatment of all scores, the comparison of the top and bottom one-third revealed no significant relationship of these two variables. Significance then could be attributed to the Medium IQ level. Also the existing significant relationship between process and attitude in the treatment of all post-test scores as shown in Table 9 could have come from the middle IQ group. This was found not substantial in both top and bottom groups in the post-tests as shown in Table 10.

Process Competency Measure
Post-Test Data

Using a two-way analysis of variance as suggested by Chao,[2] for testing main effects, F-ratios were calculated. This test statistic was used to reject or not reject the hypotheses relevant to the process competency measure post-test data. The process competency measure used by the writer is adopted from Mueller's Science Process Test.

The data shown in Table 11 were used to test hypotheses ten to eighteen inclusive. Hypothesis ten stated that there will be no significant differences between the three IQ levels (High, Medium, Low) in the post-test process competency measure. Hypothesis eleven stated that there will be no significant differences between the three class sections of subjects (Sections A, B, and C) in the post-test process measure. Hypothesis twelve stated that there will be no interaction between IQ levels and classes in the post-test process measure.

Data presented in Table 12 show a significant difference between the IQ levels in the post-test process competency measure. A significant F-ratio was computed to reject hypothesis ten at 0.01 and 0.05 levels. Further analysis shown in Table 10 gives F-ratios

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[2] Ibid., p. 320.

TABLE 11

POST-TEST MEANS AND SD'S OF IQ LEVELS AND CLASSES

IQ Levels	Protest		Content		Attitude	
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
			Class A			
High	37.28	8.67	39.7	7.67	-29.9	18.56
Medium	36.54	10.12	37.1	4.76	-36.5	22.36
Low	32.50	9.63	34.7	6.55	-33.0	23.98
Means	X = 35.44		X = 37.17		X = -33.13	
			Class B			
High	40.2	5.74	40.3	5.96	-15.8	19.04
Medium	27.7	7.77	38.6	7.30	-34.2	15.21
Low	31.5	9.97	30.9	2.18	-33.6	16.26
Means	X = 33.13		X = 36.6		X = -27.9	
			Class C			
High	41.5	9.29	44.4	10.53	- 9.3	29.4
Medium	35.4	9.28	38.4	5.78	-26.2	25.13
Low	32.9	4.30	36.3	7.89	-25.1	21.27
Means	X = 36.6		X = 39.7		X = -20.2	

TABLE 12

SUMMARY OF TWO-WAY ANALYSES OF VARIANCE RELATIVE TO TESTING DIFFERENCES BETWEEN TREATMENT GROUPS AND IQ LEVELS IN POST-TEST CRITERIA MEASURES

Criteria Measures	Source of Variation*	SS	df	MS	F-ratio
Process	A	1232.422	2	616.211	8.56**
	B	244.355	2	122.178	1.70
	AB Interaction	147.037	4	36.759	.51
	Error (within cells)	5832.142	81	72.002	
Content	A	912.955	2	456.478	9.34**
	B	219.355	2	109.678	2.24
	AB Interaction	91.632	4	22.908	.47
	Error (within cells)	3957.347	81	48.856	
Attitude	A	4183.355	2	2091.678	4.41***
	B	3171.622	2	1585.811	3.34***
	AB Interaction	17.788	4	4.447	.09
	Error (within cells)	3845.191	81	474.706	

*A refers to IQ levels;
B refers to treatment groups.

**Significant at 0.01.
***Significant at 0.05.

that failed to reject hypotheses eleven and twelve on the post-test process competency measure. Data revealed no significant differences between the three classes of subjects. This was to be expected as the investigator tried to make the learning experiences of the three classes consistent throughout the treatment period. Further analysis of the data showed no interaction between these main effects, that of IQ levels and classes in the post-test process competency measure.

Content-Understanding Post-Test Measure Data

The content-understanding examination, adopted from Brandwein's Science Teaching Tests, the World of Matter and Energy, was used to collect data relevant to hypotheses thirteen, fourteen, and fifteen. Hypothesis thirteen stated that there will be no significant differences between the three IQ levels in the post-test content competency measure. Hypothesis fourteen stated that there will be no significant differences between the three classes of subjects in the post-test content competency measure. Hypothesis fifteen stated that there will be no interaction between IQ levels and classes in the post-test content competency measure.

Table 12 shows a significant difference between the IQ levels on the criteria of content competency. Thus hypothesis thirteen was rejected. Results also showed F-ratios not significant to reject hypothesis fourteen. Thus again results revealed no significant differences between the three treatment groups. When interaction of main effects was considered, no significance was in evidence. Thus hypotheses fourteen and fifteen were not rejected.

Attitude Post-Test Measure Data

The Minnesota Teacher Attitude Inventory (MTAI) was used to gather data related to prospective elementary teacher's attitude towards teaching, particularly in her attitude towards children and school work. Hypothesis sixteen stated that there will be no significant differences between the three IQ levels in the post-tests attitude measure. Hypothesis seventeen stated that there will be no significant differences between the three classes of subjects in the post-test attitude measure. Hypothesis eighteen stated that there will be no interaction between the IQ levels and the classes in the post-test attitude measure.

Examination of the two-way analysis of data presented in Table 12 reveals that there was a significant difference between the IQ level groups when the criterion of attitude was investigated. Thus hypothesis sixteen was rejected. F-ratios revealed a significant difference between the three classes of subjects, and hypotheses sixteen and seventeen were rejected at 0.05 level of significance. However, main effects of interaction of IQ levels and classes were noticeably lacking. Hypothesis eighteen was not rejected.

Post Hoc Comparison
Post-Test Data

A post hoc comparison using Scheffe's method examined further the hypotheses that were rejected in the two-way variance repeated measures. It is recalled that the F-ratios in the two-way variance rejected the hypotheses of no significant differences between IQ levels in the post-test criteria measures on process, content, and attitude. It also rejected the hypothesis of no significance between treatment groups in the attitude post-test measure.

The investigator then used Scheffe's[3] post hoc comparisons to uncover the groups contributing to significant results of column and row effects. F-ratios and confidence intervals were computed to determine significant differences between IQ levels and between treatment groups in the three criteria measures.

As to the existence of significant row effects as found in the two-way ANOVA of the three post-test criteria measures, Table 13

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[3]Gene V. Glass and J. C. Stanley, "The S-Method," Statistical Methods in Education and Psychology (New Jersey: Prentice-Hall, Inc., 1970), pp. 388-395.

TABLE 13

POST HOC S-METHOD CONFIDENCE INTERVALS OF SIGNIFICANT DIFFERENCES BETWEEN IQ LEVELS ON PROCESS CRITERIA MEASURE

Contrast[1]	$\hat{\Psi}$	$\hat{\alpha}\ \hat{\Psi}$	$\hat{\Psi} \pm \hat{\alpha}\ \hat{\Psi}$ (2.49)
A. $u_1 - u_2$	4.1	2.191	-1.36 to 9.56
B. $u_1 - u_3$	7.7	2.191	2.24 to 13.16*
C. $u_2 - u_3$	3.5	2.191	-1.86 to 9.06
D. $\frac{u_1 + u_2}{2} - u_3$	5.7	1.897	.98 to 10.42*
E. $u_1 - (\frac{u_2 + u_3}{2})$	5.9	1.897	1.18 to 10.62*

[1] u_1 = mean of High IQ level (38.5)
u_2 = mean of Medium (34.4)
u_3 = mean of Low (30.8)

*Significant at 0.05

shows a significant difference in means between the High and Low IQ levels in the Process post-test criteria measure. Further analysis shows also a significant difference between the mean of the High IQ group and the average mean of both Medium and Low IQ groups. As there also existed a significant difference between the mean of the Low IQ group and the average mean of the High and Medium groups taken all together.

Table 14 reveals likewise a significant difference between the High and Low IQ groups in the content post-test criteria measure. A significant difference also existed between the mean of the High IQ level and the average mean of both Low and Medium IQ groups. Furthermore a significant difference also occurred between the mean of the Low IQ level and the average mean of the High and Medium groups.

TABLE 14

POST HOC S-METHOD CONFIDENCE INTERVALS OF SIGNIFICANT DIFFERENCES BETWEEN IQ LEVELS ON CONTENT CRITERIA MEASURE

Contrast[1]	$\hat{\Psi}$	$\hat{\alpha}\ \hat{\Psi}$	$\hat{\Psi} \pm \hat{\alpha}\ \hat{\Psi}$ (2.49)
A. $u_1 - u_2$	3.8	1.805	-1.14 to 8.74
B. $u_1 - u_3$	7.8	1.805	2.86 to 12.74*
C. $u_2 - u_3$	4.0	1.805	- .94 to 2.94
D. $\frac{u_1 + u_2}{2} - u_3$	5.9	1.563	2.01 to 9.79*
E. $u_1 - (\frac{u_2 + u_3}{2})$	5.8	1.563	1.91 to 9.69*

[1] u_1 = Mean of High IQ level (41.8)

u_2 = Mean of Medium (38.0)

u_3 = Mean of Low (34.0)

*Significant at 0.05.

Table 15 shows a similar pattern of significant difference existing between the High and the Low groups in the attitude post-test criteria measure. It further reveals a significant difference between the mean of the High IQ group and the average mean of both Low and Medium IQ groups taken together. Surprisingly no significant differences existed between the mean of the Low IQ group and the average mean of both High and Medium IQ groups. This could be attributed to the comparatively low scores of the Medium group.

Taking the analysis all together, the S-method produces a great disparity between the High and the Low IQ groups. This is evidenced by the significant difference between these two groups as shown in the aforementioned tables.

Regarding existing significant difference of column effects, the S-method found this true only in the post-test attitude measure. Scheffe's technique showed Class A differ significantly from Class C in the post-test attitude measure, as shown in Table 16.

To summarize, from the S-method, the investigator may conclude that there were no significant differences between the three classes of subjects in the post-test criteria measures in process and content, except that in attitude. A significant difference was noted between treatment groups, in the attitude measures yielding differences between Class Section A and Class Section C. A comparison of

TABLE 15

POST HOC S-METHOD CONFIDENCE INTERVALS OF SIGNIFICANT DIFFERENCES BETWEEN IQ LEVELS ON ATTITUDE CRITERIA MEASURE

Contrast[1]	$\hat{\Psi}$	$\hat{\alpha}\ \hat{\Psi}$	$\hat{\Psi} \pm \hat{\alpha}\ \hat{\Psi}$ (2.49)
A. $u_1 - u_2$	15.5	5.626	1.49 to 29.5*
B. $u_1 - u_3$	13.2	5.626	-27.21 to .18
C. $u_2 - u_3$	- 2.3	5.626	-16.31 to 11.71
D. $\frac{u_1 + u_2}{2} - 3$	5.4	4.872	- 6.73 to 17.53
E. $u_1 - (\frac{u_2 + u_3}{2})$	-14.4	4.872	-26.53 to -2.2*

[1] u_1 = Mean of High IQ level (-17.4)
u_2 = Mean of Medium (-32.9)
u_3 = Mean of Low (-30.6)

*Significant at 0.05.

the three IQ levels (High, Medium, Low) showed a significant difference between the High IQ group and the Low IQ group in all the three post-test criteria measures. This conclusion of significant difference is also based on the estimate of the computed confidence intervals which did not cross zero as shown in Tables 13, 14, 15, and 16. By this criterion, "confidence intervals around contrasts that do not span zero are significant by the S-method with 0.05 level of confidence."[4]

TABLE 16

POST HOC S-METHOD CONFIDENCE INTERVALS OF SIGNIFICANT DIFFERENCES BETWEEN CLASSES ON ATTITUDE CRITERIA MEASURE

Contrast[1]	$\hat{\Psi}$	$\hat{\alpha}\ \hat{\Psi}$	$\hat{\Psi} \pm \hat{\alpha}\ \hat{\Psi}$ (2.49)
A. $u_1 - u_2$	-4.9	5.626	-18.91 to 9.11
B. $u_1 - u_3$	-14.3	5.626	- .29 to -28.31*
C. $u_2 - u_3$	19.8	5.626	-23.81 to 4.21
D. $\frac{u_1 - u_3}{2} - u_3$	-11.9	4.872	-24.03 to .23
E. $u_1 - (\frac{u_2 + u_3}{2})$	- 9.6	4.872	-21.73 to 2.53

[1] u_1 = Mean of Class A (-33.4)
u_2 = Mean of Class B (-28.5)
u_3 = Mean of Class C (-19.1)

*Significant at 0.05.

[4] *Ibid.*, p. 394.

CHAPTER V

SUMMARY, CONCLUSION, IMPLICATIONS, AND RECOMMENDATIONS

A brief review of the study presenting objectives, design, experimental curriculum, and hypotheses tested is presented in this chapter. Basis of the conclusions of this study were data presented in Chapter IV. Implications for educators especially those in the area of science education and curriculum development are included in this chapter. Recommendations for implementing the findings of the study and problems for further investigation close this chapter.

Summary

The major objective of this study was to find out the effects of a physical science course using the process approach in developing the attitude and competencies of prospective elementary teachers. Specifically its purpose was to determine whether a process-oriented physical science course combined with elementary methods course would produce changes in the students' attitudes and competencies in both process and content after the treatment. Changes were measured in in post-tests on attitude (MTAI, Minnesota Teacher Attitude Inventory) and competencies on content (A Content-Understanding Test) and process (Science Process Test for Elementary School Teachers).

Also the investigator wanted to know in the study if intelligence, process, content, and attitude showed intercorrelation. Furthermore, the study included existing significant differences between the three IQ levels (High, Medium, and Low) and the three groups of subjects (Class A, Class B, and Class C) in the three criterion measures. The design was a longitudinal study without a control group. This study was an investigation which resulted from an action research done by the writer in 1969 purposely to investigate the process readiness of prospective teachers who were her students of the Cebu Normal College. Results of the investigation indicated that further study might be fruitful. Thus, a one-year (two semesters) experimental curriculum was constructed by the writer for this research study with the end in view of producing changes of her subjects in this investigation.

The experimental physical science curriculum (Science 2), incorporated content and methods of teaching science in the elementary school. The content part of the physical science course was organized around physical science concepts developed in the area, Matter and Energy. Most of the activities developing the concepts were taken from the Elementary Science Curriculum Guides 1-6, constructed in 1967 by the Bureau of Public Schools, Philippines, with the introduction of the process approach in the science curriculum. Additional activities were taken from the revised Physical Science 203 of Michigan State University to develop further the prospective elementary teacher's attitude and competencies. The experimental curriculum included laboratory modules wherein a group of four or five students investigated a series of problems in Matter and Energy. Also, individual laboratory modules consisting of a series of exercises were performed by individual students to develop the basic and integrated processes in the process approach. Such skills as observing, comparing, classifying, inferring, measuring, formulating hypotheses, predicting, controlling variables and experimenting which are taught in the elementary grades in the Philippines were developed in these laboratory modules.

The content of the methods part of the experimental curriculum included peer-group teaching activities that gave students opportunities to demonstrate a concept or a process skill. It also oriented the students on the objectives of science education and the psychological basis of the new science. Emphasis was also given on the use of the new science curriculum in the elementary grades as to the content and processes involved. The experimental curriculum also included independent study questions and lectures as an off-shoot of laboratory experiences and discussions.

Subjects of the study were 90 prospective elementary school teachers comprising of three sections of juniors registered in the course Physical Science (Science 2) of the Cebu Normal College, Philippines. During the first week of the study, the pre-tests instruments on the three criterion measures were administered. The treatment of the study followed with instruction and learning experiences, conducted as consistent as possible to the three classes of subjects (III-A, III-B, III-C). The teaching procedure for the three classes was a weekly two-hour lecture and weekly four-hour laboratory: two-hour modular laboratory and two-hour recitation laboratory. The post-tests were administered in the last two weeks of school, and were the same instruments used in the pre-tests. Scoring of these instruments followed the same procedure for both pre- and post-tests.

Pre- and post-test data provided information relevant to the testing of the hypotheses held for this study. Analysis of these data produced results relative to the testing of each hypothesis as follows:

Ho_1: There will be no mean improvement between pre- and post-tests for ability to perform process skills as measured by an examination, Science Process Tests for Elementary School Teachers. Hypothesis one was rejected.

Ho_2: There will be no mean improvement between pre- and post-tests for knowledge and understanding of physical science concepts as measured by an examination, A Content-Understanding Test. Hypothesis two was rejected.

Ho_3: There will be no mean improvement between pre- and post-tests on attitude of prospective elementary teachers as measured by the Minnesota Teachers' Attitude Inventory. Hypothesis failed to be rejected.

Ho_4: There will be no significant correlation between content and process on the pre- and post-tests. Hypothesis was rejected in both pre- and post-tests.

Ho_5: There will be no significant correlation between intelligence and process on the pre- and post-tests. Hypothesis failed to be rejected in the pre-tests but rejected in the post-tests.

Ho_6: There will be no significant correlation between intelligence and content on the pre- and post-tests. Hypothesis was rejected in the pre-tests but failed to be rejected in the post-tests.

Ho_7: There will be no significant correlation between intelligence and attitude on the pre- and post-tests. Hypothesis failed to be rejected in both pre- and post-tests.

Ho_8: There will be no significant correlation between process and attitude in the pre- and post-tests. Hypothesis failed to be rejected in the pre-test but rejected in the post-tests.

Ho_9: There will be no significant correlation between content and attitude on the pre- and post-tests. Hypothesis failed to be rejected in the pre-tests but rejected in the post-tests.

Ho_{10}: There will be no significant differences between the three IQ levels of subjects for the post-test process measure. Hypothesis was rejected.

Ho_{11}: There will be no significant differences between the three classes of subjects for the post-test process measure. Hypothesis failed to be rejected.

Ho_{12}: There will be no interaction between classes and IQ levels for the post-test process measure. Hypothesis failed to be rejected.

Ho_{13}: There will be no significant differences between the three IQ levels in the post-tests content competency measure. Hypothesis was rejected.

Ho_{14}: There will be no significant differences between the three classes of subjects in the post-test content competency measure. Hypothesis failed to be rejected.

Ho_{15}: There will be no interaction between IQ levels and classes in the post-test content competency measure. Hypothesis failed to be rejected.

Ho_{16}: There will be no significant differences between the three IQ levels in the post-test attitude measure. Hypothesis was rejected.

Ho_{17}: There will be no significant differences between the three classes of subjects in the post-test attitude measure. Hypothesis was rejected.

Ho_{18}: There will be no interaction between IQ levels and the classes in the post-test attitude measure. Hypothesis failed to be rejected.

Conclusions

On the basis of the results of this study, the following conclusions seem valid:

1. Since hypothesis one was rejected, one can conclude that the physical science course using the process approach has improved significantly the prospective elementary school teachers' ability to perform the processes. Improvement of the process competency of the subjects after the study was significant at all three IQ levels: High, Medium, Low. Results of the study also revealed pre-post gains of

Low IQ level group higher than the Medium group in the performance of process skills, although the finding was not significant.

This implies that the process activities of the experimental curriculum have enabled students at all IQ levels to learn, the basic and integrated processes which are the essence of the "new" science. The trends of the Low IQ group to do better in the processes than the Medium IQ group as shown in the significant pre-post test gains would imply that low IQ is not a deterrent in acquiring the process skills.

2. Hypothesis two was rejected on the basis of students' improving their knowledge and understanding of physical science concepts after the treatment. This improved competency was significant in all three IQ levels: High, Medium, and Low. The findings would imply that science content, like the processes, can be learned to some extent by students at all IQ levels.

3. Hypothesis three was not rejected as there were no significant improvements of students' attitude as shown in post-tests analysis. However, it is mentioned here that there was some improvement of subjects' attitude despite the fact the finding was not significant at the 0.05 level, but instead at the 0.06 level.

Results of the study showed significant improvement of attitude occurring in the High IQ group only. Since IQ was not related at all to attitude as shown in the analysis of data, the subjects' significant improvement of attitudes in the High IQ group could be related to some other variables not accounted for in this study. It could be implied that subjects who were verbal and got better results in the MTAI and IQ tests produced the significant mean differences in attitude between the High IQ and the Low IQ level groups.

4. Hypothesis four was rejected. There was a significant increased positive correlation between process and content after the study. This relationship was found true in all IQ levels. This indicates that as the students became more competent in the processes during the course, they became more competent in the science content.

5. Intelligence and process were not significantly correlated at the beginning of the study but became so after the treatment. This is based on the rejection of hypothesis five in the post-tests. In this aspect of the study, the same set of intelligence scores was tested for significant correlation with two sets of process scores, the pre- and post-tests. An overall analysis of post-test data has indicated a significant correlation of IQ and process of the subjects of the study. Since IQ did not change, the results imply a change in process competency. In the pre-tests, subjects sorted themselves out by IQ and by process competency. None were skilled in process at the pre-tests, yet those who had higher IQ's did do better at the post-tests. This implies that the high IQ subjects of the study developed better process competency than the low IQ group.

6. Intelligence and content were found to be significantly related at the beginning of the study but relationship weakened after the treatment. This is based on hypothesis six being rejected in the pre-tests but not rejected in the post-tests. This implies that treatment contributed improvement inversely, that the High IQ students did not gain as much as the low IQ group.

7. There were no significant correlations between intelligence and attitude as hypothesis seven was not rejected. This infers that IQ is not an indicator of a student's positive attitude towards teacher-pupil relationship. To the Medium IQ and Low IQ students, intelligence and attitude were hardly related at all. A look at the high IQ level gave us a decreasing negative correlation although insignificant between these two variables.

8. No significant relationship was shown between process and attitude at the start of the study. After the treatment, a significant correlation between the two variables was noted on the basis of hypothesis eight being rejected in the post-tests. The trends pointed to a significant positive correlation of these two variables in the three IQ levels after treatment. The results of this phase of the study would lead to the conclusion that as the student became more competent in the processes, she also improved her attitude towards teacher-pupil relationship.

9. Before the treatment, the correlation between content and attitude was negative and not significant. The relationship between this set of variables changed to positive and significant after the study. One can conclude from these results that as the student became more competent in the science content, she also improved her attitude toward teacher-pupil relationship. This finding was significant in all three IQ levels.

10. Hypothesis ten was rejected as a significant difference to perform the processes existed between the IQ levels. The student with the high IQ differed significantly from the student with the low IQ in the performance of the processes. This indicates that of the three IQ levels, the student with the high IQ has the better chances of improving significantly her processes than her counterpart in the Low IQ level group.

11. There were no significant mean differences between the three heterogeneously grouped class sections of subjects in their ability to perform the process skills. This was based on hypothesis eleven not rejected. This was expected as learning experiences were made as consistent as possible to the three sections in spite of different class schedules and subjects not organized according to IQ.

12. Hypothesis twelve was not rejected due to the finding that there were no significant interaction effects between IQ levels

and classes on the processes after the study. This implies that intelligence of the three levels of subjects did not produce significant differences in the processes of the three classes of the study. This indicates further that there were no significant differences in the three classes on the processes due to intelligence.

13. Hypothesis thirteen was rejected due to a significant difference existing between the IQ levels in the understanding of physical science concepts as a result of treatment. Again such differences occurred between the High IQ and the Low IQ groups. Data showed that the student with the high IQ had improved significantly her science content competency. This implies that students in the High IQ group learn science content better than students in the low IQ level group.

14. There were no significant mean differences between the three classes of subjects in knowledge and understanding of physical science concepts after the treatment. This was based on hypothesis fourteen not being rejected.

15. There were no significant interactions effects between IQ groups and class sections in knowledge and understanding of physical science concepts as shown in hypothesis fifteen not being rejected. This indicates that there were no significant mean differences between

the gains of the three classes in science content due to distribution of IQ in the class sections.

16. As revealed in the rejection of hypothesis sixteen, a significant difference in attitude is noted between IQ levels at the end of treatment. This significant difference in attitude was found to exist between the students with the highest IQ and the students with the lowest IQ. Data showed that not only did the high IQ level group improve significantly in their attitude mean score, the low IQ level group mean decreased. The variance within groups also increased.

This significant mean difference in attitude between the high IQ level and the low IQ could be attributed to the significant pre-post gains of content and process of the High IQ level. It can be further implied that the significant mean difference could be attributed to the higher IQ students doing better in the MTAI having higher verbal facility than the low IQ students.

17. Hypothesis seventeen was rejected due to the findings of significant differences in attitude between treatment groups. Analysis of data revealed a significant difference in attitude between two class sections, A and C. According to results of the study, section C excelled in the process and content measures while section A showed the least improvements of the three sections although their differences were not significant.

Again significant differences in attitude between these two sections could be attributed to marked pre-post test gains of subjects' process and content competency in section C. It is mentioned here that section C has the highest number of High IQ students (12), almost half of the total number of high IQ subjects of the study. Furthermore, students with high IQ also tended to improve their processes and content significantly. One might speculate that there is an interaction between the mean attitude and the distribution of IQ level in the class groups.

18. No significant interaction was found to exist between IQ groups and class sections on attitude after the treatment. This is shown in hypothesis eighteen not rejected. This indicates that significant differences in attitude of the three sections was not due to IQ distribution. This further implies that the three sections differ significantly in attitude due to some other variables or combinations.

Conclusions--Summary

In summary, this investigation has indicated that when a physical science course is combined with elementary science methods using the process approach, there was a significant improvement in the prospective elementary teacher's competencies in both the processes and content-understanding. However, there was no significant improvement in the students' attitude towards teacher-pupil relationship after the treatment.

In addition, this investigator has come to the conclusion that certain sets of independent variables became related after the study. An overall analysis of post-test data showed significant positive relationship between content and process, between intelligence and process, between process and attitude, and between content and attitude. Sufficient evidence was not obtained to conclude that there is a relationship between intelligence and content and between intelligence and attitude in the post-test. Data also showed significant difference existing between IQ levels in their attitude towards teacher-pupil relationship, in performing the processes, and in understanding the subject matter content in physical science. However, no significant differences existed between the treatment groups in the process and content post-tests, except in the attitude criterion measure.

A profile of the student whose change seemed to be attributed to the experimental curriculum is hereby presented.

1. The prospective elementary teacher who improved significantly her processes also improved her subject matter content. This finding was significant in the top, middle, and bottom students.

2. A student with a high IQ tends to improve her processes significantly. This is true with the middle and low IQ level groups. However, intelligence of the high IQ student was not necessarily a guarantee of process competence. As found in the study, the most competent students were not the most intelligent in the group.

3. The student with the high IQ was not necessarily the high achiever. There was sufficient evidence found in the top student whose intelligence and content competency were negatively correlated. However, a weak and insignificant positive correlation gain between intelligence and content existed in the middle and bottom students.

4. A high intelligence is not an index of a student's positive attitude towards teacher-pupil relationship. As found in the study, a negative correlation existed between intelligence and attitude in the top and bottom students on pre- and post-tests. However, a weak positive and insignificant correlation was indicated in the middle student.

5. The student who improved significantly her processes also improved her attitude on the post-test. This was found highly significant with the student in the middle IQ group, but not substantial with the top and bottom students.

6. The student who improved significantly her subject matter content also improver her attitude on the post-test. This finding was significant in the top, middle, and bottom students.

Implications for the Science Instructor

Some findings of this investigation are relevant to the college instructor. A science course integrating methods and content using a curricular innovation such as the process approach was indicated as effective in improving prospective elementary teacher's science competencies, although not improving significantly her attitude.

Since the revised elementary teacher education curriculum in the Philippines, which took effect in 1970, does not offer a separate elementary science methods course wherein the prospective elementary teacher would be acquainted with the "new" science, especially in the acquisition of the scientific processes, a science course integrating methods and content would be one answer to the present needs. Here the student is expected to develop the scientific processes in investigating scientific problems.

Another point of relevance to the science instructor was the findings that three groups of IQ (High, Medium, Low) stand to benefit in a curricular innovation, such as the process approach. This implies that it is not only the intelligent student who is expected to improve her science competencies but also the average and the below average student. This finding is noteworthy as it has been observed that some teachers refuse to teach the processes for the reason that their students are mentally poor. It should be noted, however, that a special effort should be undertaken to change student attitude in a positive direction.

Still another implication appears to be indicated. It would seem that similar teacher preparation institutions would achieve similar results if such a study were undertaken.

Implications for the Science Curriculum Specialist

The new revised elementary teacher science curriculum developed by the National Board of Education which took effect 1970-1971 school year was recently criticized by the Philippine Association of Science Teachers for not consulting science teachers and methods instructors in its revision for the reason that they are the very people who will have to implement it.[1]

An activity-centered science curriculum as revealed in the study, has brought significant changes in the prospective elementary teacher's science competencies. In the study, the experimental curriculum used was alloted four-hour weekly laboratory and two-hour lecture. Laboratory modules for developing individual processes was a major part of the curriculum.

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[1]Commission on Science Education in Teacher-Preparation Institutions, Philippine Journal of Science Teachers, VI (September-December, 1971), 24.

One criticism of the revised Philippine science curriculum has been the reduced allotment of time for the biological science course from six hours to three hours weekly and from two semesters to one semester. Furthermore, the physical science course has now been allotted one semester in the revised curriculum while still preserving its double periods to include laboratory activities. Earth and Space, a semester course, has been offered for the first time. This course is considered non-laboratory. From this revision, one cannot expect much activity in such limited time.

Also in the absence of a separate science methods course in the curriculum, a science course integrating content and methods would help prepare prospective elementary teachers to teach science as a process. Although the science methods course is integrated in the course, "Teaching the Elementary School Subjects," one cannot rely on having a methods instructor competent in all the elementary school subjects. It is the observation of the writer that the treatment of the science methods in the course is sadly neglected as methods instructors feel incompetent to teach it. These persistent pressing problems of teacher preparation would again pose challenging to the curriculum specialist who is expected again to revise the curriculum relevant to the needs of the elementary school teacher of the seventies.

Recommendations

The following recommendations are made as a result of the study.

Since the whole structure of the Philippine educational system is highly centralized and where the hierarchy of administrative policies and decisions rest on the Department of Education through its National Board of Education, it is hereby recommended that findings of this research study be studied and looked into with the end in view of improving the program of science education in the Philippines.

It is recommended that this research study be broadened and tested in other teacher-preparation institutions both private and public.

It is recommended that a similar study be conducted modifying certain variables used in the present study.

It is recommended that a study be conducted using other curricular areas to see if similar results would be obtained.

It is recommended that a study be conducted to see whether different kinds of laboratory activities are workable and effective with low IQ level in developing science competencies such as process and content.

It is recommended that intelligence and attitude test scales be constructed that would be more appropriate for prospective elementary school teachers in the Philippines.

As there is need for the training of more teachers in the field in the "new" science in the Philippines, it is recommended that the experimental curriculum used in the study be a part of an in-service training for elementary science teachers.

It is recommended that a longitudinal study be made of the participants of the study to see if gains in process and content are maintained over time.

Problems for Further Investigations

Results of the study would provide problems for further and more investigations.

The findings in this study point to the conclusion that an experimental curriculum has produced significant changes in the prospective elementary teacher's competencies. However the study was based on the old curriculum, two semesters' work of Physical Science (Science 2). Now that the curriculum has been revised and time allotted is cut in half, more research is needed to determine whether a one-semester of the course would just be as effective.

Further research is called for as to the cause of a negative and insignificant improvement of attitude of the subjects after the study. The writer did not include teacher variable, Philippine culture, family background, socio-economic status, and training of

students. However, only the top one-third student was found to have improved significantly in her attitude in the post-test. As it was revealed previously in the study that intelligence and attitude were not related, research along this line would be in order.

More research using another science course is needed for more conclusive findings. A similar study in a biological course or another science course using the process approach would be suggested.

The conclusions of the study have indicated that the process approach has brought significant changes in the students' competencies. More research comparing the process approach with another is needed to determine whether one method is better than the other.

Also, further research is called for to determine whether it was the experimental curriculum, the teacher variable, or other variables not included in the study that caused the significant improvement of the prospective teachers' science competencies.

In effect, this study was a gross study with many interactions producing gross changes. Further fine grain studies, using the same instruments, should be undertaken to see if one can isolate variables which produce changes.

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APPENDIX A

TABLE I: PRE- AND POST-TEST RAW SCORES OF PROSPECTIVE ELEMENTARY TEACHERS IN THE STUDY

AND

TABLE II: PRE- AND POST-TEST MEAN SCORES OF IQ LEVELS IN THE THREE CRITERION MEASURES

APPENDIX A

TABLE I

PRE- AND POST-TEST RAW SCORES OF PROSPECTIVE ELEMENTARY TEACHERS IN THE STUDY

Student	IQ Level*	Process		Attitude		Content	
		Pre	Post	Pre	Post	Pre	Post
1	H	19	42	-60	-13	29	39
2	H	20	40	-45	-56	26	41
3	L	11	34	-12	- 7	36	43
4	L	12	15	-18	-43	23	30
5	H	5	54	-30	-38	27	36
6	H	15	31	-36	-45	30	37
7	M	29	29	-34	-34	28	34
8	M	20	39	-45	-39	29	42
9	L	25	48	- 4	-11	31	35
10	M	37	47	-30	-25	39	47
11	H	15	41	- 5	- 1	29	40
12	H	17	44	1	30	34	40
13	M	10	22	-46	-52	28	41
14	M	4	13	-53	-60	13	25
15	M	23	42	-34	-19	26	44
16	H	31	36	-15	-10	26	39
17	M	23	30	-41	-43	41	44
18	H	35	40	-36	-41	32	38
19	M	11	39	-18	-24	36	40
20	H	15	30	-18	-12	38	44
21	H	27	45	-13	-13	28	46
22	H	31	40	-14	5	33	41
23	L	14	29	-23	-51	29	44
24	L	16	29	-50	-10	29	36

*IQ Levels: H--High; M--Medium; L--Low.

Table I.--Cont.

Student	IQ Level	Process		Attitude		Content	
		Pre	Post	Pre	Post	Pre	Post
25	L	15	19	- 3	-33	29	34
26	H	18	42	-14	- 8	28	29
27	M	12	18	- 4	-39	23	38
28	M	17	39	-48	-14	35	53
29	M	8	40	-32	-45	32	33
30	H	22	36	-44	-51	23	38
31	M	9	25	-14	9	31	33
32	L	17	25	- 2	- 4	22	30
33	H	20	49	- 7	-34	27	42
34	L	29	51	-24	-10	29	42
35	M	11	37	-28	-19	32	44
36	L	26	37	-36	-44	30	31
37	M	25	40	-14	0	38	47
38	M	23	41	-29	-41	32	43
39	H	33	42	7	- 1	33	34
40	M	4	23	-43	-40	27	32
41	M	22	38	-44	-28	33	34
42	H	24	36	-46	-41	30	31
43	M	30	42	-59	-38	26	36
44	L	14	27	-54	-58	14	30
45	M	32	54	-68	-52	31	39
46	H	4	31	-54	- 8	24	34
47	H	47	56	10	34	37	51
48	L	18	28	-13	- 5	27	28
49	L	3	30	-50	-48	21	30
50	H	17	36	-42	-25	29	35
51	M	23	40	-34	-13	30	31
52	L	12	19	-34	-63	24	31
53	L	19	25	-18	+ 4	32	33
54	L	17	32	-33	- 6	26	37
55	M	25	37	-14	- 7	31	42
56	L	14	32	-32	-50	21	24
57	H	42	46	-23	+ 7	40	59
58	L	30	32	-17	-25	34	46
59	H	9	22	-41	-32	26	29
60	L	10	23	-42	-53	14	24
61	H	13	32	-58	-37	33	40

Table I.--Cont.

Student	IQ Level	Process		Attitude		Content	
		Pre	Post	Pre	Post	Pre	Post
62	M	22	42	-11	-11	34	38
63	M	19	31	-61	-37	26	37
64	H	25	37	-32	-39	33	54
65	L	12	28	-27	-40	25	29
66	L	3	29	-32	-41	27	40
67	H	22	38	-34	-12	30	52
68	L	20	36	-39	-49	20	27
69	L	20	36	-49	-43	24	29
70	H	17	51	-41	-23	47	53
71	M	34	38	-43	- 8	33	35
72	H	19	37	-20	38	45	57
73	L	31	42	-43	-28	22	35
74	H	31	50	-13	-20	34	50
75	H	12	50	-12	-21	38	50
76	L	30	40	10	-14	35	44
77	H	27	36	-35	-14	31	47
78	M	11	36	-33	-75	30	36
79	M	34	42	-40	-28	34	36
80	M	20	22	-39	-71	22	37
81	L	14	32	-44	-55	24	32
82	L	15	21	-31	-31	24	26
83	L	6	26	-37	-33	26	32
84	M	8	29	-31	-39	23	33
85	H	24	25	-23	-43	24	27
86	M	9	30	-47	-30	30	35
87	M	21	27	-44	-66	26	31
88	L	27	31	-54	-58	22	34
89	L	10	33	-21	- 3	23	41
90	L	27	36	-22	- 5	34	42
Means		19.4	35.0**	-30.1	-27.0	29.11	37.9**
SD		9.15	9.16	17.17	22.58	6.05	7.27

**Significant at 0.05 level.

TABLE II

PRE- AND POST-TEST MEAN SCORES OF IQ LEVELS IN THE THREE CRITERION MEASURES

IQ Levels	IQ $\bar{X}$	Pre-Tests $\bar{X}$ Criteria Measures			Post-Tests $\bar{X}$ Criteria Measures		
		P	C	A	P	C	A
High	97.8	21.86	31.16	-26.43	39.83*	41.76*	-17.50*
Medium	81.6	19.40	29.63	-35.96	34.40*	38.00*	-32.96
Low	71.6	17.23	25.90	-28.46	30.83*	33.96*	-30.23
Overall $\bar{X}$	83.6	19.40	29.11	-30.31	35.00*	37.9*	-27.0

Legend:

P = Process measure
C = Content measure
A = Attitude measure

*Significant at 0.05.

APPENDIX B

A SYLLABUS OF THE EXPERIMENTAL CURRICULUM

(Physical Science)

APPENDIX B

A SYLLABUS IN PHYSICAL SCIENCE (SCIENCE 2)

(An Experimental Curriculum Combining Physical Science and Elementary Methods Course)

Cebu Normal College
Philippines

I. Brief Description of the Course

This experimental curriculum was constructed to combine Physical Science and Elementary Science Methods in the four-year elementary teacher curriculum in the Cebu Normal College, Philippines. Science Methods is incorporated in this course with the end in view of having students enrolled in the course (Science 2) acquire science skills in the new science and be able to teach science as a process.

The content of the experimental curriculum was organized around units in developing the processes and in learning concepts in physical science in the broad area of Matter, Energy, and Motion as found in the Elementary Science Curriculum Guides 1-6, of the Bureau of Public Schools, Philippines. Concepts and conceptual schemes developed around this area aim to develop the basic and integrated processes of observing, comparing, classifying, inferring, measuring,

formulating hypotheses, predicting, controlling variables, and experimenting. These are the processes taught in the elementary grades in the Philippines.

This teacher preparation program includes the following components which activities hopefully meet the goals of the course:

1. Lectures
2. Recitation laboratory
3. Modular laboratory
4. Peer-Group teaching
5. Independent study questions.

A. Lectures (2 hours a week)

The lecture portion of the course is reduced to 2 hours a week instead of the usual 3 hours of the old curriculum. Fewer topics are considered and emphasis is given on concepts formulated in the laboratory. Enrichment of these concepts and related concepts is further investigated in the students' independent study and in the lecture-discussion sessions.

B. Recitation Laboratory (2 hours a week)

Laboratory sessions are organized around a conceptual thread and in its development, scientific skills are acquired.

In this type of laboratory work, the class is divided into groups, investigating a series of problems using the process approach. Here the groups observe, measure, infer, interpret data, predict, control variables, and test hypotheses by experimenting.

C. Modular Laboratory (2 hours a week)

Modular exercises undertaken by students are highly individualized. They consist of self-instruction packages which aim to develop the processes. Most of these exercises are adopted from the process units of the science curriculum guides 1-6, which develop the basic and integrated processes.

D. Peer-Student Teaching

The objective of the peer/student teaching is to have students get the feel of teaching science as a process. Students in the group take turns demonstrating a concept or a process skill. Outstanding students may demonstrate in the Laboratory School. This is usually followed by a critique session by the class.

E. Independent Study Questions

The independent study involves questions intended to be examined in depth by students as a result of peer-peer discussions in lab sessions or peer-instructor interaction in lecture and lab sessions. Since fewer topics are considered in the lectures, this type of instructional module is in order.

II. Statement of Goals

A. Elementary Science Methods

An important objective in teaching this course is to have students be familiar with the new innovative programs, particularly that of the process approach which is the basis for the new innovative program in the elementary school science in the Philippines. The objectives are to have students acquire the process skills with the end in view of having them teach science as a process and hopefully change their attitude towards science; to orient students with common and cheap materials found in the community that are needed for teaching devices and aids in teaching the new science; to have students construct instructional materials which are behaviorally-oriented in line with the new program; to construct tests (paper-pencil types) and other evaluative measures; and to have students get the feel of teaching science as a process through peer-teaching or group-teaching experiences.

B. Physical Science Course

An important objective of the course is to have students develop concepts through the processes. Concepts are learned through laboratorized activities. These concepts are enriched through lectures and assigned readings. Acquiring process skills is attained in laboratory experiences.

III. Activities in Laboratory Sessions (4 hours a week)

A. Goals	Laboratory Modules
1. Acquiring Basic Processes	
a. Observing	Observing "creature" cards Observing mystery boxes/bags Observing mystery liquids Observing a birthday candle Observing containers having the same sounds Observing objects having the same smell Observing foods having the same tastes

Goals	Laboratory Modules
	Observing reaction of white powders subjected to liquid tests
	Observing wave pattern from a vibrating tuning fork
	Observing reflected and refracted light
b. Comparing	Comparing water and alcohol
	Comparing strips of paper
	Comparing density of liquids
	Comparing boiling points of liquids
	Comparing density of solids, liquids, and gases
c. Classifying	Classifying rocks/stones/soils
	Classifying leaves
	Classifying liquids
	Classifying buttons
	Classifying seeds
	Classifying reaction of white powders
	Classifying paper bags
	Classifying bottle tops
d. Measuring	Measuring volumes of liquids, solids, and gases
	Measuring lengths, widths, heights of objects
	Measuring weights of objects
	Measuring temperature of hot and cold liquids
	Measuring density of liquids, solids, and gases
e. Inferring	Inferring on causes of reduced mass of alka-seltzer mixed with water in a sealed container
	Inferring contents of mystery bags/boxes

Goals	Laboratory Modules
	Inferring causes of water drops forming at the sides of a cold glass Inferring causes of a suffocating candle Inferring on structure of an atom
2. Acquiring the Integrated Processes	
a. Hypothesizing	Formulating a working hypothesis on a suffocating candle Hypothesizing on the cause of rate of reaction of a substance Hypothesizing on the variables that affect the number of swings per unit time of a pendulum
b. Communicating Skills	Interpreting charts and graphs Locating points of location on x-y coordinates Graphing rate of flow of water from the hole of a container Graphing density of liquids Graphing density of solids, liquids, and gases Graphing the variables that affect the number of swings per unit time of a pendulum Graphing rate of reaction of a substance
c. Predicting	Predicting distance and number of washers in a beam balance Predicting height of bouncing balls Predicting rate of reaction of a substance by interpolation and extrapolation

Goals	Laboratory Modules
	Predicting burning time of a candle in different volumes of containers
d. Controlling Variables	Controlling variables in a swinging pendulum Controlling variables in rate of reaction of a substance Controlling variables that affect distance covered by a toy paper airplane
e. Experimenting	Investigating variables that cause different pitch of sounds Investigating the effects of heat energy on the rate of reaction of a substance Investigating the causes of increased acceleration of a moving body Investigating the causes of increased momentum of a moving body Investigating the effects of parallel and series circuits on brightness of light bulbs Investigating relationship of boiling points and density of liquids Investigating variables that affect the strength of an electromagnet Investigating relationship between distance and weight in a beam balance
3. Observing Children's behaviors in learning science	Writing anecdotal records of a child learning science as a process

Goals	Laboratory Modules
4. Making students have the feel of teaching science as a process	Students in a group take turns demonstrating a process or a concept Outstanding students may demonstrate a process or a concept in the laboratory school

B. Lectures (2 hours a week)

1. Elementary Science Methods

a. Objectives of Science Education in the Elementary School
b. Experimental Curriculum in Elementary Science

1) Basic information of the new Elementary Science Curriculum Using the Process Approach

a) Process and content
b) Orientation of the use of the Elementary Science Guides 1-6

c. Methods and Techniques in Science Learning

1) Process approach
2) Discovery approach
3) Inquiry techniques
4) Scientific methods

d. Instructional Materials in Elementary Science Teaching

1) Construction of behavioral objectives
2) Construction of lesson plans based on activities found in the Elementary Science Curriculum Guides 1-6

e. Construction of Simple Teaching Devices and Aids in Science Teaching in Line with the New Science Program

f. Construction of Tests (paper-pencil types) and other Evaluative Measures in Science Learning

2. Physical Science

   a. Matter and Energy

      1) Structure of Matter

         a) Electron theory
         b) Molecular theory

      2) Forms of Energy

         a) Wave
         b) Heat
         c) Mechanical
         d) Electrical
         e) Chemical
         f) Nuclear

      3) Conservation of Matter and Energy

         a) Einstein's Law

   b. Motion

      1) Motion and Forces

         a) Newton's three laws of motion

      2) Mass and Acceleration

      3) Balanced and Unbalanced Forces