

THE OEPC INQUIRY DEVELOPMENT PROJECT*

Principal Investigator:

Dr. Weerayudh Wichiarajote

Research Assistants:

Mongkol	Iemsam-arng
Bumroong	Boonyonk
Narin	Chamchumrus
Sura	Pratan
Samart	Srijumnonk
Somchai	Ongsuvana
Somsak	Soontornsuk
Tasanee	Kunawatanawuti
Tipa	Pechdee
Waraporn	Chai -o-pas
Yupha	Anandhasit

Educational Research Department, College of Education.
Sri Nakharinwirot University
Bangkok, Thailand.
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PREFACE

During the last decade, Thailand has undergone a rapid modernization through the processes of social economic and technological development. In this connection, the country has a great demand for qualified manpower.

The educational system is supposed to be the primary source for developing the qualified manpower. However, considering the quality of education which is mostly based upon rote-learning method, a fundamental question may be raised: Is the educational system qualified to develop the manpower for effective national de-

velopment? The answer, we are afraid, is negative.

This Research Project on "A Scientific Inquiry Model of Instruction" is an attempt to improve the quality of education at the grass-root level of teaching and learning processes. It aims at developing a teaching method which can liberate the vast human potentials through the expression of "thinking abilities", creativity and achievement motivation.

Through this research undertaking, we have found that the Investigative Method of inquiry (OEPC Inquiry) is a very promising approach to develop inquiry thinking skills, concept formation and creativity.

This Research Project has been generously supported by the Asia Foundation. We would like to express our deep gratitude and sincere thanks to the Asia Foundation for this kind support. We would like also to extend our thanks to all administrators, teachers and students who had cooperated with this Research Project.

Weerayudh and Colleagues
30 April 1975

SYNOPSIS

The Investigation Model of Inquiry (IMI) or OEPC Inquiry is the study under the **Inquiry Development Project** at Prasarnmit College of Education, Bangkok, Thailand. The Project started since 1970 by its principal investigator, Dr. Weerayudh Wichiarajote*, the College of Education**, Prasarnmit Road, Bangkok. OEPC Inquiry, as an approach or a style of instruction, attempts to encourage and promote the learner to think, to search and to investigate through the facts so that they will find the meaning of a certain degree of discovery, rather than let them merely perceive what they are supposed to **learn** according to the teacher's presentation in the class. Various teaching methods and techniques could be applied as much as suitable to reach the pre-set instructional objectives.

OEPC came from the basic research stages of **Observation, Explanation, Prediction** and **Control** as well as **Creativity** respectively. These stages of O, E, P and C are the main frameworks of the Investigation Model of Inquiry (IMI). That is the reason why **OEPC Inquiry** and **IMI** are the two phrases that are considered interchangeable as the name of this approach of teaching.

In order to find out about the effectiveness of the OEPC Inquiry in the real educational context and to obtain the much needed information in the development and implementation program of IMI in the future, including the effort concerning

the promotion of science teaching in the country, eleven studies of the first Pilot Project were carried on in 1971. This study was one of those eleven. Particularly, it was conducted mainly to determine whether the teaching of science by OEPC Inquiry would have improved the capacity of the pupils in the aspects of CREATIVITY, CONCEPT FORMATION and INQUIRY ABILITY.

After 12 weeks of the experimental treatment, the benefits from this OEPC Inquiry were found to be favorable toward improving the above-mentioned capacities. The researcher, however, suggested some more consideration and practical Research & Development program for this instructional strategy.

*Present position is at ACEID, UNESCO Regional Office for Education in Asia, Bangkok.

**Present name is Sri Nakharinwirote University

Chapter 1

INTRODUCTION AND HYPOTHESES

1. Background

If Science Education is to play a major role in economic development of the country, then the instructional technology especially the one for the improving of the teaching of science should be considered, researched and developed more so ever. We should have more ideas, techniques and approaching frame works to select and apply to the extent that we might have the best optimal treatment for the science teaching for developing technologically competent manpower required for the achieving of development goals. To this end, an inquiry approach is recommended. One of the Inquiry Process that has been studied and developed in the **Inquiry Development Project** is the **Investigation Model of Inquiry**. Dr. Weerayudh Wichiarajote proposed an **OEPC Inquiry** for the **Investigation Model of Inquiry** which is an act of seeking truth, information or knowledge about the nature, the characteristic and the relationship among variables in existing phenomena. Generally speaking, the main principles of IMI are **to make a searching Inquiry*** first, to find the underlying variables; and **to make a systematic process of investigation**** afterwards; to find the relationships so that we could proceed into the utilization stage of maximizing the desirable effects: by controlling some specific independent variables in such a way that they would effect the dependent variables in a way we want them to be.

The functions of OPEC in making a **searching inquiry** and a **systematic process of investigation** are shown in the following diagram.

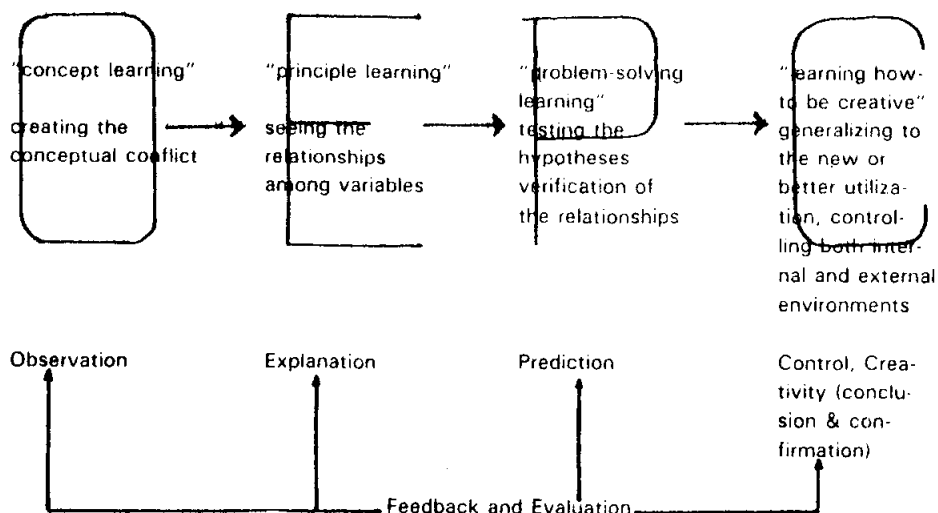


Diagram 1. The functions of O, E, P and C stages of Inquiry.

*"Suab suan" in the Thai language.

*"Saub suan" in the Thai language.

To apply the main principle of IMI as the fundamental approach to teaching, we will simply call it, the IMI approach of instruction, - i.e. the OEPC-Inquiry approach of instruction, hereafter. As seen in Diagram 1 and Diagram 2, such an approach of instruction seeks to develop and improve various cognitive styles and cognitive structures by the application of and suitable methods and techniques (as shown by the outermost circle of Diagram 2) and by providing the ADVANCE ORGANIZER, as a basic foundation for accommodating the discovery or learning of something new and necessary, and as the enhancement of Cognitive Motivation so that the learning could be pursued to reach the level of Mastery Learning. While, $Y = f(x)$ in the center of the circle emphasizes an investigation to seek for a discovery of the relationships among the variables concerned.

Then, the immediate research problem is whether it will be true that the OEPC Inquiry approach would enhance the pupils' identity and abilities in such a prescribed way; if it's true, then how could we seek the compromisation, afterwards, between the values that are good for the creation of the active cognitive-oriented society which the OEPC Inquiry would likely to improve and the values that pertain to the traditional trend. This is the problem of how to harmoniously

introduce an educational innovation into the existing educational and social system. And also, in accordance with the effort concerning the promotion of teaching of Science in the country that inspired the researcher to conduct his study to examine the effects of OEPC Inquiry approach on the dependent variables of Creativity, Concept Formation and Inquiry Ability, How to harness the potential transformation power of science and technology in national development.

Purposes of the study

1. To study the effects of IMI (OPEC Inquiry) as a teaching approach on Inquiry Ability, Concept Formation and Creativity.
2. To study the relationships among Inquiry Ability, Concept Formation and Creativity.

2. *Scope of the study*

Sampling

3 classes of the 7th graders in the purposively selected school in Bangkok (197 1) were the subjects of this study. They were as following:

Control group	21 boys 17 girls 38 S's
Experimental group I	22 boys 15 girls 37 S's
Experimental group II	18 boys 15 girls 33 S's
Total	61 boys 47 girls 108 S's

The Investigation Model of Inquiry ;

An Interactive Integration

(As designed by Dr. Weerayudh Wichiarajote
Department of Educational Research
College of Education
Bangkok, Thailand
2515)

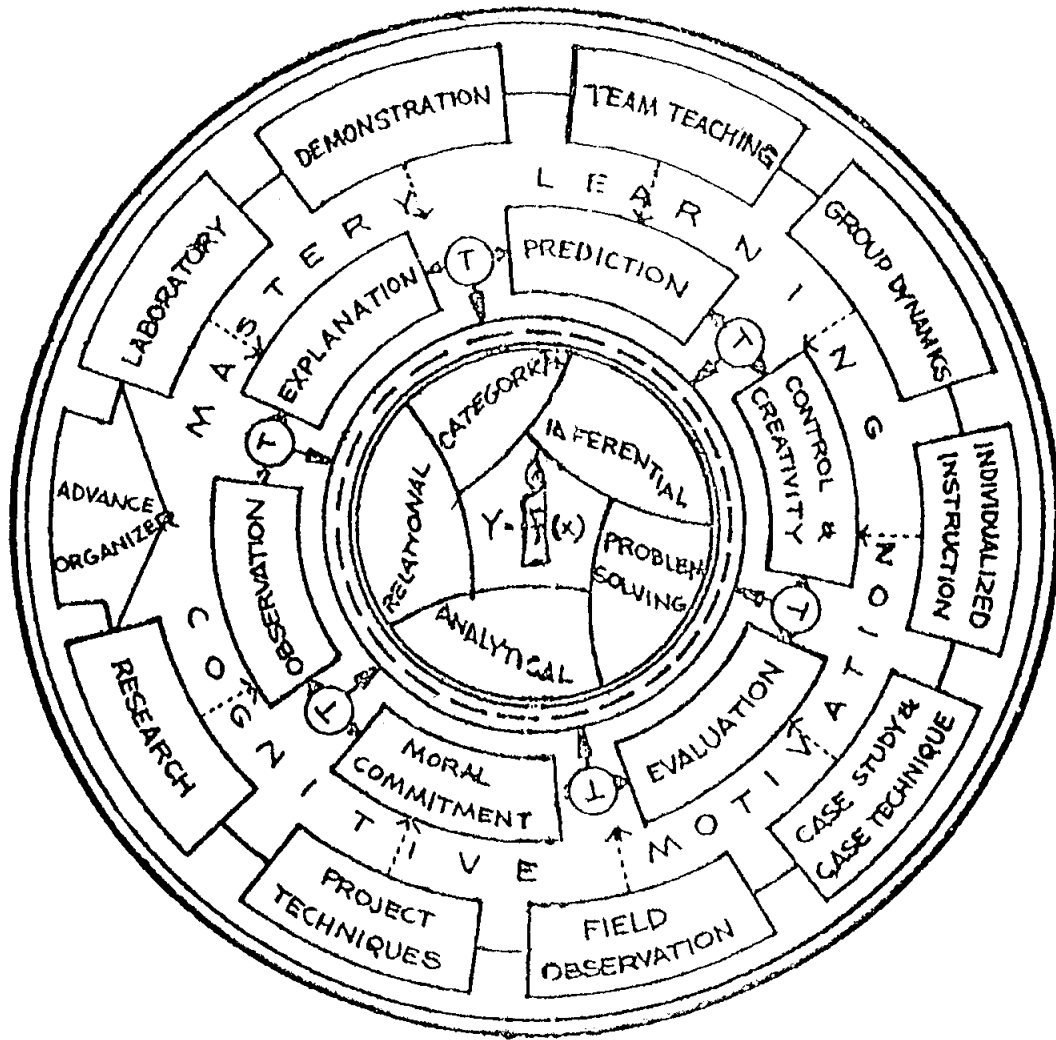


Diagram 2

โครงสร้างความคิดแสดงการปฏิสัมพันธ์ของการสอนแบบสืบสวนสอบสวน

Variables

(1) The independent Variable was the style or approach of teaching. The experimental group was treated by IMI (OEPC Inquiry) style of teaching while the Control group was the Non-IMI Style of teaching. The utilization of abstract and concrete things to teach the two Experimental groups was the same, but the visual symbol of the first experimental group was with charts and pictures, while the second's was with slides, which were the reproduction of the aforementioned charts and pictures.

(2) Dependent Variables were the abilities in three aspects, namely: Inquiry Ability, Concept Formation and Creativity. These abilities, herein, were defined as the resulted scores from the following tests

- (2.1.) Inquiry Ability tests
- (2.2.) Concept Formation tests
- (2.3.) Creativity tests

Terminology, Basic Assumptions and Operational Definitions

The researcher prescribed the terminologies that had been used as the variables in this study. Those were IMI style of teaching, that referred to the application of OEPC Inquiry principle in science teaching;

Non-IMI style of teaching, that referred to any MODEL of teaching that did not apply OEPC Inquiry Principle in teaching;

Inquiry Ability, that was general category of questioning ability which was elicited and shown as the responses from Inquiry Ability tests;

Concept Formation, that was the ability related to the Discriminative Response from the various stimuli presented by the Concept Formation Tests, here, not the one of Piaget's Conservational concept from the genetic Epistemology points of view;

Creativity, that was the ability to seek the ways to solve the problem from various possible ways from the facing stimulus and the ability to see new things, new forms and new applications from some related characteristics of the stimulus. And the stimuli were the creativity tests.

3. Theories and Related Literatures

According to Dr. Weerayudh Wichiarajote OEPC Inquiry is based on the following foundations. Philosophical foundation emphasizes the philosophy of IMI as the process-oriented (more than the product-oriented) approach of instruction.

Psychological Foundation bases on the human cognitive development of Jean Piaget, the function of the optimal discrepancy and the conceptual conflict

with the accommodating advance organizer as one of enhancing the cognitive motivation. The **Piaget's** concept of disequilibrium and the two cognitive processes of assimilation and accommodation were the foundations of the assimilative structure and accommodative structure of **IMI** approach of teaching. With the creating of conceptual conflict that is suitable to the advance organizer provided for the pupils, their cognitive structures would progress through the structures of Assimilation and Accommodation and reach to a certain degree of discovery. The teacher has to expand his responsibility not only as the disseminator of the information but also as the big helper, the coordinator, the guide etc. as to help make the pupils **THINK** more, to find more Meaning of their learning.

Research Foundation of the **IMI** could be seen through the stages of O, E, P and C. O is the same as the Concept Formation or the **Concept Learning Process**, that leads to the next processes of research. E is the same as Theorization Process, the one of Principle Learning, that would identify the relation among variables or concepts. The theoretical construct could be expected here. P is the Verification Process to test and verify the proposed theory (hypothesis). With more new information collected we could test whether the proposed hypothesis could predict the new conditions or not; whether the data reveal that the new conditions agree with the pre-set hypothesis. C is the controlling & Creativity Process. It's the generalization of the learned information and process to the new and various utilizations and also to the new ways of starting, again, the next investigation. The application of the information theory in **IMI** is to be seen largely at the O stage. Since the teacher would try to encourage the student to observe and hypothesize as much as possible he then will answer only as "yes" or "no". If the pupil's question is not clear enough, it's the teacher's turn to **probe** with the questions like, "think of the other aspects too", "there should be more than that" or "does it depend on" etc. In light of the Information theory, the questions that require "yes-or-no" answers of the pupil are with the very high efficiency in searching for the information

The main processes in **IMI** approach of instruction were summarized as follows :-

- (1) Advance organizer; the process that tries to relate the entry behaviors of the pupils with the likely-to-happen learning process, the amount and detail of this process depend on both the condition and character of the pupils and the condition and character of "what" to be learned as well.
- (2) Learning environment setting and observation; the process that pupils are stimulated to observe the facing phenomena, to look for the defining characteristics, to observe and think analytically till the conceptual conflict occurs.

Teachers are to encourage the pupils to seek for the information, to ask the question that requires "yes-or-no" type of answer. That is to train the pupil to think as well as to seek the answer by dividing the answering possibility into

two and eliminating the half that is not used. On doing this, sequentially, the "right half" will be smaller and smaller and will help the pupils a lot in seeking the right information and in training to think.

(3) Explanation, the process that pupils are "catalysed" to find the explanation of the "conceptual-conflict" problem, or observe more to find the more necessary defining characteristics from the information-seeking process, the experiment, the observation of some demonstrations etc. to set up the proposed explanation. The explanations are likely to come in the form of antecedent · consequent or cause-effect relationship, $y = f(x)$.

(4) Prediction, the process that pupils try to verify the proposed explanation (hypothesis), i.e., the using of the relational principle from the hypothesis to predict the phenomena in the other condition. The question used to verify the proposed explanation would be in the form of; "If $..(x)..$ then $..(y)..$? In science class this process is very much apt to the introduction of experiment or demonstration to test the hypothesis.

(5) Controlling, Creativity, Conclusion and Confirmation, the process that pupils are to conclude or confirm the proposed explanation relationship; and apply the principle into use, to control the new condition (independent variable) to create the needed result, or set up new conceptual conflict to start the process of observation again. When the pupils could investigate till they "discover" some reliable relationship, they, then, come to the point where they are prompted to create something or some idea that is suited to their level.

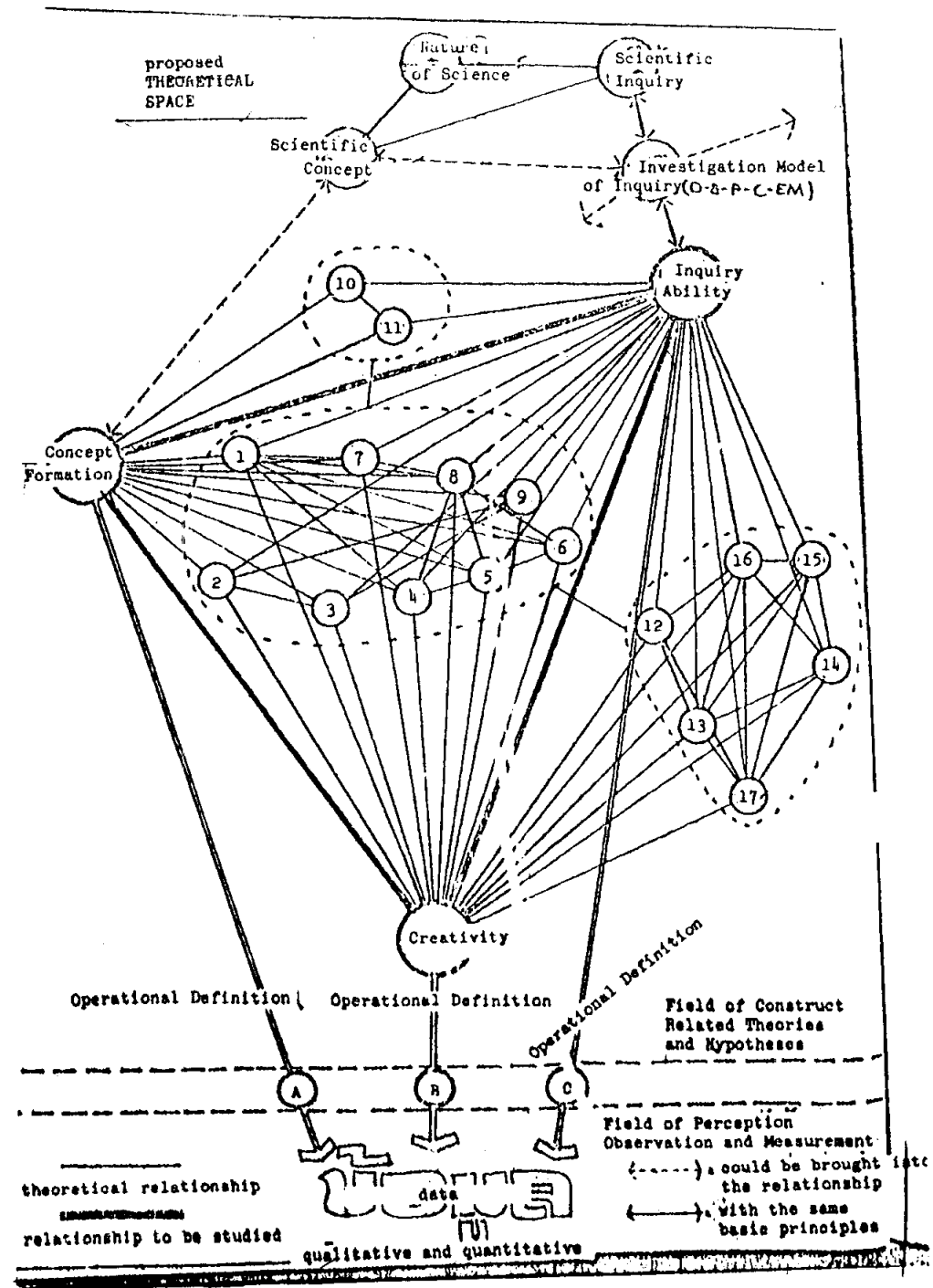
As the member of the study-group of the IMI approach of teaching, the researcher and his colleagues, hoped that the result and feedback from the studies, and the other studies to come, would provide a lot of information in developing and improving the TECHNIQUES that will best suit this STYLE of teaching in the future.

4. Theoretical Space

From the theories and related literatures, the researcher had set up the theoretical space for the proposed explanation of the afore-said variables and some principles as shown in the next page.

This theoretical space indicated the relationships among nature of science, science concept, scientific inquiry, the Investigation model of inquiry and the Inquiry ability. It also indicated the proposed relationships among Inquiry Ability, Creativity and Concept Formation. That these three variables seem to have many common characteristics, for example, they are concerned with th'a cognitive structure (1), the interpretation (2), the abstraction (3), the activeness and ability to learn (4), the reasoning (5), the imagination (6), etc., in order that they would seek the way to solve the problem (7), and the environments that are likely to

enforce those ability were the reinforcement (8), the respect of the individual's ability (9) and so forth. As for the Concept Formation, it also requires the discrimination (10), and classification ability (11); which both, in turn, are two of the main characteristics of Inquiry Ability as well. The Creativity, besides those 8 properties, also shows the diversity (12), that would lead to the discovery (13), which the requirements of the independency (14), freedom (15) to express savely, (16) and the feeling of confidence



to think (17). These 6 properties are the same as the one of Inquiry ability as well . Anyway, the indication like that is just the one of the variable - constructs from theories and hypotheses. We still need the Tests (A, B and C) as the instruments, to test and elicit responses from the pupils, according to the operational definitions of the test constructions, to measure and observe the data so that we could test or verify this indication from the theoretical space, later on.

5. Hypotheses

From the theoretical space and related literatures, the research hypotheses for this study were :

1. Concerning Inquiry Ability

- 1.1 The experimental groups should improve on the Inquiry Ability.
- 1.2 The control group should improve on the Inquiry Ability to a lesser extent.
- 1.3 The experimental groups should show higher level of Inquiry Ability than the control group.
- 1.4 Both experimental groups should show no difference in Inquiry Ability from each other.
- 1.5 The experimental groups should show the better increment of Inquiry Ability than the control group.
- 1.6 Both experimental groups should show no difference in the increments of Inquiry Ability.

2. Concerning the Creativity

- 2.1 The experimental groups should improve on the Creativity.
- 2.2 The control group should improve on the Creativity to a lesser extent.
- 2.3 The experimental groups should show higher level of Creativity than the control group.
- 2.4 Both experimental groups should show no difference from each other in Creativity.
- 2.5 The experimental groups should show the better increment of Creativity than the control group.
- 2.6 There should be no difference between the increments of Creativity of both experimental groups.

3. Concerning Concept Formation

- 3.1 Every group should improve on the Concept Formation.

- 3.2 The experimental groups should show higher level of Concept Formation than the control group.
 - 3.3 There should be no difference between two of the experimental groups.
 - 3.4 The experimental groups should show better increments of concept Formation than the control group.
 - 3.5 There should be no difference between the increments of Concept Formation of both experimental groups.
4. Concerning the relationships among those three variables. The relationships among those three variables should be positive.

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Chapter 2

RESEARCH PREPARATION AND PROCEDURE

Preparation

Eleven graduate students under the Inquiry Development Project had started working in the research preparation with the Principal Investigator, Dr. Weerayudh Wichiarajote, and other advisors since as early as October, 1970. The preparations, in brief, were as the followings:-

1. Workshop concerning IMI theory, the teaching of science, research methodology and related theories.
2. Curriculum Analysis including the analysis of the educational objectives, the instructional objectives, and content analysis both for the 7th graders and from the 1st to the 6th grades.
3. The Teaching Model including the purposes and objectives, content, advance organizer, the concept that was expected to be discovered, materials, teaching and learning behaviors, the evaluation and/or the special comment.
4. Micro teaching and preliminary feedbacks.
5. Material selection and preparation.

5.1 Instructional Materials

Based on the teaching model, some of the materials were made by the members of the group, some of the materials were borrowed from the Chemistry Department, the Physics Department, College of Education, Prasarnmit Road; or from the other schools in Bangkok.

5.2 Testing Materials

Testing Materials that were used in this study including, Creativity Test, Concept Formation Test and Inquiry Ability Test.

Creativity Test

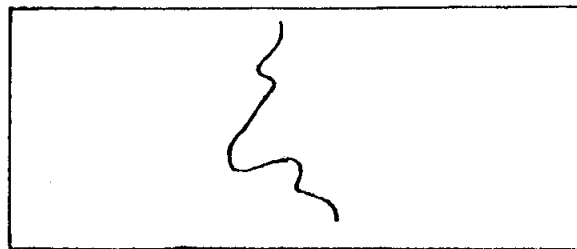
2 from 5 subtests for Creativity of Sawai Liamkaew, which were adapted from the one of Wallach & Kogan, were selected for this study. They were the subtests of similarity and the subtest of Line-meaning.

The subtest of Similarity

It was the test that required pupils to recall and compare the similarity and the difference of each given pair of things, like: "a train and a tractor". There were 10 such pairs in this subtest that the pupils were given 55 minutes to write down as much as possible the similarity and the difference they could recall.

The subtest of Line-meaning

It was the one that required pupils to consider while looking at the given line; what the line, like the example below, could be or what it looked like.



There were 8 such a line in this subtest that the pupils were given 55 minutes to write down as much as possible "the meaning" they could think it out.

Scoring Criteria

They were "Objectivity" and "validity"

The objectivity meant every subject's answer sheet was scored by the same criterion conditions. The validity meant the one towards the operational definition or the construct of Creativity, i.e., 1 point per 1 direction of meaning.

Sawai Liamkaew also used another kind of "identity score" but this kind of scoring was not employed in this study.

Test Reliability

Sawai Liamkaew (2514: 25) and Orathai Sethsakko (2514: 32-33) reported the reliability that:

Similarity Subtest was with the reliability of .900 (Sawai) and .881 (Orathai). Line-meaning Subtest was with the reliability of .894 (Sawai) and .910 (Orathai).

Concept Formation Test

2 subtests for Concept Formation of Niti Suwankiri (2515: 24-34, 100-117) were used in this study. They were the verbal tests which based on the idea of Underwood and Richardson; and the geometrical-form test which based on the one of Tagatz.

The Verbal Test

There were 20 items of verbal concept test. The pupils had to consider the main attribute of the focus word and used that attribute to select 3 from the other 6 words which possessed the same attributes. They were required also to write down that attribute in the answer sheet along with the three words selected.

The Geometrical-Form Test

There were 8 items of geometrical-form test. The pupils had to concentrate on the 4 attributes of the focus card, each attribute was with two characteristics. Those were shown in the table below:

Attribute	Characteristic
Form	quadrangle, triangle
Number	one, two
Color	red, green
Frame	one line, two lines

Only one characteristic would be intended to represent the "correct concept" for each item.

While concentrating on the focus card, the pupils had to recognize well which and which characteristics were in that focus card. Each of the next coming 2nd, 3rd and 4th card would eliminate one characteristic consequently so that the "correct concept" was concluded as the answer, at last.

Scoring criteria

The Verbal Concept Test score was just only one category of "Verbal Score", while there were as much as 4 categories of the geometrical-form test. Those four were the Ideal Strategy, Conservative Strategy, Perceptual Error and Correct Answer-Types of scoring.

Ideal Strategy


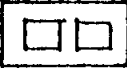
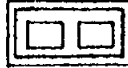


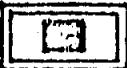







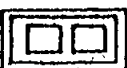
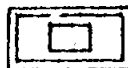

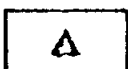
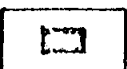
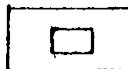



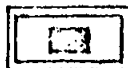

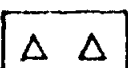
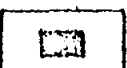
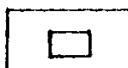
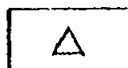

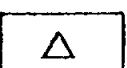
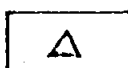
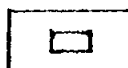

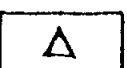
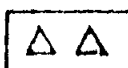


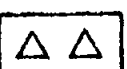
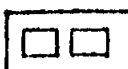


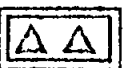

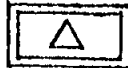
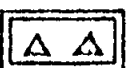
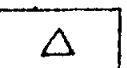
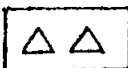
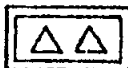
The possibility of getting this Ideal Strategy score was when the answers of each following 2nd, 3rd and 4th card were in the scope that led to the Correct Answer.

Conservative Strategy

The possibility of getting this score was both the same condition as the possibility of getting the Ideal Strategy Score and also when the answers of each following 2nd, 3rd and 4th card were in the scope that were related with the attributes of each card.

Perceptual Error

The possibility of getting this score was when it could not be applied with the criteria of both the Ideal Strategy and the Conservative Strategy to the answer of any card.

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Correct Answer

This score would be obtained when the pupil wrote down the "Correct Concept" for each item in the answer sheet.

Each category of scoring provided 1 point once it occurred.

Test Reliability

Category	After It was produced as a slide-set		
	Niti	r_{tt}	Coef. alpha
Ideal Strategy	.825	.8169	.7179
Conservative Strategy	.854	.7846	.6150
Perception Error	.843	.7901	.5673
Correct Answer	—	.7821	.6674
Average: r (by Fisher's Z table)	—	.7932	.6459

Inquiry Ability Test

2 subtests of Inquiry Ability Test of Boonluu Tongyoo (2514) and Orathai Sethsakko (2514) were employed for this study. They were the subtests of picture and passage.

The Subtest of Picture

The pupils were required to write down the questions as much as possible from 10 black and white pictures of 6" x 9" in 50 minutes.

The Subtest of Passage

The pupils were required to write down the questions as much as possible from 10 sheet passages in 50 minutes.

Scoring Criteria

1. One point would be given to every question according to the criterion of the **Number of Question**.
2. One point would be given to every question of Observation process. Two points, three points and four points would be given to every question of Explanation Process, Prediction Process and Control Process, respectively. These were the criteria of the **Characteristic of Question**.

Test Reliability

The reliability of tests, by the split-half technique, of the picture subtest = 0.8877, of the passage subtest = 0.8767.

Test Construct-Validity

- positively related ($p < .01$) with Creativity and Scientific Achievement.

- Internal consistency .94 - .96
- When divided the group of subjects into three groups of higher, medium and lower and administered the test; the difference between higher and medium and medium and lower groups were all significant at .01 level.

Procedure

The experimental procedure included the process of Pretest, Treatment and Posttest of two experimental groups and one control group.

All groups studied the same subject matter content in the topics of Energy, Fuel, Electricity and Life on Earth. The treatment had been done in the second quarter of 1971, 3 times a week for 12 weeks.

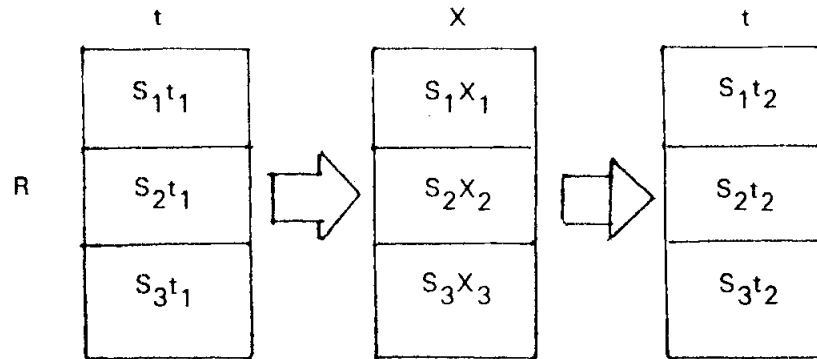


Diagram 3 The Experimental Design

- R = Random Sampling
- S₁ = Control group
- S₂ = Experimental group 1
- S₃ = Experimental group 2
- t₁ = Pretest
- t₂ = Posttest
- X₁ = Non-IMI approach of teaching
- X₂ = IMI approach of teaching - Exp. 1
- X₃ = IMI approach of teaching - Exp. 2

Data Analysis Design

- (1) The test of difference between pretest and posttest scores of each variable by using the t-test (dependent measures) technique (MacNemar, 1950: 109).
- (2) The analysis of covariance of Pretest and Posttest scores. In case that there was a significant difference between group means, the critical ratio would be

computed by the adjusted value of posttest mean score, that had been adjusted through the correlation coefficient of the regression of posttest mean score on the pretest mean score, in order to test the difference between two particular groups by t-test (adjusted mean) technique (Lindquist, 1956: 317-327).

(3) The one-way analysis of Variance-Simple Randomized Design (Lindquist, 1956: 56) of the increment of each variable computed by the difference between posttest and pretest scores. If the significant difference between groups was found, again, the critical ratio of the increment scores would be computed, in order to test the difference between the increment in each variable of the two particular groups, by t-test (independent) technique (Edwards, 1958: 104).

(4) The correlation coefficient among variables, by the Product Moment Correlation technique (Garrett, 1956: 143).

Related References from Chapter 2

- | | |
|------------------------------|--|
| Andersen, 1972: 11, 49-54 | (the Thai language) |
| Keisler, 1960: 310-315 | Inquiry Development Project 2513- |
| Thorndike, 1971: 411-415 | Orathai Sethsakko, 2514 |
| Weigand, 1971: 5-7, 42-80 | Boonluu Tongyoo, 2514 |
| Cochran, 1963: 11 | Sawai Liamkaew, 2514: 18-22 |
| MacNemar, 1959: 109 | Niti Suwankiri, 2515: 24-34, 100-117 |
| Lindquist, 1956: 56, 317-327 | Somphong Siricharoen et. al. 2506: 179 |
| Edwards, 1958: 104 | Waraphorn Chaiopas, 2515 |
| Garrett, 1966: 143 | Pote Chantaraweerakul, 2515: 27 |
| | Kaw Sawastdipanitch, 2514: 36 |
| | Weerayudh Wichiarajote, 2513 A:75 |
| | Chaowana Yuthasuriyaphan, 2514: 21-100 |

Chapter 3

Results

Only the data from sample subjects that completed every set of 76 pupils were analysed, and the finding will be illustrated here, later on.

1. Concerning the Inquiry Ability

- Hypothesis 1.1 was confirmed. The experimental groups had made a progress in Inquiry Ability. (Table 1. & 2.)

Table 1. Pretest average scores (\bar{X}) and Posttest average scores (\bar{Y}) from

Inquiry Ability tests of the experimental group 1.

Scores	\bar{X}	\bar{Y}	\bar{D}	$S\bar{D}$	t
Number of Questions from PicTure subtest	54.6923	99.3846	44.6923	5.4476	8.2041**
Characteristic of Questions from PicTure subtest	85.7308	156.5769	70.8462	8.1240	8.7206**
Number of Questions from PasSage subtest	68.8846	78.5385	9.6538	3.3613	2.8721**
Characteristic of Questions from PasSage subtest	91.8077	114.3846	22.5769	5.3130	4.2494**

** ($p < .01$)

Table 2. Pretest average scores (\bar{X}) and Posttest average scores (\bar{Y}) from Inquiry Ability tests of the experimental group 2.

Scores	\bar{X}	\bar{Y}	\bar{D}	$S\bar{D}$	t
NQPT	50.9565	78.0000	27.0435	4.3025	6.2855**
CQPT	73.2174	123.1304	49.9130	5.6105	8.8963**
NQPS	55.1304	67.3913	12.2609	3.1152	3.9358**
CQPS	81.3913	99.4348	18.0435	5.3751	3.3569**

** ($p < .01$)

- b. Hypothesis 1.2 was not supported by the data. The control group also made a progress in Inquiry Ability. (Table 3.)

Table 3. Pretest average scores (\bar{X}) and Posttest average scores (\bar{Y}) from Inquiry Ability tests of the control group

Scores	\bar{X}	\bar{Y}	\bar{D}	$S\bar{D}$	t
NQPT	76.8889	100.8889	24.0000	5.0550	4.7478**
CQPT	114.3333	141.1852	26.8519	7.4326	3.6127**
NQPS	18.0370	85.1852	17.1481	2.4499	6.9995**
CQPS	91.0370	111.8889	20.8519	3.5408	5.8889**

** ($p < .01$)

- c. Hypothesis 1.3, "the experimental groups should show higher Inquiry Ability than the control group", was confirmed by the difference in the number of questions from Picture subtest (NQPT) and the characteristic of questions from Picture subtest (CQPT), between the experimental and control groups (Table 4, 5, 6 & 7).

Table 4. The analysis of covariance of NQPT scores

sources of variation	ss _x	sp	ss _y	ss _y	df	ms _y	F
between groups	10155.6278	5789.0457	7899.9690	4796.8519	2	2398.4259	3.9244*
Within groups	34811.1616	25312.7436	62408.8205	44002.7991	72	611.1500	
total	44966.7895	31099.7895	70308.7895	48799.6509	74		

* (p < .05)

Table 5. The comparison of NQPT scores between groups, after the adjustment by the regression of \bar{Y} on \bar{X}

$$b_w = \frac{25312.7436}{34811.1616} = 0.7271$$

Samples	n	\bar{X}	\bar{Y}	\bar{Y}	t
exp.1	26	54.6923	99.6179	104.2961)	2.6316*
exp.2	23	50.9565	78.9496	85.6278)	
control	27	76.8889	100.8889	89.6614)	- .5162
exp.1	26	54.6923	99.6179	104.2961)	-1.9773*

* (p < .05)

Table 6. The analysis of covariance of CQPT scores

sources of variation	SS _X	sp	SS _Y	SS _V	df	ms _Y	F
between groups	22602.1296	6292.3866	13663.9679	16710.8416	2	9366.4207	7.0539**
within groups	77113.0284	64337.7196	149171.0289	96492.1338	72	1326.2796	
total	99716.1679	69630.1063	162824.9868	114202.9763	74		

. * (p < .01)

Table 7. The comparison of CQPT scores between groups, after the adjustment by the regression of Y on \bar{X}

$$b_w = \frac{64337.7196}{77113.0284} = 0.9343$$

Samples	n	\bar{X}	\bar{Y}	\bar{Y}	t
control	27	114.3333	141.1862	122.6403)	-3.6734** 2.1800* 1.3941
exp.1	26	86.7308	166.6769	161.8960)	
exp.2	23	73.2174	123.1304	138.8884)	
control	27	114.3333	141.1862	122.6403)	

. (p < .05)

** (p < .01)

But this hypothesis was not supported by the data from Passage subtest (Table 6 & 9).

Table 8. The analysis of covariance of NQPS scores

sources of Variation	ss _x	sp	ss _y	ss _y	df	ms _y	F
between groups	2856.3008	3030.9016	3972.9335	1011.5733	2	505.7866	2.5356
within groups	33706.2255	25281.2563	33324.0139	14361.8812	72	199.4706	
total	36562.5263	28312.1579	37296.9474	15373.4545	74		

Table 9. The analysis of covariance of CQPS scores

sources of variation	ss _x	sp	ss _y	ss _y	df	ms _y	F
between groups	1619.4545	2224.6420	3083.4747	576.6218	2	288.3109	.5313
within groups	57408.4797	44964.1211	74288.4727	39071.1633	72	542.6550	
total	59027.9342	47188.7632	77371.9474	39647.7851	74		

- d. Hypothesis 1.4, "the experimental groups themselves should show no difference in Inquiry Ability", was not supported by the data from the Picture subtest (Table 4, 5, 6 & 7). But was confirmed by the data from the Passage subtest (Table 8 & 9).
- e. Hypothesis 1.5, "the increment of Inquiry Ability of the experimental groups should be higher than that of the control group", was confirmed by the data from Picture subtest (Table 10, 11, 12 & 13). But was not supported by the data from Passage subtest (Table 14 & 15).

Table 10. The analysis of variance of the increment of NQPT scores

Sources of variation	ss	df	ms	F
between groups	6481.5050	2	3240.7525	5.0773*
within groups	46594.4950	73	638.2808	
total	53076.0000	75		

* (p < .05)

Table 11. The comparison of the increment of NQPT scores

Samples	n	\bar{D}	S^2	t
control	27	24.0000	689.9231)	-2.7844**
exp.1	26	44.6923	771.5815)	
exp.2	23	27.0435	425.7708)	2.5424*
control	27	24.0000	689.9231)	.4585

* (p < .05)

** (p < .01)

Table 12. The analysis of variance of the increment of CQPT scores

sources of variation	ss	df	ms	F
between groups	25671.3161	2	12835.6581	9.5996**
within groups	97608.6181	73	1337.1044	
total	123279.9342	75		

** (p < .01)

Table 13. The comparison of the increment of CQPT scores

samples	n	\bar{D}	S^2	t
control	27	26.8519	1491.5926)	-3.9955**
exp.1	26	70.8462	1715.9754)	
exp.2	23	49.9130	723.9921)	2.1202*
control	27	26.8519	1491.5926)	2.4764*

** (p < .01)

* (p < .05)

Table 14. The analysis of variance of the increment of NQPS scores

sources of variations	ss	df	ms	F
between groups	767.4311	2	383.7155	1.7010
within groups	16467.7268	73	225.5853	
total	17235.1579	75		

Table 15. The analysis of variance of the increment of CQPS scores

sources of variations	ss	df	ms	F
between groups	253.6452	2	126.8226	.2217
within groups	41768.7101	73	572.1741	
total	42022.3553	75		

- f. Hypothesis 1.6, "the increment of Inquiry Ability of both experimental groups should not be different", was not supported by the data from Picture subtest (Table 10, 11, 12 & 13). But was confirmed by the data from the passage subtest (Table 14 & 15).

2. Concerning the Creativity

- a. Hypothesis 2.1 was confirmed. The experimental groups had made a progress in Creativity (Table 16 & 17).

Table 16. Pretest average scores (\bar{X}) and Posttest average scores (\bar{Y}) from Creativity tests of the experimental group 1

scores	\bar{X}	\bar{Y}	\bar{D}	\bar{SD}	t
similarity	36.2308	51.2692	15.0385	1.6802	8.9505**
line-meaning	40.3462	55.9615	15.6154	3.0215	5.1681**

** (p < .01)

Table 17. Pretest average scores (\bar{X}) and Posttest average scores (\bar{Y}) from Creativity tests of the experimental group 2

scores	\bar{X}	\bar{Y}	\bar{D}	SD	t
similarity	32.2174	41.0000	8.7826	2.0898	4.2025**
line-meaning	31.7391	46.4348	14.6957	4.1800	3.5157**

* ($p < .05$)

** ($p < .01$)

- b. Hypothesis 2.2 was confirmed if we considered the whole data in comparison with the data of the experimental groups, but if we considered subtest by subtest, the data from Similarity subtest still confirmed the hypothesis while the one from Line-meaning subtest showed the deviant. (Table 18)

Table 18. Pretest average scores (\bar{x}) and Posttest average scores (\bar{Y}) from Creativity tests of the control group

scores	\bar{X}	\bar{Y}	\bar{D}	SD	t
similarity	45.4926	48.1852	2.5926	1.8345	1.4132
line-meaning	34.6296	46.4815	11.8519	1.9094	6.2070**

** ($p < .01$)

- c. Hypothesis 2.3, "the experimental groups should show higher Creativity than the control group", was confirmed by the data from Similarity subtest (Table 19 & 20). But was not supported by the data from Line-meaning subtest (Table 21)

Table 19. The analysis of covariance of Creativity scores from Similarity subtest

sources of variation	ss _x	sp	ss _y	ss _y	df	ms _y	F
between groups	2398.0583	842.8678	1339.4816	1388.1734	2	694.0867	8.3487**
Within groups	8697.0469	6782.4217	11275.1895	5985.8949	72	83.1374	
total	11085.1052	7635.2895	12614.6711	7374.0683	74		

** (p < .01)

Table 20. The comparison of average scores from Similarity subtest after the adjustment by the regression of \bar{Y} on \bar{X}

$$b_w = \frac{6782.4217}{8697.0469} = 0.7798$$

samples	n	\bar{X}	Y	Y	t
control	27	45.6926	48.1852	42.5313)	
exp.1	26	36.2308	61.2692	52.9155)	-3.8934**
exp.2	23	32.2174	41.0000	45.7760)	2.7050**
control	27	45.6926	48.1852	42.5313)	1.1195

** (p < .01)

Table 21. The analysis of covariance of Creativity scores from Line-meaning subtest

sources of variation	ss _y	sp	ss _x	ss _y	df	ms _y	F
between groups	953.0159	1146.8619	1544.2771	333.6999	2	166.8499	.7122
within groups	7914.6157	3990.7697	21401.3645	16866.7917	72	234.2610	
total	8867.6316	7137.6316	22945.6316	17200.4916	74		

- d. Hypothesis 2.4, "the experimental groups themselves should show no difference in Creativity", was not supported by the data from Similarity subtest (Table 19 & 20). But was confirmed by the data from Line-meaning subtest (Table 21).
- e. Hypothesis 2.5, "the increment in Creativity of the experimental groups should be higher than that of the control group", was supported by the data from Similarity subtest (Table 22 & 23). But was not supported by the ones from Line-meaning subtest (Table 24).

Table 22. The analysis of variance of the increment of Creativity scores from Similarity subtest

Sources of variation	ss	df	ms	F
between groups	2051.8043	2	1026.9021	11.6882**
within groups	6407.3931	73	87.7726	
total	8459.1974	75		

** (p < .01)

Table 23. The comparison of the increment of scores from Similarity subtest

samples	n	\bar{D}	S ²	t
control	27	2.5921	96.8661	-5.0031**
exp.1	26	15.0385	73.3985	
exp.2	23	8.7821	100.4506	2.3330*
control	27	2.5921	96.8661	2.2260*

. (p < .05)

** (p < .01)

Table 24. The analysis of variance of the increment of scores from Line-meaning subtest

Sources of variation	ss	df	ms	F
between groups	203.5692	2	101.7846	.4286
within groups	17334.4308	73	237.4580	
total	17538.0000	75		

f. Hypothesis 2.6, “the increment of the Creativity of the experimental groups themselves should be no difference”, was not supported by the data from Similarity subtest (Table 22 and 23). But was confirmed by the data from Line-meaning subtest (Table 24).

3. Concerning the Concept Formation

a. Hypothesis 3.1, was not supported by the data. We could not say that the progress in Concept Formation was the same in every group (Table 26, 26 and 27).

Table 25. Pretest average scores (\bar{X}) and Posttest average scores (\bar{Y}) from Concept Formation tests of the experimental group 1.

scores	\bar{X}	\bar{Y}	\bar{D}	SD	t
Ideal Strategy (IS)	17.8164	22.8462	6.2308	1.2481	4.1908"
Conservative (CS) Strategy	23.4231	25.6154	2.1923	1.1596	1.8906
Perceptual Error (PE)	8.3077	6.0385	-2.2692	1.1060	-2.0517'
Correct Answer (CA)	2.1154	3.7692	1.6538	.3841	4.3060"
Verbal Concept (WORD)	77.6538	90.9231	13.2692	1.5890	8.3509**

. (p < .05)

-- (p < .01)

Table 26. Pretest average scores (X) and Posttest average scores (Y) from Concept Formation tests of the experimental group 2.

scores	\bar{X}	\bar{Y}	\bar{D}	\bar{SD}	t
IS	12.3043	20.1304	7.8261	1.2378	6.3224**
CS	20.7828	23.8696	3.9870	.7568	4.0789**
PE	10.8696	8.1304	-2.7391	.8625	-3.1757**
CA	.8696	2.9130	2.0435	.4145	4.9294**
WORD	76.6957	88.0435	11.3478	1.5459	7.3407**

** (p < .01)

Table 27. Pretest average scores (\bar{X}) and Posttest average scores (\bar{Y}) from Concept Formation tests of the control group.

scores	\bar{X}	\bar{Y}	\bar{D}	\bar{SD}	t
IS	19.1857	21.9630	2.7778	1.0104	2.7492*
CS	23.6296	24.4074	.7778	.9433	.8245
PE	8.2963	6.6667	-1.6296	.9713	-1.6778
CA	2.7778	3.7778	1.0000	.4270	2.3419*
WORD	84.2598	89.1481	4.8889	1.0865	4.4998**

* (p < .05)

** (p < .01)

- b. Hypothesis 3.3, "the experimental groups should show higher ability in Concept Formation", was confirmed by the data from verbal subtest (Table 28, 19).

Table 28. The analysis of covariance of Verbal Concept (WORD) scores.

sources of variation	ss_x	sp	ss_y	ss_y	df	ms_y	F
between groups	877.6922	-18.3118	104.3162	153.8158	2	76.9078	3.3606*
within groups	3565.9394	874.5750	1862.2101	1647.7136	72	22.8849	
total	4443.6316	856.2632	1966.5263	1801.5292	74		

* (p < .05)

Table 29. The comparison of Verbal Concept scores after the adjustment by the regression of \bar{Y} and \bar{X}

samples	n	\bar{X}	\bar{Y}	\bar{Y}
control	27	84.2593	89.1481	88.0633
exp.1	26	77.6538	90.9231	91.4136
exp.2	23	76.6957	88.0436	88.7625
control	27	84.2593	89.1481	88.0633

-2.3959*
1.9282
.5048

* (p < .05)

But this hypothesis was not supported by the data from the Geometrical Form subtest (Table 30, 31 and 33)

Table 30. The analysis of covariance of Ideal Strategy scores.

sources of variation	ss _x	sp	ss _y	ss _y	df	ms _y	F
between groups	631.5736	203.7137	92.6753	27.1717	2	13.5858	.5444
within groups	1643.0975	564.7337	1990.9563	1796.8569	72	24.9563	
total	2274.6771	768.4474	2083.6316	1824.0286	74		

Table 31. The analysis of covariance of Cons. Strategy scores.

source of variation	ss _x	sp	ss _y	ss _y	df	ms _y	F
between groups	121.4840	46.4789	46.8242	22.8745	2	11.4373	0.6557
within groups	1072.5555	316.6527	1349.6527	1255.7951	72	17.4416	
total	1194.0395	363.1316	1389.1053	1278.6696	74		

Table 32. The analysis of covariance of Percept. Error scores.

sources of variation	ss_x	sp	ss_y	ss'_y	df	ms_y	F
between groups	105.7495	72.8813	55.5877	29.3863	2	14.6932	.9026
within groups	1003.7768	188.7503	1207.5702	1172.0776	72	16.2789	
total	1109.5263	261.6316	1263.1579	1201.4639	74		

Table 33. The analysis of covariance of Correct Answer scores.

sources of variation	ss_x	sp	ss_y	ss'_y	df	ms'_y	F
between groups	46.0182	21.9282	11.8787	2.1733	2	1.0869	.3387
within groups	179.9292	60.0981	251.1081	231.9348	72	3.2088	
total	225.9474	82.0263	262.9868	233.2086	74		

- c. Hypothesis 3.3, "between the two experimental groups there should be no difference in Concept Formation" was confirmed by the data (Table 29, 30, 31, 32 and 33).
- d. Hypothesis 3.4, "the increment of Concept Formation in the experimental groups should be higher than that of the Control group", was supported by the data from Verbal subtest (WORD), and the Ideal Strategy scoring category of the Geometrical Form subtest (Table 34, 35, 36 and 37).

Table 34. The analysis of variance of the increment of WORD scores.

sources of variation	ss	df	ms	F
between groups	1018.6321	2	509.3161	10.1060**
within groups,	3678.9994	73	50.3973	
total	4697.6316	75		

** (p < .01)

Table 35. The comparison of the increment of WORD scores.

samples	n	\bar{D}	S^2	t
control	27	4.8889	31.8718)	
exp.1	26	13.2692	65.6446)	-4.3537**
exp.2	23	11.3478	54.9644)	.8667
control	27	4.8889	31.8718)	3.4183**

** (p < .01)

Table 36. The analysis of variance of the increment of IS scores

sources of variation	ss	df	ms	F
between groups	316.8215	2	158.4107	4.6171*
within groups	2504.5864	73	34.3094	
total	2821.4079	75		

* (p < .05)

Table 37. The comparison of the increment of IS scores.

samples	n	\bar{D}	S^2	t
control	27	2.7778	27.5641)	
exp.1	26	5.2308	40.5046)	-1.5275
exp.2	23	7.8267	35.2411)	-1.4754
control	27	2.7778	27.5641)	3.1594**

** (p < .01)

But the hypothesis was not supported by the data in the other scoring categories of the Geometrical Form subtest (Table 38, 39 and 40)

Table 38. The analysis of variance of the increment of CS scores.

sources of variation	ss	df	ms	F
between groups	68.3504	2	34.1752	1.3949
within groups	1788.5312	73	24.5004	
total	1856.8816	75		

Table 39. The analysis of variance of the increment of PE scores.

sources of variation	ss	df	ms	F
between groups	15.5746	2	7.7873	.3100
within groups	1833.8465	73	25.1212	
total	1849.4211	75		

Table 40. The analysis of variance of the increment of CA scores

sources of variation	ss	df	ms	F
between groups	14.0404	2	7.0202	1.6487
within groups	310.8412	73	4.2581	
total	324.8816	75		

- e. Hypothesis 3.5, "between the two experimental groups there should be no difference in the increment of Concept Formation", was confirmed by the data (Table 35, 37, 38, 39 and 40).

4. Concerning the Relationship

The hypothesis, "there should be a positive relationship among these three variables", was confirmed by the data as seen in the matrix (Table 41). These average Z scores of both within one variable and among all variables were computed after the transformation of each correlation coefficient among sub-categories of all 3 variables into Z scores (Arkind and Carlton, 1950: 122-123), the average Z scores then were retransformed, again, into the average correlation coefficients within and among the variables.

Table 41. The correlation coefficient among and within variables.

	Inquiry Ability	Creativity	Concept Formation
Inquiry Ability	.7658**	.5649**	.4700**
Creativity		.3507**	.3959**
Concept Formation			.5511**

** (p < .01)

In order to indicate the relational nature both within and among tests, subtests and subcategories; the correlational coefficient matrix among the variables will be illustrated later as in table 42.

Table 42. The correlation coefficients among various kinds of scores

	Inquiry Ability				Creativity		Concept Formation				
	NQPT	CQPT	COPS	NOPS	Simi- larity	Line- meaning	IS	CS	PE	CA	WORD
NQPT	1.0000	.9461	.6116**	.5374**	.4555**	.2715**	.2803*	.2525*	-.2328**	.2833**	.3720**
CQPT		1.0000	.6025**	.5370**	.4111**	.2671*	.5207**	.2468*	-.2405*	.2990**	.3325**
NQPS			1.0000	.9316**	.4922**	.3831**	.3741**	.3034**	-.3175**	.3840**	.2882**
CQPS				1.0000	.4052**	.2999*	.3166**	.2307*	-.2467*	.3606**	.1548
Similarity					1.0000	.3507**	.2750*	.3670**	-.3053**	.3712**	.3772**
Line-meaning						1.0000	.0816	.1246	-.1595	.0646	.1129
IS							1.0000	.7203**	-.7248**	.8343**	.2159*
CS								1.0000	-.9146**	.6765**	.1330
PE									1.0000	.6807**	.1938
CA										1.0000	.2250*
WORD											1.0000

* (p .05) ** (p .01) n = 86

DISCUSSION, EVALUATIVE SUMMATION AND RECOMMENDATIONS

1. General **Discussion**

The main purpose of this study was to inquire into the effects of teaching of science by the Investigation Model of Inquiry approach of teaching. It was found that the application of IMI on Science Teaching had improved the pupils' capability of Creativity, Concept Formation and Inquiry Ability more than the conventional teaching that the IMI was not applied to.

In order to evaluate this study, the researcher had discussed through the **internal** and external validities as his principal criteria (Weerayudh Wichiarajote, 2516A; Pote Chantaraweerakul, (no date); Van Dalen, 1956:244-253, 261-266, 442-454).

Internal Validity

- All hypotheses had been tested from the data available through testing instruments with reliability. The fact that only the data of 76 pupils were used in the hypotheses testing had been considered as another sampling procedure limitation which criterion was "... from the sample subjects that had done **all the subtests** in this study".

- Extraneous variables might exist and confound the results of the study to some extent. For examples:

It had been conducted in the regular servicing school and naturally there were some factors that were out of our capacity to manage as we would like them to be, eg., the grouping of the pupils had been done by the school regulations.

The pupils interactions out of classes.

The difference in the teachers' personality and characteristics and teaching techniques.

The too-many-tests effects.

The learning from tests

Including the socio-economic status of S's might be different. But as far as the observation could be employed and the public type of the experimental school was concerned, the researcher would like to assume that they were, generally, in the same population.

Concerning the extraneous variables, since the general controllable extraneous variables had been aware of and controlled. For examples, the general school conditions, the same measuring instruments, the same content materials etc,. The technique of statistical control

(Huck, 1972 : 42-46) had also been employed. The researcher admitted that this was not as rigidly controlled as the one in the laboratories. He furthered his comment that, probably, the extraneous variables might be less influential than the factors like; the period of time treated, the explicitness of the teaching model, the competency of the teachers of proceed on the model both in the experimental and control groups. These experimental factors were to be discussed later.

External Validity

- The school was purposively selected (Cochran, 1963 : 11), so it was not a random sampling unit. But by one of the purposes that it had been selected we might be able to say that this school was a (purposively) representative of the general upper primary school in Bangkok. Then the next problem was that how high we could be sure that it represented the general upper primary school of the whole country.

The researcher suggested the consideration of this study as a pilot project that followed the principles of the field experimental educational research to stir the spirit of inquiry of whom it would concern, to stir the movement of science education research and the development and to seek for the better information for improving the approach of teaching.

He also proposed a hypothesis for the further study that the other groups of pupils should similarly enjoy the benefits of IMI approach of teaching and hoped that it would really lead to many more studies in this area.

2. Discussion about Variables

Creativity

- The data from Similarity subtest supported the research hypothesis more than the data from Line-meaning subtest. The researcher discussed the contention of Similarity subtest, to recall and compare, that was much agreed with the OEPC Inquiry process; to observe the physical defining attribute first, this was to train the pupils to think analytically, and proceeding on with the explanation, prediction - testing hypothesis and controlling-creative process. And this finding reconfirm the effect of OEPC Inquiry training on the pupils' Creativity. Where as one of the contention of Line-meaning subtest, to grasp the relationship among the differences in forms, this aspect might agree with the general conventional teaching as well.

The researcher suggested the other possibilities behind this result, for examples:

1. The period of treatment might be too short to efficiently effect the improvement of Creativity which requires a higher level of thinking

capacity of divergent thinking (Sawai Liamkaew, 2514), of thinking differently from the normal ways (Lindgren, 1966), of not just irrationally imitating from the others (Surang Koawtrakul, 2509). He discussed the previous six years under the hidden messages (Bennett, 1973 : 9, 11-12) of the educational system that the pupils were used to learning by heart, to think convergently, that needed much more effort to improve the creative thinking.

2. The pilot project, as the step towards the practice of OEPC Inquiry still needed a lot of techniques, and the competency to effectively practice in the school situation that tended to be the content-oriented system (Bennett, 1973: 6-9). He explained that these OEPC Inquiry practitioners were so new to competently control and adjust the process so that in such a rigid time-table like that, oftenly, the whole process of O E P and C were not completed before the end of the allotted time.
3. The competition among pupils, who were friends of each other and know, somehow, that they were to be compared to each other. And, as for the pupils in the control group, the feeling of trying the new things and of changing the atmosphere from the regular class, when they were to perform the tests.

Concept Formation

- The data obtained did not distinctly support or oppose the research hypotheses that all of the groups should improve on the Concept Formation. It was, however, likely to indicate the less-varied liness of Concept Formation scores of the experimental groups than the ones of control group. This pointed out the effects of IMI approach of teaching on Concept Formation. Though, Concept Formation itself could be developed along with the level of maturity, but its rate of development would be quickened if there was a certain treatment concerened (Bantoon Chernpathanaphong, 2515 : 36).

More than that, the data indicated the cases that the experimental groups possessed higher Concept Formation than the control group; that the increment of Concept Formation was larger in the experimental groups. These were not in line with the findings of Voelker (Ramsey and Howe, 1969 : 32), which there was no difference between the concepts the pupils learned from two strategies of generalization. The one placed more roles on pupils and the other on the teacher. The researcher commented that it might be because the Concept Formation, herein, was emphasized on the characteristics and strategies of the formation of concept than the learning of concept as Voelker did. Another discussion was that Voelker studied on the basis of the two apparently opposite sides of the continuum while the approach of IMI here tried to seek the compromization in each

classroom situation. Consequently the latter was likely to agree with the suggestion of Kolb (Ramsey and Howe, 1969 : 32) that if the teacher tried to harmonize the related concepts into the integrated unit that would help facilitate the forming of concepts.

Since Concept Formation required the analytic observation for the necessary data, the researcher saw to it that this would eliminate the irrational inference of the pupils, to some extent. So that they could think more rationally. They could employ the scientific way in seeking their knowledge (Brandwin, Watson & Blackwood, 1958 : 28) in solving the problems (Reed, 1946 : 71-87) in reasoning and thinking as the basis for the further and higher level of learning (Weerayudh Wichiarajote, 2512 : 82-83)

Inquiry Ability

— As both the control and experimental groups had shown the $p < 0.1$ difference between pretest mean scores and posttest meanscores, the researcher suggested the following discussion

1. It conformed to the previous finding (Orathai Sethsakko, 2514) that the average 13 years old pupils, which were able to show the ability of reciprocal thinking, of hypothetical thinking, of combinatorial structuring etc.; were also prompted to the Inquiry Ability. Then he commented one more question that, in general, how much the educational system had encouraged those capacities of our pupils to be cognitively developed.
2. The learning-from-tests effects and the competition.
3. The out of class interaction might provide the opportunity for the dissemination of new information among the members of both the control and experimental groups.

The significant difference between the experimental groups and the control group both in Inquiry Ability and the increment of Inquiry Ability made it possible to say that IMI approach of teaching is one of the treatments to develop the Inquiry Ability. This finding was in agreement with all the other 10 studies in the Project, and be in line with the study of Suchman (1962).

On the fact that the scores from Passage subtest did not show the significant difference between the control and experimental groups, the researcher proposed the supposition that IF the treatment was extended to the longer period and the extraneous variables had been eliminated off as much as we could, it MIGHT better be seen.

Comparison **within** the experimental groups

- Though this was not the main purpose of this study the differences among these two experimental groups could be considered as the comparison of results of the two types of media utilization. These were only the differences, of the visual symbol presentation, while the other abstract and concrete presentations were still the same and message content was the same. Those were also the reasons why research hypotheses had been set up that the result should not be different, The effects on Concept Formation supported those hypotheses. So did the ones from Line-meaning subtest of Creativity and Passage subtest of Inquiry Ability. The other findings rejected the hypotheses.

This was to say that the quality of message was explicitly influenced by its media. It was of the same opinion as “the medium is the message” of Marshal McLuhan (Bennett, 2516 : 6) and that of the characteristic of the contact will influence the perceiving of message (De Fleur and Larsen, 1958 : 40). The medium itself contains its own message or meaning that will be sent off at the same time as the message intended by the sender is sent. Here, for example, the still picture possesses its own message (Somphong Siricharoen, et. el., 2506 : 33-74), while the slide projection also processes its own different message (Pruang Kumut, 2516) as well.

Another point of interest might be the interactions between medium and message, medium and learner, message and medium and learner as well as medium and other environments.

In this study the use of still picture in presenting the visual symbol showed better result than the one of slide projection; by the data from Creativity (Similarity) and inquiry Ability (Picture).

One more explanation about this was, since the slides used for projection were just the reproduction from those still pictures, thus might lessen the quality of the reproduced positive slides, to some extent.

The reason why the data from Creativity (Line-meaning) and Inquiry Ability (Passage) did not show such a difference might simply be that the influences of media utilized were less than the other aspects of treatment.

More than that, the experimental group 2 that was with slide projection showed the significant ($p < 01$) improvement in the CS and PE of Concept Formation distinctively from the experimental group 1. The Concept Formation (Geometrical Form) itself employed the slide projection as its media of presentation. This suggested some influences of the familiarity and transferability in learning.

These interesting aspects were worth studying in the more details

The relationship among variables

- The positive relationships between Inquiry Ability and Creativity were the same as the finding of Orathai Sethasako (2514 : 57) and the other colleagues of the Project who studied these relationships as well (Bamroong Boonyong. 2514; Somchai Ongsuwan, 2515).

The fact that Inquiry Ability was highly positively related ($p < 0.1$) with Line-meaning suggested the tendency of Inquiry Ability to be related with Creativity more on the analytical and categorical aspects than the aspect of relational mode of thinking, which was agreeable with the findings of another colleague in the Project (Noo Prathan, 2516) that Inquiry Ability was highly positively related with analytical and categorical cognitive styles, but tended to show the non-significantly negative relationship with the relational cognitive style. Inquiry Ability and Concept Formation were significantly positively related. This supported the afore-said theoretical construct (Theoretical Space P. 101. So did the relationship between Creativity and Concept Formation as well as the one between Inquiry Ability and creativity.

As a generalization, we could say that the CONSTRUCT of Creativity, Concept Formation and Inquiry Ability was existed and agreeable with the THEORETICAL SPACE. Or we could reasonably explain the relational construct of those three variables by that proposed theoretical space. But the details of that might need to be changed, to be modified or reformulated. That would be up to the further more researches and studies and also the new ways of looking.

The Evaluative Conclusion of this Study

- The study had completed its objectives of determining the effects of OEPC Inquiry in the educational context with the emphasis on three dependent variables of Creativity, Concept Formation and Inquiry Ability.

It was reasonably valid but there were still many points awaiting for the careful consideration and improvement.

Recommendation for the Instructional Research and Development

- There should be more encouragement on the research and development programme to find the various techniques that could effectively and efficiently develop the human resource, especially the quality of thinking and scientific literacy.

The IMI itself, as a way of thinking and as theory and principle, has also developed through the process of accommodation and assimilation, through the verification process so that the new synthesis is broader and more substantial than it used to be when it was just started. It also needed

further research and development in many areas, like the following suggestions :

1. There should be the study in the rural area of the country
2. There should be the study for the out-of-school education as well.
3. There should be more basic studies with the rigid control as well as the application ones.
4. There should be the study in the other levels of pupils
6. There should be the study in the other subject content
6. The specific **IMI test** should be considered and distinguished from the Inquiry Ability test that followed the operation of just "to ask" or "to inquire".
7. Considering the complete Interactive Integration IMI model with the added EM (Evaluation and Moral Commitment), the researcher would like to repeat that diagram (p. 4), to emphasize that OEPC without EM might not be a complete process for human society.

Recommendation for Educational Process and the Teacher Training

– Teaching-and-learning process, as a system, is with a possibility to be developed. The people who are involved, or are going to be involved, in the teaching-and-learning process should consider it as a system. The competency needed to develop each element and subsystem should also be considered as such. The Project had confirmed, to some extent, that the teaching competency development is possible.

The researcher recommended these following recommendations for educational process and the teacher training.

1. The basic teaching competency should be considered and developed, particularly the ones concerning IMI.
2. On curriculum development effort, besides the specialists in the subject content and the servicing teachers, there should include the ones in the basic competency development and also the style and technique of teaching.
3. The competencies and special techniques particularly needed in various educational environments, e.g., the up country, in the very large classroom, out-of-school education etc., should be researched, developed and publicized.
4. IMI is with the interdisciplinary characteristic, i.e., the behavioral science, psychology, philosophy, science process and so forth. And this covers many fields of education such as the instructional media, instructional system technology, educational administration and supervision, educational commu-

nication, personality development and guidance, message design, educational research, educational psychology, curriculum development including the method of teaching in the particular fields of content and so forth. It is needed, for the benefit of human community, that the strong co-operation **among** the specialists in different fields should be materialized.

6. The interactions among teacher and pupils, the familiarity towards the IMI and the environmental backgrounds should be considered in the application of IMI to the real educational contexts.
6. Concerning the resistance to innovation (Schime, 1968; Mieler, 1971; Wee-rayudh Wichiarajote, 2516), the delicate and wise techniques of communication and dissemination of information is necessary (Chom Phumiphark, **2506**; Wyck, 1971 : 90-91)
7. Schools and departments concerning with education and the teacher training should co-operate with, and inquire into these teaching competencies.
8. The centre for research and development for the teaching style, teaching competency, curriculum and teaching, educational system evaluation and improvement should be encouraged.

That would be also the centre of co-operation among many fields of interest, and of specialization, and should be with some educational authority.

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พิมพ์ที่

ห้างหุ้นส่วนจำกัด โรงพิมพ์ชวนพิมพ์

469 ถนนพระสุเมรุ แขวงบวรนิเวศ เขตพระนคร กรุงเทพฯ 10200

โทร. 2803542, 2810541, 2813180, 2822114 แฟกซ์ 2813181

นายจิโรจน์ ตรีสงคราม ผู้พิมพ์ผู้โฆษณา พ.ศ. 2539

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