INQUIRY TRAINING AND DIVERGENT THINKING

by

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ABSTRACT

This thesis was designed to explore the merits of J. Richard Suchman's Inquiry Development Program. Its primary focus was on the analysis of the relationship between the program and divergent thinking.

The research was prefaced by a critical review of the literature including models, definitions and difficulties in measuring creative thinking. The relationship between creativity and intelligence and creativity as an attitude and the compatibility of Richard Suchman's view on inquiry with E. Paul Torrance's view on divergent thinking are explored and elaborated.

A description of the experiment, its rationale and design is included. It was hypothesized that students participating in the Inquiry Development Program would be able to transfer their inquiry skills to the solution of discrepant events in physical science film-loops, the Discrepant Event Test and the Torrance Tests of Creative Thinking. It was further hypothesized that there would be sex differences on the Torrance Tests of Creative Thinking and that there would be differences between the experimental and control groups on science content knowledge and critical thinking ability.

It was concluded, at the outset of the study, that

the experimental and control groups were equivalent. Since the N was small (53), the means on factors deemed likely to be relevant to the study were checked. No statistically significant difference ($p > .05$) between the groups were found on sex distribution, academic rank, reading ability and general intelligence.

The results of the study showed that the experimental group scored statistically higher on the Inquiry Development Program Film-Loop Test ($p < .001$), the Discrepant Event Test ($p < .001$), and the Torrance Tests of Creative Thinking composite scores ($p < .001$) and sub-scores of fluency ($p < .01$), flexibility ($p < .001$) and originality ($p < .001$). For the above measures, analyses of covariance were performed on post-test scores, using the pretests as the covariate.

The scores of the experimental and the control groups were not found to be statistically significant ($p > .05$) on science content knowledge and critical thinking ability as measured by the Sequential Tests of Educational Progress in Science and the Social Studies Inference Test, respectively. There were no statistically significant sex differences on any of the pretest or posttest scores of the Torrance Tests of Creative Thinking in the control group. In the experimental group the only statistically significant ($p < .05$) sex difference occurred on the flexibility posttest, with the girls scoring higher than the boys.

It was recommended that this investigation be considered a pilot study to be replicated on a larger scale involving more students and a larger range of the Inquiry Development Program activities.

To the People at Simon Fraser University

who fostered my autonomous inquiry.

To Margaret

Benjamin and Michael

who made it worthwhile.

We want the children to become autonomous inquirers . . . The child comes to assume that if you always do what you are supposed to do, listen when you are supposed to listen, and read the pages in the book you are supposed to read, you can usually be sure of having the right answer. But now we were asking these children to think, and to generate questions in pursuit of discovery. This required them to plan, to make decisions, and to think creatively.

--J. Richard Suchman

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CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

The challenge of teaching children to think more effectively has preoccupied educational investigators for centuries. Plato[1] drew a distinction between teaching as giving instruction and education as drawing out what is already latent in the learner. John Dewey,[2] J. Richard Suchman's forerunner, argued that education is more than the mere transmission of information, that education should encourage the development of the natural tendencies of the child, especially the tendency towards inquiry. B. Joyce and M. Weil[3] recently delineated fifteen major teaching models to meet specific needs in educational situations. One such model, the Inquiry Development Program provides the focus for this study.

Inquiry training is the use of the Inquiry Development Program procedures to make students aware of the inquiry process. The students are trained to inquire systematically into the cause of discrepant events in physical science portrayed by coloured, silent film-loops. The central motivating force, according to J. R. Suchman, is a sense of incompleteness or disharmony which captures the student's curiosity and sets up a

cognitive dissonance in the form of irresistable psychological pressures to find a way to assimilate the event.

Students initiate the process of inquiry by formulating questions about the events, objects, conditions and properties presented in the film-loop. The teacher does not reveal the scientific explanations for the discrepant event but responds to student questions in terms of "Yes," "No," or requests for clarification of the question. The students, simulating the role of a scientist actively engaged in inquiry, gain practice and confidence in asking questions about physical science events and begin to develop a systematic means of problem solving.

The research which led to the development of the Inquiry Development Program was directed by J. Richard Suchman[4] from 1957 to 1962 under the title of the Elementary School Training Program in Scientific Inquiry. The students participating in this program were reported to show marked effects on motivation and autonomy. Motivation, however, was not measured by an instrument, it was a value judgement by the researchers and autonomy was considered to be synonomous with question fluency, since inquiry questions were student initiated.

Students who participated in inquiry training were found to ask significantly ($p < .0001$) more questions than a control group. This observation, however, was derived from a

test (Questest)[5] which was similar to the treatment (inquiry session) of the experimental group. The principal difference between the posttest and the program itself, was that individual subjects inquired with the experimenter in isolation from their peer group. Individual subjects did not therefore, have the opportunity to assimilate and accommodate peer-group questions and theories, as they did in their regular program sessions. The experimental group had in effect twenty-four 'practice' sessions in inquiry before they took the final test which was in essence, an extension of the inquiry sessions. The control group had only one 'practice' session (the pretest) before taking the final inquiry test (posttest). The evidence for increased fluency should therefore be qualified by stating that the inquiry-trained students were found to ask significantly ($p < .0001$) more questions when trained by the inquiry program and tested in the manner and content of the inquiry programs.

The question of whether the inquiry skills developed in the inquiry training model in physical science are transferable to areas other than the program itself becomes important. This apparent limitation in the research on the Inquiry Development Program provides the problem focus for this thesis.

D. Ausubel,[6] J. R. Suchman's most eminent critic, called for new evidence for the transfer value of the Inquiry

Development Program. He suggested that the instruments used should be independent of the training procedures in that program. J. R. Suchman admitted that the ultimate test of his program would be revealed by its transfer value. A teaching model is of limited merit if the skills gained by students cannot be shown to transfer beyond the content and format of the model. To have educational significance and impact, the skills gained by students should transfer to other contexts, other subject areas and to student's interactions with the real world.

PURPOSE OF THE STUDY

An initial objective of this study was to investigate the validity of J. R. Suchman's findings that students who have been exposed to the Inquiry Development Program ask significantly more questions about discrepant events portrayed by physical science film-loops.

If the ability of students to think with greater fluency when faced with other discrepant events can be increased, then one can pose the question as to whether the ability of students to think with greater flexibility and originality is also increased. Measures of fluency, flexibility and originality are considered by Guilford and Torrance to be central components of divergent thinking. The question that is being asked is therefore, does the Inquiry Development Program

increase the divergent thinking ability of students?

The inquiry program encourages students to formulate precise questions in determining the causal relations of discrepant events. This process is basically divergent since the students must brainstorm, examine and eliminate many variables and possible alternative causal factors in attempting to generate an explanation which is compatible with the data. Furthermore, the end product of inquiry is subject to a constant metamorphosis. The student's theory must be compatible with available data which is continually being unearthed. Theories are therefore created, modified, refined and/or rejected by the student as more information is gathered. There is no single correct answer which explains the discrepant event. Many student theories may, to differing degrees, account for the data. This method may be contrasted with the convergent approach in which students attempt to determine a single correct answer to explain a given phenomenon.

The main objective of the Inquiry Development Program, is to improve inquiry skills rather than to give answers. It is true that physical science laws may account for the discrepant events in the Inquiry Development Program, however, the laws and their relations to the cause of the discrepant events are not revealed to the student by the teacher.

Several minor objectives were investigated in this study. G. Schlenker[7] concluded from an Inquiry Development

Program investigation, that there was no difference between the experimental and the control group in elementary school science content. However, a similar study by B. Clark[8] indicated that gain in subject content was greater in the control than in the experimental group. Therefore, a minor objective of this study is to investigate the question of whether or not there are differences between inquiry trained and control students in science subject matter.

Many studies in the literature suggest that there are sex differences on tests of creativity. F. Bills[9] found that girls scored significantly higher than boys on some of the problem-solving tasks, upon completion of the Inquiry Development Program. Therefore, another minor objective of this study is to investigate the question as to whether there are sex differences on scores of the Torrance Tests of Creative Thinking.

The final minor objective of this study is to investigate the critical thinking ability of inquiry trained students. The students in the Inquiry Development Program are given practice in identifying and recognizing the limits of data, in making valid inferences and in forming theories from inferences and data, in a logically rigorous manner. Since these are the main components of critical thinking, one can pose the question as to whether the critical thinking abilities of inquiry trained students are enhanced.

It has been established by D. Butts and H. Jones[10] and W. Jones[11] that inquiry trained students can improve their problem-solving ability measured in a mode and content similar to the Inquiry Development Program, i.e., the Tab Inventory of Science Processes Test. Since this study is primarily aimed at the transfer value of the Inquiry Development Program, an area other than physical science, i.e., social studies, was chosen to test the problem-solving abilities of inquiry trained students. The criterion measure was Hilda Taba's Social Studies Inference Test.

Notes

[1]Plato, *Republic*, Book 7, ed. D. J. Allan (London: Methuen, 1965).

[2]J. Dewey, *Democracy and Education* (New York: Macmillan, 1916).

[3]B. Joyce and M. Weil, *Models of Teaching* (Englewood Cliffs, N.J.: Prentice-Hall, 1972).

[4]J. R. Suchman, *The Elementary School Training Program* (Washington, D.C.: ERIC Document Reproduction Service, ED 003530, 1962).

[5]Ibid., appendix C.

[6]D. P. Ausubel, "An Evaluation of the Conceptual Schemes Approach to Science Curriculum Development," *Journal of Research in Science Teaching* 3 (1965):255-64.

[7]G. Schlenker, "The Effects Of An Inquiry Development Program on Elementary School Children's Science Learnings" (Dissertation Abstracts, New York University, 1970).

[8]B. M. Clark, "An Experiment In Cultivating Creative Thinking Abilities In The Classroom" (Dissertation Abstracts, Iowa State University, 1968).

[9]F. L. Bills, "The Development Of Divergent Thinking As A Function Of Inquiry Training" (Dissertation Abstracts, Utah State University, 1970).

[10]David P. Butts and Howard L. Jones, "Inquiry Training and Problem Solving in Elementary School Children," *Journal of Research in Science Teaching* 4 (1966):21-27.

[11]W. W. Jones, "An Investigation Of The Effect Of Acknowledging Successful Autonomous Discovery By Seventh Grade Students Exposed To The Inquiry Development Program" (Dissertation Abstracts, University of Northern Colorado, 1972).

CHAPTER II

REVIEW OF THE LITERATURE

The ambiguities and inconsistencies in the area of 'creativity' and 'divergent thinking' necessitated a rather extensive review of the literature to clarify the concepts and the hypothesized relationship between divergent thinking and Inquiry Training. To facilitate this purpose, the Review of the Literature has been divided into two sections. Parts I and II are devoted to a review of the literature on creativity and inquiry training, respectively.

Part I begins with a thumbnail sketch of the history of creativity culminating with the surge of interest generated by the launching of Sputnik and Guilford's challenge to researchers. Guilford's pioneering work in the area of creativity is described and discussed. Taylor's model for curriculum reform representing a practical classroom application for harnessing Guilford's suggestions for encouraging creativity and Taylor's hopes for the Inquiry Development Program are discussed. Ambiguities in the use of the term 'creativity' are detailed. The relationship and distinction, as suggested by Torrance and Guilford, between creativity and intelligence is delineated. Evidence is presented to support Torrance's

contention that creativity is at least somewhat attitudinal and is thus capable of undergoing change. The difficulties of measuring creativity are investigated. Torrance Tests of Creative Thinking are described and an investigation into their criticisms, reliability and validity is undertaken. The section ends with a differentiation between Torrance's and Guilford's views on creativity.

Part II begins with a description of J. R. Suchman's Thinking-Learning-Acting Model of inquiry. The objectives and strategy of the Inquiry Development Program are outlined and the procedures for an inquiry session are detailed. Suchman's views on inquiry are expounded and his critics are noted. The research involving the Inquiry Development Program is described. This section ends with a drawing together of the concepts shared by E. P. Torrance and J. R. Suchman leading to an interface and fusion of their ideas and providing support for the central hypothesis of this thesis.

I

HISTORY OF CREATIVITY MEASUREMENT

Books on intelligence written fifty years ago would have been unlikely to deal with the topic of creativity. Butcher explains that, "'creativity,' however defined, was considered, except by a few brash pioneers, to be on the fringe of psychology and hardly capable of being investigated

by empirical methods."[1] Galton,[2] Havelock Ellis,[3] and Cox[4] described intelligence of men and women of genius but few attempts were made to investigate creative abilities and their correlates. Spearman,[5] Burt,[6] and Vernon[7] accounted for 'creativity' in terms of general intelligence.

In the last couple of decades there has been a shift in the concept of creativity. Researchers began to believe that creativity could be distinguished from general intelligence both conceptually and in terms of assessment.

Butcher[8] describes the climate of opinion during the early fifties in the U.S.A. as being favourable to any new suggestions for diagnosing, encouraging and using original scientific talent. The launching of Sputnik by the U.S.S.R. intensified the value of and the quest for scientific creativity and originality. Parnes and Brunelle's[9] research indicates that 1,250 articles were published in the eighteen months preceding 1967.

J. P. Guilford,[10] in his presidential address to the American Psychological Association in 1950 sparked a new wave of enthusiasm toward the investigation of creativity by calling for a renewed surge of interest in this area. Butcher[11] suggests that Guilford's distinction between divergent and convergent thinking and his call to his associates for careful experimental investigation of this topic gave renewed interest to the distinction earlier suggested by William James,

Sully, Stout, Woodworth, and Thurstone.

GUILFORD

J. P. Guilford considers that:

> Creativity refers to the abilities that are most characteristic of creative people . . . and that all individuals possess to some degree all abilities . . . creative acts can therefore be expected, no matter how feeble or infrequent, of almost all individuals.[12]

Guilford[13] proposed a multifactor theory of intelligence. He hypothesized five intellectual operations, four contents, and six products which interact to produce 120 separate abilities. Guilford's use of factor analysis rests on the assumption that each factor of the intellect ". . . is sufficiently distinct to be detected by factor analysis . . . [and] that the factors themselves can be classified because they resemble one another in certain ways."[14] He hypothesized that ". . . each intellectual component or factor is a unique ability that is needed to do well in a certain class of problem."[15]

Guilford postulated five major operations or groups of intellectual abilities: factors of cognition, memory, convergent thinking, divergent thinking and evaluation. He describes them as follows:

> Cognition means discovery or rediscovery or recognition. Memory means retention of what is cognized. Two kinds of productive-thinking operations generate new information from known information and remembered information. In divergent-thinking operations we think in different directions, sometimes searching, sometimes seeking variety. In convergent thinking the information leads to one right

> answer or to a recognized best or conventional answer. In evaluation we reach decisions as to goodness, correctness, suitability, or adequacy of what we know, what we remember, and what we produce in productive thinking.[16]

Guilford classified intellectual factors according to the kind of material or content involved. The content may be figural, symbolic, semantic, or behavioral. Guilford defines his own concepts:

> Figural content is concrete material such as is perceived through the senses . . . Symbolic content is composed of letters, digits, and other conventional signs, usually organized in general systems, such as the alphabet or the number system. Semantic content is in the form of verbal meanings or ideas.[17]

"Behavioural" content was added to the model on a purely theoretical basis to represent the general area sometimes called "social intelligence."

Guilford explains the relationship between operations and content: "When a certain operation is applied to a certain kind of content, as many as six general kinds of products may be involved."[18] He postulated six kinds of products: units, classes, relations, systems, transformations, and implications. These ". . . serve as basic classes into which one might fit all kinds of information psychologically."[19]

As a result of Guilford's Model of the Intellect, investigators began to realize that tests which measured convergent thinking operations did not give a complete analysis of the intellect. The most important outcome of Guilford's model, relative to this study, is the renewed interest and concomitant

surge of investigation into the area of divergent thinking. The divergent thinking abilities which Guilford isolated were: ideational fluency, spontaneous flexibility, associational fluency, expressional fluency, adaptive flexibility, and originality to be divergent thinking abilities.

Ideational fluency is displayed by listing a class of responses. Spontaneous flexibility is displayed by listing many classes of responses as in Guilford's uses of the common brick problem. Associational fluency is displayed by listing responses that are associated in a specified way to a given thing. Guilford's example is to list words meaning about the same as "good" or to list words meaning about the opposite of "hard." Expressional fluency is displayed when phrases or sentences are formed given the first letters of each word. Adaptive flexibility is considered a figural divergent-thinking ability. It is displayed by the successful problem-solving activities such as the match problem.

The match problem involves a configuration of seventeen matches, ten of which circumscribe a rectangle, inside of which the remaining seven matches form six equal and contiguous squares in two rows of three squares each. The task is to take away four matches leaving only three squares. If the subject imposes the limitation upon himself that the squares must be equal, then he will not solve the problem successfully. Guilford considers that "originality" is

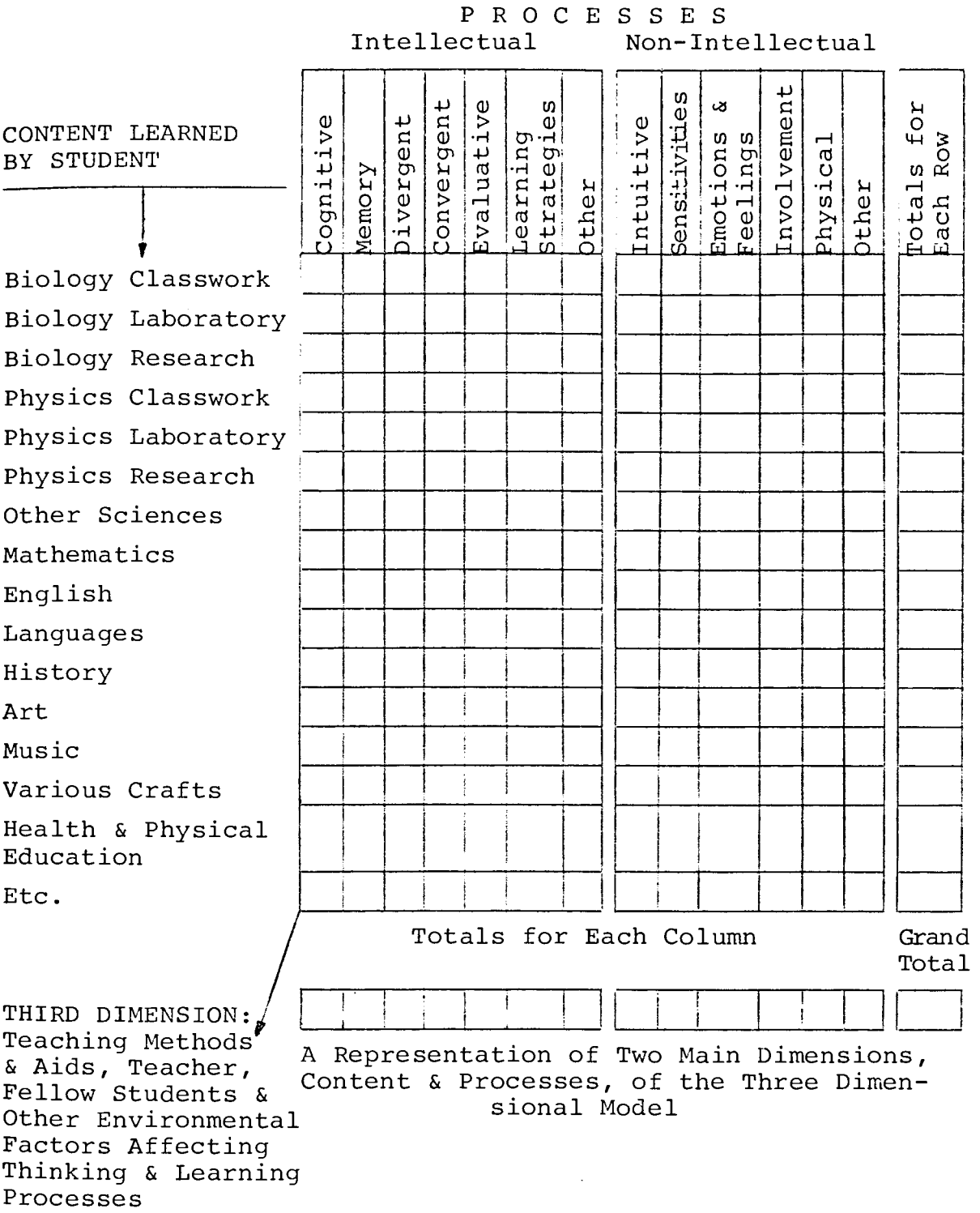
"adaptive flexibility with semantic material, where there must be a shift of meanings . . . [The subjects must produce] shifts or changes in meaning and so come up with the novel, unusual, clever or farfetched ideas."[20]

Guilford summarizes his concept of divergent thinking by stating that, "A unique feature of divergent productions is that a *variety* of responses is produced."[21] This may be contrasted with the limited number of acceptable responses in convergent thinking.

TAYLOR'S MODEL FOR CURRICULUM REFORM

Taylor's model for curriculum reform is a response to Guilford's challenge to educators, to direct themselves to the specific problem of improving the divergent thinking abilities of students rather than leaving the process to chance. Taylor developed his model to ensure that student learning and experience is not confined to a narrow educational spectrum (see Fig. 1). His proposal extends "the idea of a single type of 'the gifted' to the more accurate, research-grounded finding of multiple types of high-level talent."[22] He believes that much work should be done to improve creative behaviour ". . . such as productive thinking, innovativeness, resourcefulness, curiosity in action, discovery abilities, etc."[23]

Taylor suggests a



A Representation of Two Main Dimensions, Content & Processes, of the Three Dimensional Model

Fig. 1. Taylor's Model For Curriculum Reform, Processes in Students[24]

> . . . three-dimensional curriculum model in which two dimensions are student-centered, while the third is centered on teacher behaviours, methods, media etc. The knowledge dimension concerns the subject matter being learned by the student--his knowledge intake rather than the knowledge output of the teacher.[25]

Taylor's concern is with categorizing the actual learnings and experiences of students, rather than assuming that they have taken place.

His model has been subdivided into cells, each of which represents one process-content combination. Other classifications of student processes, curriculum contents and teacher strategies could be used. "The processes-in-students dimension is subdivided into intellectual and non-intellectual so as to utilize research such as Guilford's structure-of-the-intellect model."[26]

The advantage of Taylor's model is that it could be used to identify groups of gifted students and deprived students. It could also serve as a process evaluation for the teacher who may assume that certain types of learnings and experiences are taking place.

"The main task of the schools is indicated in the third dimension. The school must discover what has to be done to fill in the desired process-content (talent knowledge) cells at one time or another in the curriculum."[27] The school and the teacher must determine the procedures to use to ensure that the students experience intended intellectual processes. Taylor sees this task in terms of "educational

engineering." He believes that all students should experience every learning and thinking process at some time in the total curriculum, although individual teachers would perhaps specialize in different methods suitable for particular types of talents.

Taylor suggests that the Inquiry Development Program represents a promising vehicle for achieving this end, "If Inquiry Training ever gets a fair trial."[28] C. Taylor and H. Harding envision its potential in terms of offering viable strategies in the educational engineering of inquiry and creativity skills.

Taylor, however, makes the provocative suggestion that perhaps parents and teachers teach students not to ask questions which are not easily answered. He suggests that this phenomenon could account for the "fourth-grade slump" in certain creative thinking abilities, since this is the age in which student's questions become more difficult to answer. Torrance has used the term "fourth grade slump" to refer to the sharp decrease in the developmental curve of creative thinking abilities which typically occurs with fourth grade children.

H. Harding, in his commentary on Taylor's model for curriculum reform, is even more critical of the forces mitigating against children becoming autonomous inquirers. His scepticism is revealed in the following remarks:

> The fact remains that in our society the art of questioning is not popular. (Its greatest practitioner, Socrates, was put to death.) Today the persistent questioner is not a welcome companion, he annoys. Samuel Johnson reminded us that "Questioning is not the mode of conversation among gentlemen." Teachers nowadays think of students who persist with questions as discourteous. They are unladylike or ungentlemanly. Are what passes for good manners in the classroom more valuable than the process of creative thinking?[29]

DEFINITION OF CREATIVITY

Misinterpretations and disputes have occurred in the literature because of the veritable quagmire state of the definitions of creativity. Researchers often refer to the term 'creativity' as though it had one universally accepted definition. As a result they sometimes are referring to different senses of the term in their written reports and dialogues. This practice contributes to the ambiguity and vagueness in the literature on creativity. After surveying this problem, Yamamoto[30] concluded that there is no absolute need for everyone to agree on a single, universal meaning of 'creativity,' but at least investigators should be clear about what they mean by this word.

The word 'creative' is loosely used to refer to anything which is novel or different from the norm. Thus the term 'creative' may refer to a flower arrangement as well as an act of genius on the part of a world renowned Physicist. Unfortunately, a word which should be reserved to name a complex, multi-facet phenomenon is often misused to name only one

facet of the phenomenon. Ambiguities in creativity theory and inconsistencies in the research data on creativity can often be traced to vagueness in the definition of creativity, particularly vagueness of categories and linear vagueness.

A major source of ambiguity is vagueness of categories of the term creativity. In such cases, a researcher will, for example, make use of the term 'creativity' to denote a process, when another person to whom the researcher is attempting to communicate, has just used the term to refer to a product of creativity.

M. Rhodes[31] concluded from collecting forty definitions of creativity that these definitions could be grouped into four categories: (1) process, (2) product, (3) person, and (4) press. The term 'process' refers to "motivation, perception, learning, thinking and communicating." The term 'product' refers to, "a tangible form which is the result of an idea." The term 'person' refers to information about "personality, intellect, temperament, physique, traits, habits, attitudes, self-concept, value systems, defense mechanisms, and behaviour." The final term 'press' refers to "the relationship between human beings and their environment."

D. MacKinnon[32] has similarly concluded that creativity can be thought of in terms of four senses of the word. His categories are: (1) the creative process, (2) the creative product, (3) the creative person, and (4) the creative

situation. Kneller concurs with Rhodes and Mackinnon:

> Reliable definitions of creativity seem to fall into four categories. Creativity may be considered from the standpoint of the *person who creates*, that is, in terms of physiology and temperament, including personal attitudes, habits, and values. It may also be explained by way of the *mental processes*--motivation, perception, learning, thinking, and communicating--that the act of creating calls into play. A third definition focuses on *environmental and cultural influences*. Finally, creativity may be understood in terms of its products, such as theories, inventions, paintings, carvings, and poems.[33]

The general acceptance of at least four categories of creativity necessitates the clarification of the particular category to which one is referring, when expressing ideas or reporting information on the topic.

Linear vagueness leads to another source of ambiguity in the literature on creativity. This term refers to vagueness which results from the use of two terms both of which continue along the same spectrum. In this case, the boundaries which separate the two senses of the term have not been observed or clarified. For example, disputes may arise because one researcher may consider that creative acts must have significance to all mankind, while another may consider that an act may be deemed creative even if it only has significance to one individual. Still other researchers may reserve the term creative for a position along the individual to mankind spectrum somewhere in the middle, or the cut-off point may depend upon other impinging criteria.

Thus, even when vagueness of category is clarified,

ambiguities may result from linear vagueness. Barron defines creativity, "quite simply, as the ability to bring something new into existence."[34] However, this product of creativity could refer to something new to the individual, the society or to all mankind. The problem is one of linear vagueness. A basic problem in establishing criteria for creativity is to distinguish between acts of "genius" in which something novel and highly valued is produced for the benefit of all mankind, and creative acts which relate to the immediate world of individual experience. Creativity may be a component of genius. However, creativity may exist separately from acts of genius. Certainly, the use of the term creativity, describes a sense of the word which is separate from and more common then the acts of genius.

Kneller suggests that, "We create when we discover and express an idea, artifact, or form of behavior that is new to *us*."[35] Barron concurs with Kneller:

> A man may think a thought which for him is a new thought, yet it may be the most common thought in the world when all thinkers are taken into account. His act is a creative act, but when the "something new" that is produced is something new in the population of thoughts he can claim as his own, not something new for mankind as a whole.[36]

Duckworth further explores Kneller's claim.

> The wonderful ideas I am referring to need not necessarily look wonderful to the outside world. I think there is no difference in kind between wonderful ideas which many other people have already had, and wonderful ideas which nobody has happened upon before. That is, the nature of

> creative intellectual acts remains the same, whether in an infant who for the first time makes the connection between seeing things and reaching for them . . . or an astronomer who develops a new theory of the creation of the universe. In each case, it is a matter of making new connections between things already mastered.[37]

Thus the creative process which leads to an act of genius may be the same as one which leads to a personal revelation. The *process* may be similar, but the *product* and its value to others, may indeed be distinct.

Torrance (and Guilford) contend that the *process* of creativity entails four basic operations: fluency, flexibility, originality, and elaboration. Torrance defines his variables of fluency, flexibility, originality, and elaboration as follows:

> The number of relevant responses produced by a subject yields one measure of ideational fluency. The number of shifts in thinking or number of different categories of questions, causes, or consequences, gives one measure of flexibility. The statistical infrequency . . . or the extent to which the response represents a mental leap or departure from the obvious and commonplace gives one measure of originality. The detail and specificity incorporated into the questions and hypotheses provide one measure of ability to elaborate.[38]

He defines 'creativity' by stating that,

> Creative behaviour occurs in the process of becoming sensitive to or aware of problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; bringing together in new relationships available information; defining the difficulty or identifying the missing elements; searching for solutions, making guesses, or formulating hypotheses about the problems or deficiencies; testing and retesting them; perfecting them; and finally communicating the results.[39]

THE RELATIONSHIP BETWEEN CREATIVITY AND INTELLIGENCE

In his presidential address to the American Psychological Association in 1950, J. P. Guilford predicted that correlations between I.Q. scores and creative ability would be low. He was unable to cite specific evidence at that time because of the lack of adequate measures of creativity.

Getzels and Jackson[40] investigated the relationship between intelligence and creativity. In this major study, intelligence was measured by the Stanford-Binet, the W.I.S.C., and the Henmon-Nelson group test. Creativity was measured by a series of tests taken or adapted from Guilford and Cattell consisting of tasks involving: word association, uses for things, hidden shapes, fables and make-up problems.

Correlations between the creativity measures and I.Q. were calculated for the 292 boys and the 241 girls separately. All correlation coefficients were positive, and of moderate size, i.e., between +.1 and +.5. A high creativity group was formed by grouping the top-scoring 20 per cent on composite creativity scores, but below the top scoring 20 per cent in I.Q. The high I.Q. group had the top-scoring 20 per cent on I.Q. but were below the top-scoring 20 per cent on creativity. The study omitted those subjects who were in the top 20 per cent on both scores.

Getzels and Jackson reported quite high correlations

(between +.3 and +.6) between some of the individual creativity tests and both verbal and numerical achievement for the whole sample. This difference could not be accounted for in terms of motivation, since there was no difference between the two groups on McClelland's 'need for achievement' measure. The differences were attributed to the predictive limitations of the traditional intelligence tests. Burt[41] suggested that the creativity tests used by Getzels and Jackson form very satisfactory additions to any ordinary battery for testing the general factor of intelligence. Torrance[42] concurs with Burt and suggests that intelligence tests have long been useful in guiding and assessing mental growth and intellectual potentiality and that they will continue to be useful. He describes creative thinking abilities "as just one part of the expanded and expanding concept of the human mind and its functioning." Torrance maintains that one can be both highly intelligent and highly creative. He claims that, in any one group of children, who have been identified as being highly intelligent or highly creative, about 30 per cent of them will be both highly intelligent and highly creative.

Jackson and Getzels also found personality or attitudinal correlates of creativity. They concluded that the high I.Q. group was rated slightly higher by teachers on 'desirability as a student.' The groups also differed in their attitudes towards success in adult life. The

correlation between the qualities the high I.Q. group valued for themselves and the qualities which they thought would be conducive to success in adult life was quite high. The qualities of the high I.Q. students were also seen to be more conforming. The correlation between the qualities they said they would like to possess and the qualities they thought teachers tended to approve of was higher than the high creativity group. The high creativity group valued a sense of humour more than the high I.Q. group.

The most striking finding of the study was that the high creativity group equalled the high I.Q. group in scholastic achievement in spite of having an average I.Q. of twenty-three points lower (127 compared to 150). It must be noted, however, that both means are more than one standard deviation above the population mean. It was also concluded that 70 per cent of the high creativity group is excluded from the sample if the students are selected on the basis of I.Q. scores alone.

De Mille and Merrifield[43] criticized the Getzels and Jackson study as being ill-designed and inadequately reported. The sample studied was an atypical one, the mean I.Q. being 132, and a large proportion of the families came from families of lecturers at the University of Chicago. They cautioned that generalization from this exceptional sample to the general population must be made with care.

Attempts to replicate Getzels and Jackson's work with more typical and representative groups of children have produced conflicting results. Torrance[44] has given support to the Getzels and Jackson finding that 'creative' children were more successful in academic achievement than could be expected from their I.Q.

Hansan and Butcher[45] replicated the Getzels and Jackson study with 175 Scottish secondary school children. Correlations between I.Q. and creativity were less pronounced than in the Getzels and Jackson study. I.Q. correlated more highly with total 'creativity' score than did nine out of ten of the separate 'creativity' tests. The Getzels and Jackson finding of teacher preference for high I.Q. students was partially confirmed.

Butcher[46] offers two explanations for the discrepancies between his study and the Getzel and Jackson study. Firstly, the theory of I.Q. 'threshold' suggests that up to a level of about I.Q. 120, general intelligence is the most important factor in determining school achievement. At levels beyond an I.Q. of 120, creative abilities seem to become important. Secondly, the kind of school environment would determine the qualities which make up the 'desirability' as a student's score. In more permissive, flexible educational environments, characteristics of 'creative' students would be highly valued. In rigid, authoritarian educational

settings characteristics of 'intelligent' high I.Q. students would be more highly valued.

Wallach and Kogan[47] used non-verbal patterns to obtain an index of creativity and report a fair degree of success in establishing separate measures of creativity and intelligence. With a total sample of 151 ten- and eleven-year-old children, they found an average correlation between measures of creativity of about +.41, an average correlation between measures of intelligence of +.51 and an average correlation between the creativity and intelligence measure of only about +.1.

Yamamoto, Torrance, Crockenberg, and Getzels and Jackson found evidence to support the theory of I.Q. "threshold." Yamamoto[48] concluded that correlations between I.Q. and creativity decreased as I.Q. increased. The correlation between I.Q. and creativity scores was .88, .69 and .30 for groups with I.Q. scores of 90 and less, 90 to 110 and 110 to 130, respectively. Torrance[49] reported correlations between creativity scores and I.Q. of .50 for children with I.Q. scores below 120; but only .20 for children with I.Q. scores above 120. Crockenberg,[50] found correlations between I.Q. and the Torrance Tests of Creative Thinking ranging from -.15 to .09 in a group of gifted children with I.Q. scores ranging from 97 to 156 ($\bar{X}$ = 137, s = 13.14). Getzels and Jackson[51] found the relationship of creative potential and creative production to the traditional I.Q., to be substantial in the lower

range of I.Q. but to be close to zero when groups of superior I.Q. are concerned. When the whole range of I.Q. is included (60 to 150) there is a characteristic scatter plot. When I.Q. is low, scores on creative potential can only be low. When I.Q. is high, there can be a wide range in performance on creative tasks.

Anderson summarizes the data on I.Q. threshold:

> We can think of ability levels in terms of thresholds and ask questions as to the amount necessary to carry on a task and then consider the factors that determine function beyond this threshold. There are cut-off points or levels above which the demonstration of ability in relation to environment demands is determined by the presence of other factors.[52]

THE NATURE AND NURTURE OF CREATIVITY

An important issue for this study hinges on the question of the extent to which creativity is essentially a set of attitudes or personality (nurture) and hence can be effected by environmental forces, compared to the extent to which creativity is an inherited trait (nature) and cannot be effected by environmental forces.

In the Committee Report on Criteria of Creativity, it is stated that:

> The product of creative behaviour should be the first object of study; after the product is judged "creative" the term can then be applied to the behaviour which produced it and also to the individual who produced it. Using this criterion, creativity may be defined as a characteristic with which a person is born; a talent, a unique capability, an aptitude.[53]

Steinberg suggests that creativity can be viewed as an attitude as opposed to an aptitude, "as a cognitive, stylistic or motivational mode of interacting with one's environment." In this perspective, "the emphasis is on personality rather than on achievement, on expressive or being qualities rather than on problem solving or product making qualities."[54]

The studies of Adorno[55] involving the problem of race prejudice indicate that personality factors can influence the creativity of individuals. Highly prejudiced persons were found to share many characteristics, referred to as authoritarian personalities. This type of personality was characterized by: rigidity and inflexibility, concreteness of thinking, an inability to handle abstractions easily; conforming and conventional behaviour. The characteristics of the authoritarian personality are the antithesis of the creative attitude and often serve to limit creativity.

Richard Crutchfield studied conformity and character. He identified individuals who could be characterized by their high conforming behaviour and those who exhibited non-conforming or independent behaviour. Persons of extreme independence of behaviour exhibited the following characteristics: "intellectual effectiveness, ego strength, leadership ability, maturity of social relation and an absence of inferiority feelings, rigid and excessive self-control and authoritarian attitudes."[56]

According to Crutchfield, the conforming personality exhibits: "a narrow range of interests, submissiveness, compliance, overacceptance of authority, conformity, tendency to do the things that are prescribed, over-control of impulses, inhibitedness and needless delay or denial of gratification."[57] Crutchfield's definitional claim suggests that creativity and high conformity are essentially antithetical in nature.

Rokeach[58] suggests that closed mindedness is a general personality trait related to the ability to form new cognitive systems of various kinds: perceptual, conceptual, aesthetic. He developed a Dogmatism Scale to measure the extent to which the mind is open or closed. Rokeach claims that closed mindedness is related to a high degree of rejection of opposing beliefs, a dogmatic orientation and a belief system closed to new ideas and resistant to change.

Frenkel-Brunswik[59] concluded that some people find it difficult to tolerate and manage ambiguities and inconsistencies and surprises. When faced with an ambiguous situation, they quickly fix on one concrete interpretation. Such characteristics would severely limit the fluency, flexibility, and originality of thinking.

The evidence suggests that there is an attitudinal component in the pheonomenon of creativity and thus creativity may be effected by environmental forces. Torrance has made this explicit assumption in developing and using his tests

of creative thinking.

DIFFICULTIES IN MEASURING CREATIVITY

The phenomenon of creativity has proved to be an elusive entity. Most of the instruments for measurement or estimation of creative thinking are developed after Guilford's suggestion based on his factor analytic model of the human intellect. However, many researchers have attempted to use real life criteria, i.e., peer group assessment and teacher nominations, to identify creativity.

In assessing creativity, Harmon[60] postulated the procedure of working backwards from an ultimate criterion, a measurement of individual scientists' total creative scientific accomplishment based on panel assessment by fellow scientists, to some more immediate and "feasible" working criteria, such as papers, patents, rate of achievement, and present performance. From this criterion, behavioural attempts were made to establish predictors of the behaviour. This retrospective method, however, does not allow for the prediction of creativity. The creative assessment could take place long after an accomplishment was completed or an assessment could be changed historically with the changing values of our society.

Yamamoto points to the untenability of Harmon's method:

> A difficulty in this very reasonable procedure is that it is almost impossible to find a criterion which is not contaminated by other features of human traits and behaviour, especially by intelligence.[61]

In school situations, such "feasible" criteria as honour point ratio and achievement test results are apparently quite poor for creativity assessment. Teacher nominations have been found inadequate by Holland.[62] Getzels and Jackson[63] and Torrance have found that peer nominations present some problems, when used for creativity assessment.

THE TORRANCE TESTS OF CREATIVE THINKING

Description of the Torrance Tests

Torrance describes the development of his tests:

> The Torrance Tests of Creative Thinking represent the culmination of nearly nine years research by their author, Dr. E. Paul Torrance, and his colleagues into the nature of creative thinking and its assessment. They also represent a pioneering venture into making available to the research and educational community instruments designed to detect and measure, in a useful and functional fashion, creative thinking potential in children, adolescents and adults.[64]

Alternative methods of measurement have been abandoned in the development of the Torrance Tests of Creative Thinking; "not because they are not valid ones, but because they are too expensive, too elaborate, or require materials and equipment that would be difficult to make available for wide-spread use."[65] The Torrance Tests of Creative Thinking are now extensively used in educational research. In responding to the question, Can we teach children to think creatively?, Torrance

refers to 142 studies in the area of creativity. Of these studies, 103 involved the use of the Torrance Tests of Creative Thinking to measure subjects' performance. Torrance has classified the strategies of teaching into nine categories:

1. Training programs emphasizing the Osborn-Parnes Creative Problem Solving procedures; Osborn, Parnes or modification of it.
2. Other disciplined approaches such as training in general semantics, creative research, and the like.
3. Complex programs involving packages of materials, such as the Purdue Creativity Program; Covington, Crutchfield and Davies' Productive Thinking Program; and the Myers and Torrance ideabooks.
4. The creative arts as vehicles for teaching and practicing creative thinking.
5. Media and reading programs designed to teach and give practice in creative thinking.
6. Curricular and administrative arrangements designed to create favorable conditions for learning and practicing creative thinking.
7. Teacher-classroom variables, indirect and direct control, classroom climate, and the like.
8. Motivation, reward, competition, and the like.
9. Testing conditions designed to facilitate a higher level of creative functioning or a more valid and reliable test performance.[66]

It is interesting to note that Trefinger,[67] a most ardent critic of creativity tests in general, concludes that the Torrance Tests of Creative Thinking are the most satisfactory instruments available for use with groups of elementary school children.

A description of the Torrance tests is given by their author:

> The types of tasks or activities chosen for the tests were those that could be most easily and economically administered and scored, and that had stood best the tests of reliability and validity while at the same time

> sampling as many different kinds of manifestations of creative thinking ability as possible. The Verbal Tests consist of seven parallel tasks, each battery requiring a total of 45 minutes in addition to the time necessary for giving an orientation, passing out booklets, and giving instructions. Each task is believed to bring into play somewhat different mental processes, yet each requires the subject to think in divergent directions, in terms of *possibilities*. A standard toy elephant (Form A) and toy monkey (Form B) are provided in an Examiners Kit (available from the publisher) for use as props in administering Activity 4. The activities involve: asking questions about a drawing, making guesses about the causes of the event pictured, making guesses about the possible consequence of the event, producing ideas for improving a toy so that it will be more fun for children to play with, thinking of unusual uses of tin cans or cardboard boxes, asking provocative questions, and thinking of the varied possible ramifications of an improbable event.[68]

Torrance admits that his tests do not attempt to sample the entire universe of creative abilities:

> Since a person can behave creatively in an almost infinite number of ways, in the opinion of the author, it would be ridiculous even to try to develop a comprehensive battery of tests of creative thinking that would sample any kind of universe of creative thinking abilities. The author does not believe that anyone can now specify the number and range of test tasks necessary to give a complete or even an adequate assessment of a person's potentialities for creative behavior. He does believe that the sets of test tasks assembled in the Figural and Verbal Batteries, Forms A and B, sample a rather wide range of the abilities in such a universe. He would be the first to admit, however, that these test tasks do not sample the entire universe of creative abilities. A number of the other test tasks developed by him call into play other abilities that he believes are a legitimate part of this universe, but limitations of time and certain procedural difficulties have influenced him to omit them from the present wide-range, general purpose batteries.
>
> . . . . . .
>
> [Torrance:] has made deliberate attempts to construct test activities that are models of the creative process, each involving different kinds of thinking and each contributing something unique to the batteries under development. Test tasks or activities are thus fairly complex

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> and have features that make use of what we know about the nature of the creative thinking processes, the qualities of the creative products and creative personalities. An attempt is made, however, to assess the products that result from the administration of these test activities in terms of Guilford's divergent thinking factors (fluency, flexibility, originality, and elaboration).[69]

The tests include an extensive scoring manual for evaluating specific student responses. "In devising the scoring procedures presented in the Scoring Guides, an effort has been exerted to make the evaluation of responses as simple and as economical as possible without sacrificing any of the essence and richness of the records."[70]

Torrance defines his variables of fluency, flexibility, originality, and elaboration as used in scoring his tests:

> The number of relevant responses produced by a subject yields one measure of ideational fluency. The number of shifts in thinking or number of different categories of questions, causes, or consequences, gives one measure of flexibility. The statistical infrequency of these questions, causes, or consequences or the extent to which the response represents a mental leap or departure from the obvious and commonplace gives one measure of originality. The detail and specificity incorporated into the questions and hypotheses provide one measure of ability to elaborate.[71]

Torrance admits that in some of the activities" a deliberate attempt has been made to stimulate all four types of divergent thinking (fluency, flexibility, originality, and elaboration) and to set up a conflict among the response tendencies represented by them."[72] Fluency is stimulated by the instructions, "see how many objects or pictures you can make";

flexibility, by "make as many different pictures and objects as you can"; originality, by "try to think of things that no one else will think of"; and elaboration, by "put as many ideas as you can into each one and make them tell as complete and interesting a story as you can." The time is not adequate to permit emphasis on all four kinds of thinking. Thus, individual response tendencies come into play.

Torrance considers that creative thinking is one aspect of problem solving. He agrees with Newell, Shaw, and Simon that problem-solving may be called creative:

> To the extent that one or more of the following conditions are satisfied:
> 1. The product of the thinking has novelty and value (either for the thinker or for his culture).
> 2. The thinking is unconventional, in a sense that it requires modification or rejection of previously accepted ideas.
> 3. The thinking requires high motivation and persistence, taking place either over a considerable span of time (continuously or intermittently) or at high intensity.
> 4. The problem as initially posed was vague and undefined, so that part of the task was to formulate the problem itself.[73]

The Torrance Tests of Creative Thinking meet all four of Newell, Shaw and Simon's criteria for creative problem solving. In Torrance's tests, the student is challenged "To see how good you are at thinking up new ideas and solving problems."[74] The tasks are designed to elicit the novelty, ingenuity and interest of the subject. The atmosphere of challenge encourages the students to think in terms of products which have novelty and value.

In the cardboard box task, the student is challenged to

> List as many of these interesting and unusual uses as you can think of. Do not limit yourself to any one size of box. You may use as many boxes as you like. Do not limit yourself to the uses you have seen or heard about; think about as many possible new uses as you can.[75]

The tasks and testing atmosphere create a psychological pressure of high motivation to work with persistence at high intensity to maximize the individuals particular orientation towards fluency, flexibility, or originality within the time limits given. The directions for the activities are specific but the student is not instructed how to elaborate responses or brainstorm alternatives to be considered in problem solving. The subjects' fluency, flexibility, originality, and elaboration scores reflect the extent to which they were capable of more fully defining the test problem.

The tasks, especially the unusual uses of cardboard boxes or tin cans, require modification and rejection of previously accepted ideas. These tasks are, "in part a test of ability to free one's mind of a well-established set."[76]

This strategy lends itself to Sir Fredrick Bartlett's[77] definition of "adventurous thinking" which he maintains is characterized by getting away from the main track, breaking out of the mold, being open to experience, and permitting one think to lead to another. Simpson [78] has similarly defined creative ability as the initiative which one manifests by his

power to break away from the usual sequence of thought into an altogether different pattern of thought.

Criticisms of Creativity Tests

Several criticisms of creativity tests in general and the Torrance Tests of Creative Thinking in particular, have been noted in the literature. Some of the critical attacks are justified and have been acknowledged by Torrance; others are the result of a misinterpretation of Torrance or a concern with the product rather than the process definition of creative thinking.

The main criticisms have been: (1) the use of the term 'creativity,' (2) criteria for creativity, (3) time limitations and external pressure in the testing situation, (4) lack of a quality indicator in the tests, (5) the testing conditions, and (6) low intercorrelations between task activities. In evaluating these criticisms, it must be remembered that the Torrance Tests of Creative Thinking are mere instruments designed to assess the complex phenomenon of creativity. As in any other area of complex inquiry, there are no perfect instruments.

Torrance designed the Torrance Tests of Creative Thinking to measure a specific sense of creativity. It is therefore unfair to evaluate his tests in terms of other researcher's definitions of creativity with which Torrance may not agree. To reiterate, Torrance defines creativity by

stating that,

> Creative behaviour occurs in the process of becoming sensitive to or aware of problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; bringing together in new relationships available information; defining the difficulty or identifying the missing elements; searching for solutions, making guesses, or formulating hypotheses about the problems or deficiencies; testing and retesting them; perfecting them; and finally communicating the results.[79]

The question of whether Torrance's tests measure creativity in general, is an invalid question. This point is made explicit by the fact that the Torrance tests are labelled tests of 'creative thinking' rather than tests of 'creativity.' The question of whether the phenomenon which E. P. Torrance defines as 'creativity' adequately defines a phenomenon under investigation, is a separate question. Another distinct question involves the appropriateness of the use of the Torrance Tests of Creative Thinking in measuring a particular facet of creativity. This is a decision which must be made by individual researchers. If the tests are not appropriate to the problem, then the fault lies with the researcher who chose the test and not with the designer of the test.

It was previously noted that creativity may have myriad definitions such as those characterized by M. Rhodes four categories: person, process, press, and product. It would be unreasonable to expect one instrument to assess every facet of a phenomenon which is so complex that it may actually refer to different phenomena depending on the use of the term.

The Term Creativity. Torrance acknowledged that Cronback;[80] Elkind, Deblinger, and Alder;[81] and other educational psychologists consider that the term 'creativity' is too value laden and should not be used to designate the kinds of behaviour involved in studies to teach children to think creatively. Torrance responds to this criticism:

> On this score, I can only say that I believe the word [creativity] describes the behavior investigated more adequately than any other word I know. Furthermore, an effort has been made to stay within the limits of a definition I chose for my research in 1958. If one does not care to accept this definition, it is his privilege to use another label.[82]

Torrance's response is a weak argument, if it is an argument at all. Crockenberg[83] suggests that creativity tests should be labelled measures of fluency and originality.

Many disagreements occur in the literature when one uses the term creative rather than a term such as 'diverger.' Hudson points to the connection between these two terms:

> Whatever the logical connection between convergence or divergence and originality, psychologists are prone to view the topic as one and the same. Many psychologists, particularly American ones, see the diverger as potentially creative and the converger as potentially uncreative.[84]

Criteria For Creativity. Crockenberg[85] recognizes that the ability to use ideas is taken as a measure of creativity, and that many researchers would agree that it was a component of creativity. However, he argues that this is not a sufficient criterion.

It may be recalled that Torrance does not state that the production of ideas is a sufficient criterion of creativity. Referring to the tasks in the Torrance Tests of Creative Thinking, Torrance states that, "he would be the first to admit, however, that these tasks do not sample the entire universe of creative abilities."[86] The production of ideas merely gives a measure of creative thinking potential. It does not guarantee that a person will perform a significant creative act in his lifetime. Trefinger, a critic of creativity tests, admits that,

> While divergent-thinking measures certainly do not tell the entire story about creativity, it is quite likely that these measures do assess intellectual abilities which play an important role in creativity. If creativity is viewed as a complex kind of human problem-solving (in which case the term "creative problem-solving" would be preferable), divergent thinking may be a necessary, although not a sufficient, component.[87]

Time Limits. Wallach and Kogan[88] suggest that creativity cannot be governed and circumscribed by time limits. Anderson suggests that actual creative processes involves a long time perspective when compared to the time limits on creativity tests:

> What seems to appear is that deep concern with a problem over a long period of time on the part of an able person results in a creative output. Our tests of ability measure the level of ability, not whether the person will be deeply concerned.[89]

Wallach and Kogan concur with Anderson in maintaining that the imposition of time limits reduces or limits the time

necessary for the incubation of ideas.

One might consider whether this limitation is applicable to attempts to measure 'potential' for creative thinking. The Torrance tests are designed to discriminate between and among creative individuals along the variables of fluency, flexibility, and originality. The time limits thus facilitate this objective by forcing the child who has a tendency towards fluency, flexibility, or originality to choose to spend a disproportionate amount of his or her time in pursuing their particular orientation, since there is not enough time to exhaust all of the fluency, flexibility, and originality possibilities in each of the tasks. Torrance explains: "The time is not adequate to permit emphasis on all four kinds of thinking. Thus, individual response tendencies come into play."[90]

Torrance investigated the effects of time limits on final scores of the Torrance Tests of Creative Thinking. The test task, adapted from a procedure developed and validated by Burkhart and Bernheim,[91] required the students to produce unusual questions about ice. He administered the test to seventy-five gifted sixth-grade students with the standard time limits. The students were then asked to continue working on the tests for the next twenty-four hours. Torrance found a product-moment coefficient of correlation between the two scores of .23 and concluded:

> Although this coefficient of correlation is statistically significant at the five percent level of confidence it yields a forecast frequency of only about three percent. Thus, the untimed, take home administration appears to be measuring something somewhat different from what is measured by the standard timed administration with a five-minute limit.[92]

A significant advantage of timed testing is the maintenance of rigor in the experimental setting. It gives the experimenter greater control over possible confounding variables, such as self-motivation, and intervention by other persons or other factors. By maintaining the time limits, Torrance is further able to standardize the motivational level and the external pressure between the students, in the testing situation.

Monfrans, Feldhusen and Ferris[93] reported that students scored higher on the verbal form of the Torrance Tests when the standard time limits were imposed. They experimented with four alternative methods of administering the Torrance Tests of Creative Thinking: (1) the standard, timed testing procedures described in the test manual; (2) a procedure designed to produce incubation prior to administration according to standard procedures; (3) administration as a take home test to be returned four days later; and (4) administration with a relaxed, playful, game-like set as recommended by Wallach and Kogan. The take home administration yielded higher scores on the figural tests than any of the other administrations but the standard administration yielded the

highest verbal scores.

Crockenburg[94] criticized creativity tests on the basis of the external pressure in the testing situation which requires the students to stay at the task until the time limit is over. She contended that this behaviour is discrepant with the expectation that self-motivation is an important determinant of creative behaviour and that this would show a discrepancy between those who are creative on the Torrance Tests of Creative Thinking and those who are creative when there is no explicit, external pressure to produce.

It may be recalled that Torrance considered creative thinking required high motivation and persistence, taking place either over a considerable span of time or at high intensity. The testing conditions tend to create conditions for students to work at high intensity. It could also be remembered that Torrance is interested in controlling self-motivation since his objective is to detect and measure creative thinking potential, controlling for as many confounding variables as possible.

The case that Torrance makes for using time limits has previously been presented. The time limits help to create a psychological pressure which forces the student to make a choice between spending a disproportional amount of time in being fluent, flexible, or original in his thinking. It gives an added measure of uniformity of testing conditions and adds

to the discriminatory power of the test. Torrance considers that his tests measure a qualitative rather than a quantitative assessment of divergent thinking potential. Thus it remains to be seen if additional time allotments would change the discriminatory power of the test, since the ranking of pupils on divergent thinking could remain the same.

Factors such as time limits, opportunity, self-motivation, importance of the problem to the person, quality and importance of the solution to the problem are important in determining any discrepancy between the scores on the Torrance Tests of Creative Thinking and the actual completion of a significant creative performance or product. These factors however are factors which may or may not occur in varying degrees at some future date. It is not the task of the Torrance Tests of Creative Thinking to predict the possible presence of these factors at some future date. Such predictions would be mere conjecture. These factors will be revealed at that future date and therefore cannot be taken into account when one is measuring creative potential by assessing the central components of the creative process. From the data on the Torrance tests it may be predicted that all factors being equal, the subjects with high scores on fluency, flexibility, and/or originality will likely behave more creatively in their lifetime. The relationship is however, neither sufficient nor necessary.

Torrance acknowledges the criticism that ". . . being able to think creatively is not the same as thinking creatively."[95] Equipping students with the skills of creative thinking and with the motivations to continue thinking creatively does not guarantee that the students will have a chance to behave creatively as adults. Torrance concedes that a high level of abilities which are measured on the Torrance Tests of Creative Thinking (fluency, flexibility, originality, and ability to sense deficiencies, elaborate and redefine) ". . . does not guarantee that the possessor will behave in a highly creative manner. A high level of these abilities, however, increases a person's chances of behaving creatively."[96]

Testing Conditions. Crockenburg suggested that testing situations are not conducive to the measurement of creative thinking. She claims that the Torrance Tests are

> ". . . administered under what can only be described as a test-like atmosphere. The activities are in a booklet form similar to the I.Q. and standardized achievement tests with which most children are familiar. Inside the booklets numbered spaces are provided for responses, in a fashion reminiscent of classroom test-taking. In addition the test is timed, although the children do not know what the time limits are.[97]

Lasswell and Rogers[98] proposed that a warm and non-evaluative relation between the examiner and the examinee will heighten the expression of creativity. Rogers suggests that creativity is heightened under a condition of

'psychological safety.'

Dentler and Mackler[99] investigated the relationship between originality and the inter-personal situation of the testee and the test administrator. Originality was defined as the degree to which verbal responses to a task were statistically uncommon. The criterion measure was Torrance's Tin Can Uses Test which requires the subject to write down interesting and unusual uses for tin cans. The test administrator of the control group (indifferent test administrator) portrayed an inter-personal style paralleling typical competitive examination rituals. The role of the test administrator of the experimental group (psychologically safe) was that of a friendly and pleasant person who had confidence that the group of high academic achievement undergraduates, would do well on the tests.

Dentler and Mackler found that subjects low on paranoid-type anxiety (caused by the test administrator) exhibited a greater mean originality score than highly anxious subjects. They also found that greater mean originality was produced by subjects in the experimental or safe group, than under the control conditions.

Wallach and Kogan[100] administered creativity tests under ego-centered, competitive, and evaluational pressures in the context of mass aptitude testing and compared the results with tests administered under a game-like, relaxed and

task-oriented atmosphere. The subjects produced significantly higher scores under the game-like conditions.

The testing conditions in the Torrance Tests of Creative Thinking are compatible with the testing conditions recommended by Dentler and Mackler and Wallach and Kogan. They do however, appear to be discrepent with Crockenberg's description of them.

Torrance takes extreme care not to create test anxiety in children. He cautions test administrators:

> Examiners should note that the word "test" has not been used on the booklet, nor in the printed instructions. If the examinees' materials most be referred to, the use of a word like "booklet" or "exercise" is suggested. . . . in general, a game-like, thinking or problem-solving atmosphere [should] be created. Try to avoid the threatening situation frequently associated with testing. Create the expectation that examinees will enjoy the activities and invite them to have fun. The psychological climate both preceding and during the use of the tests, should be as comfortable and stimulating as possible.[101]

The atmosphere of the activities is reflected in the suggested administrator's comments to the pupils.

> I believe you will have a lot of fun doing the activities we have planned for this period. We are going to do some things that will give you a chance to see how good you are at thinking up new ideas and solving problems. They will call for all of the imagination and thinking ability you have. So I hope that you will put on your best thinking cap and that you will enjoy yourself.[102]

Torrance remarks that "Motivation is indisputably important in creative thinking."[103] His analogy between the assessment of jumping potential and creative thinking potential, is an apt one:

> One would not measure the jumping potential of children of a particular school by photographing them as they pass by a particular spot and finding out how high they just happened to be jumping. He would do something to motivate them to jump by providing competition, a challenging jumping task or situation, or the like. This factor is quite critical in the measurement of any kind of performance that requires the use of expensive energy. The more expensive the energy required, the more important are motivational factors. Since creative thinking requires rather expensive energy, motivational factors are especially important in the measurement of the abilities involved in creative thinking.[104]

The Lack of a Quality Indicator. Crockenberg[105] argues that the Torrance tests (and other creativity tests) do not attempt to measure the 'quality' of responses. According to her, a person may produce a response that is novel and appropriate to the problem, but utterly trivial.

The Torrance Tests of Creative Thinking do not score responses which are not relevant to the problem. There is no quality score, however, responses which are unusual and show creative strength are given higher scores on the variable of originality. To the extent that only appropriate responses are scored, the quality of the responses are controlled. The appropriateness of a response to a given situation was also considered important by Kneller: ". . . an act or an idea is creative not only because it is novel but also because it achieves something, that is appropriate to a given situation."[106]

If one were assessing the merits of a product in terms of creativity, the quality of the *product* would be of critical importance. However, Torrance is sampling from a universe of

variables which he believes encompass the *process* of creativity. The purposes and intent of Crockenberg and Torrance are thus discrepant.

Even if it were desirable to build a quality score into the Torrance Tests of Creative Thinking, the scoring of the responses on a spectrum of 'quality' would be highly value-judgemental and subjective. It would be very difficult to find a group of experts who could agree on the weighting of the scores for quality responses. The originality score is thus a more objective score. Furthermore, it is a measure of quality in the sense that a response is given a heavier weighting when it is appropriate and statistically infrequent.

The quality of student scores may be revealed by looking at the relationship between the student's responses to the tasks and by looking at the tasks themselves which determine the range of student responses. Torrance has chosen his tasks on the basis of his belief that they could be used to model the creative process.

Torrance[107] admits that he strongly favours and has used more "real life" criteria for creativity measurement. However, in developing a creativity measurement, the events he chose ". . . were ones which could be most easily and economically administered and scored, and that stood best the tests of reliability and validity while at the same time sampling as many different kinds of manifestations of creative

thinking as possible."[108]

Low Intercorrelations. Wallach and Kogan,[109] Vernon,[110] Thorndike,[111] and others have criticized Torrance either for failing to give adequate information concerning the intercorrelations among the measures derived from the tests or for the relatively low intercorrelations among tasks. However, Torrance remarks that such criticisms are based on the untenable assumption that creative thinking ability is a pervasive, unitary function. He was aware that the intercorrelations would be relatively low before constituting his tests into batteries. Torrance explains his rationale for choosing the tests:

> The test tasks selected for inclusion in the Figural and Verbal Forms A and B were chosen deliberately because it was believed that they call into play different parts of a universe of abilities that may legitimately be conceptualized as creative thinking abilities. In some cases, these decisions were based on factor analysis data.[112]

Reliability of the Torrance Tests of Creative Thinking

Two test-retest reliability studies on the Torrance Tests of Creative Thinking have been cited by Torrance. The first study involved 118 fourth, fifth, and sixth grade pupils in Wisconsin. The second study involved fifty-four fifth grade pupils in Minnesota. Alternate forms of the verbal (and figural) tests were administered to the control groups one-to-two weeks apart. The experimental groups were

administered the tests eight months apart. The results of these test-retest studies are shown in Table I.

Table I Test-Retest Reliabilities of the Torrance Tests of Creative Thinking

Measure	Coefficients of Correlation		
	Wisconsin Group	Minnesota Group	
		Experimental	Control
Verbal Fluency	.93	.87	.79
Verbal Flexibility	.84	.84	.61
Verbal Originality	.88	.79	.73

Gorlaski[113] obtained coefficients of test-retest reliability on student teachers after a ten-week interval, of .82, .78, .59, and .83 for fluency, flexibility, originality, and battery total, respectively. The criteria measure were three of the Torrance Tests of Creative Thinking: Ask-and-Guess, Product Improvement, and Unusual Uses.

Sommers[114] tested and retested college students after an interval of ten weeks. He obtained reliabilities of .97 and .80 for two samples of subjects on tasks in the Verbal and Figural Torrance batteries consisting of: Picture Construction, Incomplete Figures, Circles, Ask-and-Guess, Product Improvement, Unusual Uses, and Consequences.

Mackler[115] tested the same subjects three times with three different forms of the Ask-and-Guess task. He obtained

reliabilities of .82 (between the first testing and the second testing two weeks later); .89 (between the second testing and the third testing two weeks later); and .84 (between the first and third testing four weeks later).

The test-retest reliabilities of the Torrance Tests of Creative Thinking compare favourably with other standardized tests used in this study. The alternate form reliability, i.e., the estimate of the extent to which parallel forms of a test measure the same concepts and skills, of the Gates-MacGinitie Reading Test is .87 for vocabulary and .89 for comprehension. The split-half reliability is .92 for vocabulary and .96 for comprehension. The alternate form reliability of the Sequential Tests of Educational Progress in Science is .88 for the AB order and .87 for the BA order. The Kuder-Richardson Formula 20, which estimates the extent to which the items in a test form measure the same concepts and skills, is .89. The odd-even reliability coefficients for the Henmon-Nelson Tests of Mental Ability is .93. The Kuder-Richardson Formula 20 for the subtests of the Social Studies Inference Test is: Accuracy = .52, Discrimination = .24, Inference = .60, and Over-Generalization = .54. The odd-even reliability is reported for three of the subtests: Inference = .68, Discrimination = .69, and Over-Generalization = .54.

Validity of the Torrance Tests

Construct Validity. In defending the Construct Validity of his tests, Torrance[116] points to numerous studies comparing personality characteristics of high scorers and low scorers on the tests and to correlations between the tests and other measures.

Weisberg and Springer[117] compared the personality characteristics of highly creative and less creative fourth grade children, using the composite scores from the Ask-and-Guess test, Unusual Uses of Tin Cans, and the Circles test from the Torrance Tests of Creative Thinking. The highly creative students were rated significantly higher on strength of self-image, ease of early recall, availability of Oedipal anxiety, and uneven ego development. They also showed a tendency toward unconventional responses, unreal percepts, and fanciful and imaginative treatment on the blots in the Rorschach Ink Blot Test.

Torrance[118] compared the personality characteristics of the most creative boy and girl in twenty-three classes of grades one through six, with their less creative controls. The criterion measures of creativity were the composite scores from the Ask-and-Guess, Product Improvement, Consequences, Unusual Uses, Picture Construction, Incomplete Figures, and Circles tests. The highly creative children were found to have a reputation for producing wild or silly ideas. Their

drawings and other responses were characterized by a high degree of originality, humour, playfulness and relative relaxation.

Fleming and Weintraub[119] obtained a coefficient of correlation of -.41 (significant $p < .01$) between attitudinal rigidity and the composite scores of the Product Improvement, Unusual Uses, Ask-and-Guess, Circles, and Incomplete Figures tests (as measured by the Frenkel-Brunswick Revised California Inventory). Correlations of -.37, -.40, and -.32 were found between attitudinal rigidity and originality, fluency, and flexibility, respectively.

Yamamoto[120] investigated the relationship of creativity, as measured by the tests used in the Fleming and Weintraub study, and a measure of originality obtained from the evaluation of imaginative stories of twenty fifth grade and twenty sixth grade children. Coefficients of correlation of .49 and .51 respectively, were obtained for the two groups.

Long and Henderson,[121] using the Parallel Lines test and the Children's Opinion Scale, concluded that the high creative group of students tended to be able to withhold opinions under conditions of information inadequacy, to withstand the uncertainty of an undecided state, and to resist premature closure, compared to less creative students. The sample was composed of forty-eight second grade, sixty-three

third grade, fifty fourth grade, forty-nine fifth grade, sixty-three sixth grade, and fifty-four seventh grade students.

Clark[122] obtained a coefficient of correlation of .32 (significant $p < .01$) between the composite score of the Verbal and Figural Form A of the Torrance Tests of Creative Thinking, and a measure of preference for open-structure learning experiences of 177 pupils. An open-structure learning experience was defined as one in which the goals were either set by the teacher of the pupils but the materials, activities, and methods were not specified. A closed-structure learning experience was defined as one in which the goals, materials, activity, and methods were specified by the teacher.

In a separate study, Hamburg[123] obtained a coefficient of correlation of .24 (significant $p < .01$) between the same composite creativity score used in Clark's study, and preference for open-structure learning experiences, using a sample of 241 pupils in grades three through six.

Concurrent Validity. There is no one generally accepted criterion of concurrent validity for the measurement of creativity. However, Peer Nominations, Teacher Nominations, Sales Productivity, and Educational Achievement have been considered to represent measures of concurrent validity.

Yamamoto[124] found a correlation of .24 between a battery of Torrance Tests of Creative Thinking and Peer

Nominations of fluency, flexibility, and inventiveness.

Torrance and Gupta[125] found that teachers were able to differentiate students on fluency (F-ratio = 14.98), flexibility (F-ratio = 8.08), and originality (F-ratio = 16.15) but not on elaboration (F-ratio = 1.48) using a sample of thirty-one fourth-grade teachers and 800 pupils.

Nelson[126] compared the scores on the verbal form of the Torrance Tests of Creative Thinking with a group of high-creative and low-creative students, based on a list of personality characteristics of creative persons. The verbal measures differentiated the two personality characteristics groups at a statistically significant level ($p < .01$): fluency ($t = 3.62$), flexibility ($t = 3.63$), originality ($t = 3.35$), and elaboration ($t = 3.58$).

Wallace[127] found that the scores from a battery of the verbal form of the Torrance Tests of Creative Thinking could be used to discriminate between saleswomen in "creative" and "non-creative" departments. Creative departments were defined as those in which high customer service was involved. Non-creative departments were defined as those in which low customer service was involved. Analysis of variance showed that the mean score on the Torrance Tests of Creative Thinking were higher for the saleswomen in the creative departments.

Bish[128] obtained a correlation ranging from .36 to .42 (significant $p < .01$) between the California Achievement

Test and the Verbal and Figural Form A of the Torrance Tests of Creative Thinking. The correlations increased when I.Q. was partialled out of this sample of 210 fourth, fifth, and sixth grade children.

Circelli[129] obtained correlations between the composite scores of the Verbal and Figural Form A of the Torrance Tests of Creative Thinking and the Gates Reading Test (.32), California Arithmetic Test (.26), and the California Language Test (.26), using a sample of 609 sixth grade pupils.

DIFFERENCES BETWEEN E. P. TORRANCE AND J. P. GUILFORD

There are basically two approaches to the measurement of creativity; one of these is represented by Guilford and Merrifield and the other by E. P. Torrance. Guilford[130] applied factor analytical theory to his structure of the intellect model and proposed that measures of creativity represent single factors. From this theoretical construct he has developed a variety of tests to evaluate each of the thirteen separate traits or abilities in terms of only one, or at the most two scores per instrument.

Torrance[131] has made a deliberate departure from the factor analytic tests of Guilford. He was interested in finding creative people and studying the characteristics of their behaviour. Torrance attempted to construct tasks which would be models of the creative process. Each task requires several

types of thinking such as fluency, flexibility, and originality. Scoring does not depend on a single predetermined correct response, but on the number, novelty, and variety of responses to a given complex stimulus.

Mackler and Spotts[132] and Mackler and Shontz[133] have found evidence to support Torrance's view of creativity as a personality trait rather than a set of distinct abilities as Guilford suggests. Mackler and Spotts maintain that Guilford's approach to creativity as a set of discrete factors suggests that persons should be high or low on particular factors (e.g., flexibility and originality) without respect to the type of creative task undertaken. Therefore, a high level of inter-task consistency among individuals could be expected. However, Torrance's approach suggests that it is the person and not a set of task-independent factors which account for creativity scores. Creative persons are not necessarily expected to be equally creative in all situations. Therefore, Torrance's theory does not lead to the expectation of a high inter-task consistency on creativity tests.

Mackler and Shontz administered creativity tests to coeducational undergraduate students. Their results showed intra-test consistency and relatively low inter-test stability, supporting Torrance's concept of creativity. In the Mackler and Spotts study, four tests developed by Torrance and by Guilford and Merrifield were administered to 114 male university

students. The results paralleled the findings of Mackler and Shontz. Creativity scores on all four tests showed high intra-test consistency and relatively low inter-test stability. These studies lend support to Torrance's views that it is premature to think of tests of specific creativity factors as Guilford does.

Yamamoto[134] maintains that transfer of training concerning creativity had not been investigated and therefore, it cannot be known whether 'creativity' is general or specific to stimulus situations. More evidence supporting either Torrance's or Guilford's views on creativity is required to settle this issue.

II

The use of the Inquiry Development Program to promote autonomous inquiry skills, is often referred to as inquiry training. According to Suchman the goals of his program are:

> . . . to develop the cognitive skills of searching and data processing, and the concepts of logic and causality that would enable the individual child to inquire autonomously and productively; to give the children a new approach to learning by which they could build concepts through the analysis of concrete episodes and the discovery of relationships between variables; and to capitalize on two intrinsic sources of motivation, the rewarding of experience of discovery and the excitement inherent in autonomous searching and data processing.[135]

The Suchman philosophy is not entirely new. John Dewey pointed to the limitations of teacher-directed learning and argued that true education is more than a mere

transmission of information. Dewey[136] and Suchman[137] both appeal to educators to encourage the development of the natural tendencies in the child to inquire actively. However, neither Dewey nor Suchman ever proposed that student inquiry replace the acquisition of information by other means, as critics often suggest. Suchman admits that there is not enough time in the school day for students to discover everything they need to know.

THE THINKING-LEARNING-ACTING MODEL

J. R. Suchman's Inquiry Development Program in Physical Science is based upon his thinking-learning-acting model which outlines the thinking-learning processes students experience when they learn through inquiry. Figure 2 outlines his model. Suchman has defined the terms in his model as follows:

> Meaning The pursuit of meaning is a fundamental human activity and is probably the chief motivation for most inquiry. Before trying to analyze the complex process by which people make experience meaningful, we must first consider what meaning is and how it is possible for the meaning to be generated.
>
> Perceiving is the result of an interaction between whatever is "out there" and available to our senses, and what is already internal and available to our thinking. We don't use our senses simply as wide open windows to bring in everything from outside. The world is too complex--besides, we are not interested in everything. Instead, we are selective.
>
> Encounter There is a point of contact in time and space between man and his environment. Life is a succession of such contacts. People encounter the real world around them in many ways. They encounter minute objects, large

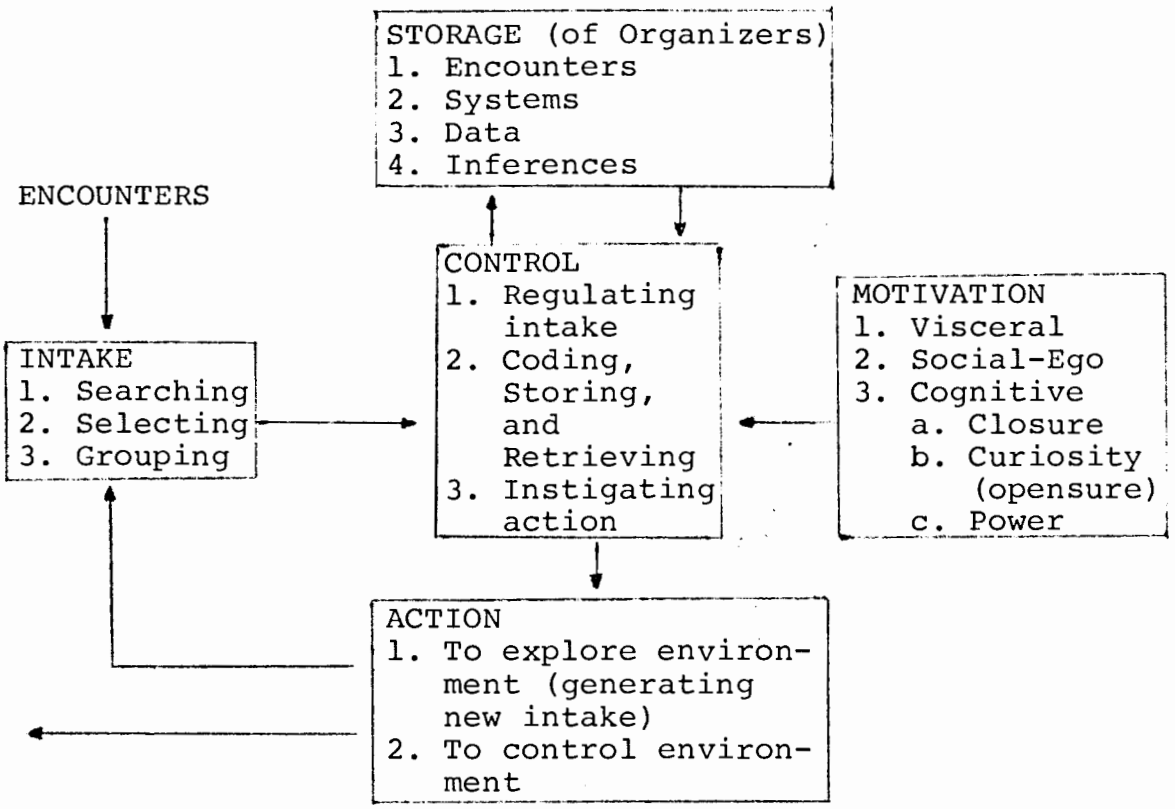

Fig. 2. Suchman's Thinking-learning-acting model

complex events, and people. The main points about encounters are: (1) the environment may offer a great many or only a few; (2) the individual can generate more encounters for himself by playing an active role and stirring things up; (3) a teacher can increase the numbers of encounters for his pupils by enriching and activating the environment, surrounding the children with more stuff, and giving them more of a chance to get at it.

Organizer The organizer resides within the person; it is a particular condition of the mind that permits the learner to respond to encounters in selected ways. An organizer helps the person to impose some degree of order upon his encounters. It affords a framework for new encounters and makes the encounters meaningful. An organizer is available because of what has happened in the past. It is a pattern which guides the selection, grouping, and ordering of encounters. Organizers take many forms. One is produced through the retention and recall of a previous encounter. The second time a person watches

a baseball game, the encounter will be more meaningful simply on the basis of the first game that was seen. . . .[138]

Action This function is the best starting place, because it is most clearly evident in the learner. Obviously, the learner moves about, talks, and manipulates objects. Any teacher or parent knows how much drive a child has to move about and do things. The drive is present at birth and throughout his life, although, as he gets older, other functions begin to replace some of the action. While older persons can sit still for longer periods and watch, read, or think, the school-age child approaches his world mobilized to do things.

Control It is difficult to imagine what humans would be like without the control function. Even in the case of a newborn baby, certain internal regulations cause crying when he is hungry or in pain; others make him focus on and follow objects in his field of vision. (Gesell identified dozens of patterns of control in newborn infants and showed that the absence of controls usually indicated impairment.) School-age children have highly sophisticated control systems. All of these are triggered and regulated in a creative or adaptive way in response to (a) the desire of the child, (b) his knowledge and experience, and (c) what he perceives in his environment.

Intake The human is a perceiving creature. Through his senses he encounters his environment. But at no time is he taking in all that is available. What he sees, hears, and feels is selected and organized by him.

Storage If you stop to think about it, it is fairly clear that what you perceive is a function of what you know. When I listen to music on the radio, I can usually tell when Beethoven is being played. I think I can tell the difference between Bach and Mozart, but I rarely notice mistakes in performance, unless I am very familiar with the selection and the mistake is a bad one. Some persons cannot only identify every composer and opus, but can sense slight deviations in tempo and pitch which I could never detect. Critics and most good musicians have knowledge that enables them to make refined discriminations and to find meaningful patterns in what would seem far less meaningful to a musical layman. This is true in thousands of ways throughout our daily lives. We all develop specialized knowledge which sharpens and organizes our intake as well as our action. . . .[139]

Systems Systems give you a structure for separating certain dimensions from the whole. They are tools for categorizing or characterizing your world, for extracting meaning from any encounter through analysis. If we could not categorize or analyze, we would have the enormous job of interpreting every encounter as a completely unique experience. Although we might recognize an encounter as having a vague familiarity, we could never know why this was so. Neither would we be able to describe, explain, or relate it to something else. Systems, then, are the instruments by which we organize the similarities and differences of our world and which thus enable us to create the structures of our disciplines.

Data We also provide children with data that has been generated by applying systems to encounters. When we state that Pike's Peak is 14,110 feet high, we rely upon somebody's previous application of the system of linear measure (feet) to the encounter of the mountain itself. The resulting statement is data.

Inference Data represent in effect discrete samplings of the environment. As one accumulates samplings, he begins to construct or abstract beliefs, theories, generalizations, or principles about the nature of the thing he is sampling. This is commonly known as inference or induction. . . .[140]

Visceral level Survival theoretically takes precedence over all other motivational levels. . . . Fortunately, the visceral needs of the average child are met.

Social-ego level Man is a social creature. As such, he is concerned with how he rates with others and with himself. Children want to be accepted and liked by their parents, teachers, and peers as well as by themselves.

Cognitive level When visceral and social-ego pressures are not strong, a child's activities can be motivated at the cognitive level. There seem to be at least three basic kinds of cognitive motivation:

1. Closure: When a person's knowledge seems incomplete or inadequate to him, when something puzzles him that he can't figure out, when he wants an answer, a solution, a final and satisfying explanation, he is said to be seeking closure. He is disturbed by the open-endedness of things. Closure motivation is common among children. Most people enjoy the satisfaction

> of finding new meaning where it was absent. They feel better about the world when all the parts fit together and they feel they have a handle on it.
> 2. Curiosity: This is very different from closure. Some people want to open the world up--to find new problems rather than solve old ones. There can be great pleasure and satisfaction in probing, wondering, and doubting, even when it never leads to closure.
> 3. Power: Knowledge is power, and many people pursue knowledge for that reason. Being able to predict and control one's environment gives one a sense of sureness and competence. Some people feel this more than others, but it cannot be ignored as a basis for motivation in learning. . . .[141]

A SCHEMA FOR INQUIRY

A schema for inquiry consists of three stages in the inquiry sessions. According to J. R. Suchman, they are:

Stage I. Episode Analysis of physical science films:

The students verify the facts of the film at this stage by identifying objects, verifying conditions of the objects and the changes in these conditions as the demonstration progresses.

Stage II. Determination of Relevance:

The students isolate relevant variables and necessary conditions at this stage. They set up hypothetical experiments in the form of questions and manipulate one variable at a time, while controlling for possible confounding variables. The variable is regarded as relevant when the results of the demonstrations are, or could be effected by these manipulations.

Stage III. Induction of Relational Constructs:

The reason the relevant variables are necessary is determined at this stage.

PROCEDURES FOR AN INQUIRY SESSION

The Inquiry Development Program provides students with a concrete focus for inquiry in the form of coloured, silent film-loops with a duration of approximately two minutes. The film-loops portray physical science discrepant events which motivate the students to analyze and to determine the cause of the event.

A set of rules for both the student and the teacher prevents the inquiry session from becoming a game of "Twenty Questions." They are:

Rule 1. "Student's questions should be phrased in such a way that they can be answered yes or no." The information that the teacher gives the student is in the form of data.

Rule 2. "Once called upon, a student may ask as many questions as he wishes before yielding the floor." When the student has finished asking his questions, he responds "I pass." The students are asked to respond in the order of raising their hand. An episode analysis chart is kept on the overhead projector to keep track of the student questions which have been asked.

This chart also represents a tally of the type of questions asked and the information gained. Tape recordings are also made of the episode.

Rule 3. "The teacher does not answer yes or no to statements or theories, or to questions that attempt to obtain the teacher's approval of a theory." The teacher does not offer approval or disapproval of any theory, but welcomes each theory as a useful starting point for further inquiry. The 'correct' explanation of the episode is never explained by the teacher. Students are encouraged to propose and test theories but no particular theory is approved or disapproved by the teacher.

Rule 4. "Any student can test any theory at any time."

Rule 5. "Any time the students feel a need to confer with one another without their teacher's presence, they should be free to call a conference."

Rule 6. "Inquirers should be able to work with experimental kits, Idea Books, or Resource Books at any time they feel the need."[142]

SUPPORT PROCESS PROCEDURES

J. R. Suchman's original procedure for inquiry sessions has been modified by emphasizing support process procedures in developing questioning strategies. The only

teacher responses allowed in the original version were: "yes," "no," or requests for a restatement of the question. In the modified version, developed by Arthur Costa and Charles Lavaroni[143] in conjunction with J. R. Suchman, the teacher is permitted to make more alternative responses to student questions, giving more support to the process of developing questioning strategies.

To ensure that the teacher is responding to the precise question asked, the teacher may request the student to clarify ambiguous words or concepts. The meanings of scientific terms and concepts may also be clarified. For example, the word 'hot' may take on significance if the student is referring to the concept of boiling rather than of very warm. In some instances the timing of the sequence of events is crucial and the students must state whether they are referring to the beginning, middle or end of the film-loop. The teacher may reveal the proper scientific names for apparatus when the student uses incorrect or vague labels.

'Experiments' are designed in the minds of the students and are 'performed' by asking questions and receiving feedback from the teacher. The results of the experiment are thus immediately attained and conclusions may then be drawn by the students.

Experiments represent an attempt to manipulate the variables involved in determining the importance of the

variable and its relationship to the causation of the event. Experiments may take the form of asking, "Would X still happen if Y?"; "If I put X in place of Y, would the same thing happen?"; "If I changed X in Y manner, would the same thing happen?" Questions may also be formulated in terms of the converse of X or in terms of variations of X. Questioning strategies are thus developed in verifying data and eliminating alternative causal factors.

When students ask, "If it (the discrepant event) had something to do with X," they are asking the teacher to say if the variable X is important. This strategy tends to short-circuit the inquiry process and the teacher must therefore direct the student to determine this information through experimentation. For example, students may be invited to answer their own question by designing an experiment having something to do with X. Once this is done, the teacher may ask if their experiment helped them to decide "If it had something to do with X."

When students think they know the cause of a discrepant event, they may wish to present it as a theory. The teacher may not tell them if it is correct or incorrect. However, he may ask if they feel comfortable with the theory or if they are satisfied with it in terms of all the data collected. The teacher may ask if the theory would still hold if it were discovered that X was the case. Students may

react by: (1) continuing to be comfortable with the theory, (2) incorporating new data into the theory, (3) modifying the theory, or (4) rejecting the theory and starting anew.

RESEARCH RELATED TO THE INQUIRY DEVELOPMENT PROGRAM

The main results of J. R. Suchman's research[144] were marked effects on the motivation, autonomy, and question fluency in the experimental group. The effects of motivation were a value judgement by the experimenter, since there was no attempt at measurement. Autonomy was regarded as an index of question fluency, since each question is an act of initiation and not a response. A psychological test for autonomy was not given. Thus the main result of the study is an increase in the number of questions asked by the students in the experimental group. However, the question fluency score was the result of the Questest, which was identical to the experimental treatment except that it was administered to students isolated from their peer group.

G. Schlenker[145] compared the Inquiry Development Program to the didactic, lecture-demonstration type of teaching with 582 pupils in grades five through eight. At the end of the sixteen-week experimental treatment, the students who were exposed to the Inquiry Development Program showed a significantly greater fluency and productivity in using the skills of inquiry as measured by J. R. Suchman's Questest.

This study thus corroborated Suchman's earlier findings. The experimental group was further shown to develop a significantly greater understanding of science and scientists as measured by the Test On Understanding Science. G. Schlenker also found no difference between the experimental and control groups in mastery of the usual elementary school science content as measured by the Stanford Achievement Test in Science.

B. Clark[146] compared the Inquiry Development Program with a more traditional teacher-centered approach. Two hundred and four grade eight students took part in the five-week study. A physical science achievement test and the Torrance test, Thinking Creatively With Words were used as a pretest and posttest. Teacher lectures, demonstrations and teacher-centered class discussions were found to be superior to inquiry teaching in yielding student growth in subject matter achievement and creative thinking ability. However, B. Clark concluded that a teaching experiment lasting only five weeks may not be long enough to adequately evaluate the teaching program.

F. Bills[147] attempted to increase the divergent thinking skills of students with a five-week experimental treatment using Suchman's Inquiry Development Program. Six creativity tests developed by Guilford, were used as pre- and posttest measures, with 142 grade eight students. They

were: Ideational Fluency, Utility Test (spontaneous flexibility), Associational Fluency, Expressional Fluency, Plot Titles (originality), and Possible Jobs (elaboration). The experimental group showed gains on four of the six creativity tests. However, the gains of the total experimental group were not significant at the .05 level of confidence. The girls in the experimental group showed a significant ($p < .01$) gain on the Plot Titles (originality) Test. Girls of high intelligence showed a significant increase ($p < .05$) on the Expressional Fluency Test.

David P. Butts[148] developed the X-35 Test of Problem Solving using a "tab" format which allows the students to select the kinds and amounts of information they consider will enable them to solve a physical science discrepant event problem. This technique simulates the inquiry processes in the Inquiry Development Program and samples the student's problem solving and reasoning ability. The instrument presents the student with (1) a specific problem, (2) a series of data or experimental items which he might wish to employ in solving the problem, and (3) a list of possible solutions to the problem, one of which is correct. The student selects questions the answers to which give relevant, additional or extra, duplicate or irrelevant information. The students continue inquiry by pulling the tabs on the listed questions thereby finding the answers. The examiner is aware of the

questions which the student considers important by listing the tabs pulled. He is also aware of the ability of the student to ask relevant questions since the questions have previously been categorized as relevant, additional, duplicate, or irrelevant. Furthermore, the student's ability to rigorously solve the discrepant event can be judged by comparing the students' solution to the discrepant event with the pattern of questions asked.

The X-35 Test was later modified and became known as the Tab Inventory of Science Processes (TISP). David P. Butts and Howard L. Jones[149] studied the effects of the Inquiry Development Program on the TISP test with 109 sixth-grade students. One inquiry session a day was given for three weeks. The researchers concluded that inquiry training resulted in more effective problem solving ($p < .05$).

W. Jones[150] investigated the effect of acknowledgement of successful autonomous discovery. Forty-nine seventh graders were randomly assigned to two classes for the study. Both the experimental and the control class were taught by the investigator using the Inquiry Development Program. In the experimental group, successful autonomous discovery was acknowledged by such comments as "Right," "OK," or "That agrees with what most scientists believe at this time." Successful autonomous discovery was not acknowledged in the control group. Jones concluded that adherence to the Inquiry

Development Program procedure of not acknowledging successful autonomous discovery results in greater science achievement gains as measured by the Cooperative General Science Test. Exposure to either the recommended Inquiry Development Program procedures or the modified instructional technique of acknowledging successful autonomous discovery significantly increased the problem-solving abilities of these grade seven students measured by the Tab Inventory of Science Processes (TISP) test.

CRITICISMS OF J. R. SUCHMAN

D. Ausubel, J. Richard Suchman's most renowned critic, claims that "Grand stretegies of discovery, like the scientific method, do not seem to be transferable across disciplinary lines--either when acquired within a given discipline or when learned in a more general form apart from specific subject-matter content. Ausubel, however, concedes that ". . . the only kinds of transfer that have been empirically demonstrated in problem-solving situations are the transfer of specific skills, the transfer of general principles, and the transfer of general approach or orientation to a specified class of problems."[151]

Ausubel[152] notes that the Inquiry Development Program does not significantly enhance the quality of questions asked by students, although it does increase the number of

valid questions. He stresses the need for new evidence for the transfer value of the program which is independent of the training procedures. A crucial issue, according to Ausubel, is that it has not been demonstrated that there is a transfer of inquiry skills to problem-solving situations in other contexts, disciplines, or subdisciplines. The inquiry approach is founded on the premise that there is a general heuristics of discovery. Ausubel disagrees with this premise. He argues that the critical thinking and problem-solving abilities of many pupils can be improved. However, this is not the same thing as saying that most pupils can be trained to become good critical thinkers and problem solvers.

Suchman has claimed that "the schools must have a new pedagogy with a new set of goals which subordinates retention to thinking . . . Instead of devoting their efforts to storing information and recalling it on demand, they would be developing the cognitive functions needed to seek out and organize information in such a way that would be most productive of new concepts."[153]

The main disagreement between Ausubel and Suchman is that of linear vagueness between the degree of importance of inquiry methods and its place in the curriculum. Ausubel admits:

> . . . it is highly defensible to utilize a certain proportion of classroom time in developing appreciation of and facility in the use of scientific methods of inquiry and

> of other empirical, inductive, and deductive problem-solving procedures. But this is a far cry from advocating that the enhancement of problem-solving ability is the major function of the school.[154]

Suchman admits that there is not enough time in the school day for students to discover everything they need to know. However, he claims (as does Bruner) that the acquisition of the ability to discover knowledge autonomously is more important than the acquisition of content knowledge. On this point, Ausubel and Suchman disagree.

Suchman has, on occasion, taken a moderate position:

> We do not suggest that inquiry or discovery should replace good, didactic exposition. If a child had to discover every new relationship for himself, a great deal of time and energy would be wasted. Gifted children in particular are capable of acquiring elaborate conceptual systems through explanations and demonstrations. But more basic than the attainment of concepts is the ability to inquire and discover these autonomously. Inquiry Training is not proposed as a new way to teach science, but as a way of teaching basic cognitive skills that are just as important to the intellectual development of the child as reading and arithmetic. It belongs in the science program and in every other curriculum area that requires the performance of empirical operations, inductive and deductive reasoning, and the formulation and testing of hypotheses.[155]

R. Buell[156] suggests that one should not expect a significant effect from Suchman's Inquiry Development Program using a sample of grade five or six pupils, since Gabel's results indicated that "until puberty (i.e., about seventh grade) there is little interest in, nor in Piagetian terms, structures for inquiry process."[157] Buell was making reference to Suchman's original study which incorporated a sample of

grade five and six pupils.

An examination of Gabel's study raises the question of the validity of Buell's claim. Gabel presented students with two methods of teaching (definite and indefinite, e.g., 1492 vs. late in the fifteenth century) and two methods of testing (definite vs. indefinite). He concluded that the definite method of presentation of quantitative terms in social studies material is more effective than the indefinite method, and that the scores were higher on tests using definite quantitative terms than on tests using indefinite terms. Gabel found that the percentages of correct response increases in size from grade to grade in all forms and in all types of quantitative concepts and suggests that this may be due to a natural maturation in the ability to synthesize definite and indefinite meetings. Gabel concluded that this ability manifests itself at about the age of the average pupil who is in the seventh grade, since there was a wider increase in score on all concepts (time, area, distance and size) between the sixth grade and the eighth grade than between the eighth and tenth or tenth and twelfth.

Buell's criticism of the Inquiry Development Program, is based on the tenuous assumption that older students who score higher on tests consisting of 'definite' items when taught using 'definite' instruction in social studies, provides evidence in support of the claim that pre-adolescent

students do not have interest or structures for inquiry process in science.

Biehler disagrees with Buell's criticism and suggests that grade five and six pupils are at the most appropriate age for inquiry training:

> These upper elementary-grade pupils have just achieved mastery of the symbolic mode of thought, which involves formal operations (to use the terms of Bruner and Piaget). Younger pupils may not be capable of similar types of thinking, and older students might be bored or blasé about such demonstrations.[158]

Suchman concurs with Biehler and declares that pupils in the concrete operations stage are capable of inquiry training:

> When the child reaches the stage at which he can think operationally, he sees each manipulative act as a isolated, reversible move that has a specific result. He becomes more process-oriented. He regards the action and its result as a unit. He can internalize this unit, store it, combine it with other units and use it to form rules and generalizations. Thus, through operational thinking the child can go beyond the data and can form constructs that will enable him to predict and control events which he has never before witnessed.[159]

INTERFACE: E. P. TORRANCE AND J. R. SUCHMAN

The emphasis of Torrance's definition of creativity is on the searching and exploring aspect of the process of hypothesis-forming, testing, and communication of results. This aspect of creativity, Guilford refers to as "divergent thinking." Torrance's definition of creativity reflects the essential aspects of Suchman's Inquiry Development program. To reiterate, Torrance defines creativity by stating that,

> Creative behaviour occurs in the process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results.[160]

Suchman explains his concept of creativity by stating that

> Creative thinking has two defining characteristics. First it is autonomous; that is, it is neither random nor controlled by some fixed scheme or external agent, but is wholly self-directed. Secondly, it is directed toward the production of a new form--new in the sense that the thinker was not aware of the form before he began the particular line of thought.[161]

Torrance suggests five principles for rewarding creative thinking:

1) Be respectful of unusual questions,
2) Be respectful of the unusual ideas of children,
3) Show children that their ideas have value,
4) Provide opportunities for self-initiated learning and give credit for it,
5) Provide for periods of non-evaluated practice or learning.[162]

R. Suchman's Inquiry Development Program satisfies all five of Torrance's conditions for creativity. Unusual questions and ideas are treated with respect. The students are never criticized, no matter how unusual their questions or ideas are. Any question can be used to instigate further inquiry. The decision to reject an idea or a theory is the student's decision and not the teacher's. All student ideas have value. The extent to which ideas could have or did lead to fruitful inquiry is determined in the final debriefing session and by the extent to which student theories are

compatible with all the data. Providing opportunities and giving credit for self-initiated learning is the basis of the program. Suchman states that, "most creative thinking occurs when the thinker is free to play with ideas, to invent, to take chances, to change his mind and reverse direction."[163] This is fostered in an atmosphere of non-evaluated practice or learning. Suchman stresses that the teacher must "respond positively to the student and neutrally to the product of the student's thinking."[164] The students are not verbally rewarded or punished for their contributions to inquiry. The teacher responds with non-evaluative comments. Moreover, the students operate within a "low pressure system" in that they are given "protected time" in which they can continue to ask questions without other students interrupting them. The "protected time" lasts until the responding student gives up the floor by saying, "I pass." Torrance[165] concurs with Suchman's concept of "low pressure" by stating that, the absence of serious threat to self, the willingness to risk, is necessary in fostering creativity.

Suchman delineated the role of the teacher in fostering autonomous inquirers:

1) stimulate and challenge the students to think,
2) ensure freedom of operations,
3) provide support for inquiry,
4) diagnose difficulties and help the students overcome them, and
5) identify and use the "teachable moments" when new organizers can be introduced most effectively.[166]

This role, is supportive of Torrance's five principles for rewarding creative thinking.

The central motivating force in the Inquiry Development Program is a sense of incompleteness or disharmony in the form of discrepant events. The discrepant events, according to Suchman are designed to be ". . . discrepant enough to make him [the student] curious--to build up irresistable pressures in the child to find a way of assimilating the event."[167] Torrance concurs with Suchman by stating that ". . . awareness of incompleteness in knowledge is a powerful motivating force."[168]

Torrance agrees with Suchman's hypothesis that a discrepant event will cause the student to enter into a natural creative process to make sense out of the event and to discover the meaning which is obscured by the discrepant event. Torrance remarks:

> If we sense some incompleteness or disharmony, tension is aroused. We are uncomfortable and want to relieve the tension. Since habitual ways of behaving are inadequate, we begin trying to avoid the commonplace and obvious (but incorrect) solutions by investigating, diagnosing, manipulating and making guesses or estimates. Until the guesses or hypotheses have been tested, modified, and retested, we are still uncomfortable. The tension is unrelieved, however, until we tell somebody of our discovery.[169]

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CHAPTER III

METHODS AND PROCEDURES

SOURCES OF DATA

The data in this study were obtained from two grade five classes at a large elementary school in a metropolitan city in British Columbia. On the basis of father's occupation (labour 50 per cent, semi-skilled 30 per cent, and para professional 20 per cent), the large majority of children could be classified as of working and lower-middle class backgrounds.

All of the students were ranked according to high, medium, and low academic achievement based on teachers' records. Students from each of these three categories were then randomly assigned into two groups which were randomly designated as either the experimental or the control group.

The initial sample consisted of fifty-six students. One student in the experimental and two students in the control group transferred to another school before the posttest sessions were completed. All were in the bottom quartile of the sample based on academic rank, the Henmon-Nelson and the Gates-MacGinitie tests.

Three students transferred into the school before the

completion of the study and were randomly assigned to either the experimental or the control group. Their posttest scores do not appear in the data for this study, since they had missed the pretesting sessions and had completed less than one-half of the science sessions. The total number of students participating in this investigation was therefore fifty-three, with twenty-seven students in the experimental group and twenty-six students in the control group.

HYPOTHESES

In carrying out this study it was necessary to hypothesize that the Inquiry Development Program will increase the fluency of questions asked by students when tested with content and format similar to the training sessions. J. R. Suchman found this to be the case in his study, the Elementary School Training Program in Scientific Inquiry.

It was further hypothesized that the inquiry trained students would be able to transfer their increased questioning fluency to discrepant events with other than physical science content. For this purpose the discrepant events in the Discrepant Event Test and the Torrance Tests of Creative Thinking were chosen.

It was hypothesized that creative thinking abilities can be developed and that the Inquiry Development Program will foster their growth. Torrance remarks,

> As young children gain practice in the process of encountering puzzling phenomena, they should show definite improvement in the investigative nature of their questioning.[1]

> Creative thinking abilities--certainly those measured by the Torrance Tests of Creative Thinking--are susceptible to development through educational experiences. Thus, children who have educational experiences that permit them to learn in creative ways would develop differently from those who experience only what their environment happens to provide or those who are taught in such a way as to discourage creative ways of learning.[2]

The hypothesis that there will be transfer of inquiry skills from the Inquiry Development Program to the Torrance Tests of Creative Thinking is based on the assumption that generalized thinking skills are transferable between similar activities in different content areas. It was assumed that inquiry skills are generalized thinking skills which can operate in specific content areas. This assumption does not exclude the possibility of specific thinking skills also operating in such specific content areas.

Ausubel is skeptical of specific kinds of discovery strategies transferring across disciplinary lines. He contends that:

> Grand strategies of discovery, like the scientific method, do not seem to be transferable across disciplinary lines --either when acquired within a given discipline or when learned in a more general form apart from specific subject-matter content.[3]

However, Ausubel recognizes that a generalized transfer may occur within a class of problems.

> . . . the only kinds of transfer that have been empirically demonstrated in problem-solving situations are the

> transfer of specific skills, the transfer of general principles, and the transfer of general approach or orientation to a specified class of problems.[4]

Since girls at the grade-five level generally perform better academically than the boys, it was hypothesized that the girls would score higher than the boys on the subscores and the total scores of the Torrance Tests of Creative Thinking.

The problem-solving skills of inquiry-trained students have been examined by D. Butts and H. Jones[5] and W. Jones[6] using content and format similar to the Inquiry Development Program. Rather than replicate these investigations, it was hypothesized that inquiry-trained students could transfer their problem-solving skills in terms of critical thinking, to a format and content removed from the Inquiry Development Program. The Social Studies Inference Test was chosen for this purpose.

The precise hypotheses investigated in this study are listed in the null form:

1. There will be no statistically significant difference in mean scores between the experimental and the control groups on questioning fluency measured by the Inquiry Development Program Film-Loop Test.
2. There will be no statistically significant difference in mean scores between the experimental and the control groups on questioning fluency measured by

the Discrepant Event Test.

3. There will be no statistically significant difference in mean scores between the experimental and the control groups on the subscores of fluency, flexibility and originality and the total scores on the Torrance Tests of Creative Thinking.
4. There will be no statistically significant difference in mean scores between the experimental and the control groups in science content measured by the Sequential Tests of Educational Progress in Science.
5. There will be no statistically significant sex difference in the means of the subscores and the total scores on the Torrance Tests of Creative Thinking.
6. There will be no statistically significant difference in mean scores between the experimental and the control groups on the subscores of the Social Studies Inference Test.

The .05 level of confidence was chosen as an acceptable level for determining the statistical significance of the above hypotheses. Where pretest and posttest measures were available, analyses of covariance were conducted.

PRETESTS AND POSTTESTS

The experimental and the control groups were given the same pretests and posttests. The pretests were: Hilda Taba's Social Studies Inference Test for grades three to six (see page 106 and appendix B), the Torrance Tests of Creative Thinking Verbal Form Part A (see page 33), the Inquiry Development Program Film-Loop test (see page 104), and the Discrepant Event test (see page 105).

The Inquiry Development Program Film-Loop pretest required the students to list all the questions that could help them determine the cause of the portrayed discrepant events. The test film entitled "Cartesian Diver" was the same used by J. R. Suchman in his original study. The Discrepant Event pretest took the form of a written discrepant event test entitled the "Pearl Problem" (see page 106). This test required the students to list the questions which could help them solve the discrepant event.

The posttests were: Hilda Taba's Social Studies Inference Test for grades three to six (the same form as the pretest), the Torrance Tests of Creative Thinking Verbal Form Part B, the Inquiry Development Program Film-Loop test (see page 104), and the Discrepant Events test (see page 106). The Inquiry Development Program Film-Loop test took the same

format as the pretest but was based on a different film entitled "Boiling Water by Cooling." This was the same film as used by J. R. Suchman in his original study posttest. The Discrepant Event posttest took the same format as the pretest but was based on a different problem entitled the "Salt March" (see page 106). The Sequential Tests of Educational Progress Form 4B Science, the Henmon-Nelson Tests of Mental Ability grades three to six Form B, and the Gates-MacGinitie Reading Tests Survey D, Form 3 were also administered. Students were ranked according to their overall academic achievement and the sex of each student was noted.

THE INDEPENDENT VARIABLE

The independent variable was the presence or absence of Inquiry Training for twenty sessions. The experimental treatment consisted of a one-hour inquiry session per week. The first portion of each session was spent in viewing the film-loop and in active inquiry into the discrepant event presented in the film. The inquiry session consisted of viewing the film and applying J. R. Suchman's inquiry technique to verify data, search for causal relationships, generate and test hypotheses which may crystallize into tenable explanations or theories. The final portion of each inquiry session was devoted to a critique in which the students and teacher discussed the dimensions of the process of inquiry

and the effectiveness of their strategy for searching and data processing.

The experimental group's Inquiry Training period was scheduled at the same time as the control group's library period, which took place in a separate area of the building. Likewise, the control group's science period was scheduled at the same time as the experimental group's library period. The control group's science unit was the curriculum prescribed Elementary Science Study (ESS) unit entitled "Coloured Solutions."

The different coverage of material between the experimental and control group is not of significance to this study, since the posttests are independent of specific content knowledge gained in either the experimental group's inquiry sessions or the control group's curriculum sessions. The major difference between the experimental and control group was the process of inquiry which involved strategies in asking questions to gain maximum information, verify data, predict consequences, deduce causes, and develop tenable theories.

THE EXPERIMENTAL DESIGN

The investigation took the form of a pretest-posttest control group design. It is a true experimental design except for the fact that the school participating in the study was not chosen by random assignment. The effects of history,

maturation, testing, experimental mortality, instrumentation, statistical regression and selection, which Campbell and Stanley[7] consider important in maintaining high internal validity, have been controlled as much as possible given the scale of this investigation. Student individual differences of sex, academic achievement and intelligence quotient were controlled by their respective notation and measurement. Other individual differences were controlled through random assignment which predicts that individual differences will be equally dispersed between the two groups. A sample of two variables (reading ability and intelligence quotient) were checked at the outset of the study to ensure that the random assignment resulted in comparable groups.

Since the total sample was not randomly drawn from a given population and since the sample size was small (N = 53), the external validity of this investigation is low. The results cannot be generalized beyond the two classrooms and the school which participated in the investigation. However, it is likely that the results of this study could be replicated in other classrooms since the sample shares many characteristics typical of average students. The general academic achievement and intelligence quotient of the students approaches that of a theoretically normal population. The sample did not consist of 'bright' students, as is often the case in similar investigations.

CONTROL OF POSSIBLE CONFOUNDING VARIABLES

The selection process controlled for many potential confounding variables. The selection of students into the experimental and control groups was based upon stratified random sampling using the variable of past academic achievement. High, medium and low academic groups from two classrooms were pooled and then randomly assigned to either the experimental or the control group.

The experimental and the control group had approximately an equal number of students from the experimenter's class and from another teacher's class. This fact controlled for effects of history, i.e., inquiry teaching which may have been taught during non-experimental time. Maturation, the effects of testing, experimental mortality, statistical regression and the selection of students were controlled by random assignment.

Teacher personality represents one significant variable controlled for by having the same experimenter apply the treatment to both the experimental and the control groups. The literature suggests that often the most significant variable in experiments of this kind, is the personality and motivational differences between teachers. Another advantage of having one teacher-experimenter was that the students did not see the experimenter as a foreign investigator and attempt to conform to his expectations in the testing situation,

i.e., the Hawthorne Effect. The pretests and the posttests were regarded by the students as a natural introduction to and outgrowth from the science units.

The pretests were not scored until the conclusion of the investigation, to avoid influencing the experimenter's expectations and motivational level. The intelligence factor was controlled by random assignment and was further measured by the Henmon-Nelson Tests of Mental Ability grades three to six Form B and the student's academic rank.

INSTRUMENTS

Descriptions of the instruments are limited to the Inquiry Development Program Film-Loop Tests, the Discrepant Event Tests and the Social Studies Inference Test. The assumptions, rationale, and description of the Torrance Tests of Creative Thinking have been presented in detail (see page 33). Descriptions of the Sequential Tests of Educational Progress in Science, the Henmon-Nelson Tests of Mental Ability, and the Gates-MacGinitie Reading Tests have not been included since they are well known in educational testing. Their reliabilities have been reported on page 54.

The Inquiry Development Program Film-Loop Test

In his original research, J. R. Suchman measured each student's inquiry skills with a 'questest' which consisted of

a one-hour private inquiry session based on Inquiry Development Program film-loops. Suchman hypothesized that there were differences between the experimental and the control group on all his questioning categories. One purpose of this thesis was simply to compare the number of questions asked by the experimental and the control group. This objective did not merit the time and financial requirements of the 'Questest.' Therefore, a simplified version of the 'Questest' labeled the Inquiry Development Program Film-Loop Test was given to the experimental and the control groups in the usual science class setting, using the same pretest and posttest film-loops as in the 'Questest,' i.e., "The Cartesian Diver" and "Boiling by Cooling," respectively.

The pretest and posttest required the students to list as many questions as they could to help them solve the discrepant event. For the purpose of this study, appropriate student questions were given one point and the total number of questions asked formed the fluency score. These tests were similar to the experimental treatment, except that: (1) they were written rather than oral, (2) the teacher provided no feedback to the questions generated, and (3) the students could not assimilate and accommodate their peer-group's questions and theories.

The Discrepant Event Test

The Discrepant Event Tests were designed to test for

transfer of increased questioning fluency using discrepant events with other than physical science content. The pretest version entitled "The Pearl Problem"[8] took the following form:

> Several years ago a Japanese ship left port and headed for the open sea. When it had reached a spot about 500 miles from the nearest port of land, the captain gave a signal and the crew spilled a half a ton of pearls over the side. What questions can you think of that might help explain this apparently unreasonable (and true) happening?

The posttest discrepant event entitled "The Salt March" was adapted from a description by D. Birch[9] and took the following form:

> Several years ago in India 25,000 people marched to the salt fields. They told the police what they were going to do. They were going to gather salt. It was against the law to gather salt without paying the tax on it. The Indian people were not going to pay the salt tax. Four hundred Indian police were waiting with steel-tipped clubs. When the first group of Indian people went to gather salt, they were beaten up with the huge clubs. Their bodies were picked up and carried away. Another large group went to gather salt and were beaten up and carried away. In groups of twenty-five, the people marched to the salt fields and sat down. Again, they were beaten up by the police, and the bleeding bodies were carried away. At the end of the day everyone left. The Indian people felt that the day had been a great success. What questions can you think of that might help explain this apparently unreasonable (and true) happening?

The Social Studies Inference Test

Hilda Taba[10] claims that her Social Studies Inference Test measures: (a) the ability to discriminate between the various items given in the test problems, (b) the ability to draw inferences or "to go beyond that which is given," (c) the ability to recognize the limits of the data, to refrain

from overgeneralizing or from being over-cautious, and (d) the tendency to make errors which represent contradictions to what the data tell or suggest. The test assesses the student's ability to interpret what is given in a situation and to make judgements regarding the validity of inferences from these data. The students are presented with a story describing a situation in which certain behaviours or events are inter-related. They are given a number of choices in the form of inferences of varying degrees of plausibility or probability of occurrence, predicated on generalizations around which the situations are written. In effect, the descriptive stories contain information that permit students to select 'valid' inferences if they know or understand the basic generalization of which the data are specific instances.

The Social Studies Inference Test is broken down into four sub-scores: (a) discrimination, (b) inference, (c) caution, and (d) over-generalization. The test includes ten situations with a total of sixty-eight items: fourteen "discrimination" items, eighteen "over-generalization" items, and thirty-six items scored either "inference" or "caution." The students mark the items by indicating whether they believe a statement to be probably true, probably false, or equivocal ("can't tell").

The Discrimination score measures the student's ability to distinguish between relevant and irrelevant data. The

Inference score measures the student's ability to make inferences from data including the logical operations of interpolating, extrapolating, predicting, hypothesizing, and explaining. In interpreting the data the student is required to make inferences in regard to (a) how he or another individual was likely to behave under given circumstances, (b) whether an event will or will not occur, and (c) whether an event was responsible for the occurrence of another event. For a given inference only one of the alternatives, "Probably True," "Probably False," or "Can't Tell" is correct. The sum of the correct alternatives for the inference items forms the Inference score.

When the nature of the data is such that the most plausible answer is either "Probably True" or "Probably False" and the subject selects "Can't Tell" he or she is considered to be cautious, and is given a point on the Caution score. The Overgeneralization score measures the extent to which the student unjustifiably arrived at conclusions with minimal evidence.

If the Inquiry Development Program is successful it should follow that the students trained in the Inquiry Development Program should be likely to have a high discrimination score (since they should be good data discriminators), a high inference score (since they should be good at making logical inferences from data), a low caution score (since they should be good data discriminators and should have confidence in

their ability to make inferences) and a low over-generalization score (since they should have learned not to generalize beyond the data and have learned to base their conclusions on verified data).

METHODS OF ANALYSIS

Complete data on the pretest and posttest measures in this study were obtained from the fifty-three fifth grade students. There were twenty-seven students in the experimental and twenty-six students in the control group. The analysis of covariance was used to determine statistical significance of posttest scores for the experimental compared to the control groups on the Torrance Tests of Creative Thinking, the Inquiry Development Program Film-Loop Test, the Discrepant Event Test, and the Social Studies Inference Test. In the above analyses, pretest scores were used as the covariate. Since only posttest scores were collected for the Sequential Tests of Educational Progress, a t-test analysis was conducted.

The mean, standard deviation, t-value, degree of freedom and the two-tailed probabilities were obtained for the student's academic rank, the Gates-MacGinitie Reading Tests, the Henmon-Nelson Tests of Mental Ability and the male and female subscores and total scores on the Torrance Tests of Creative Thinking. The Chi-square test was used to determine any statistical significance between sex distribution in the experimental and control group.

Notes

[1]E. P. Torrance and W. R. Nash, "Creative Reading and Questioning Abilities of Young Children," *Journal of Creative Behavior* 8, no. 1 (1974):15.

[2]E. P. Torrance, *Torrance Tests of Creative Thinking, Norms-Technical Manual* (Princeton, N.J.: Personnel Press, 1966), p. 9.

[3]D. P. Ausubel, "An Evaluation Of The Conceptual Schemes Approach To Science Curriculum Development," *Journal of Research In Science Teaching* 3 (1965):258.

[4]Ibid.

[5]D. P. Butts and H. L. Jones, "Inquiry Training and Problem Solving in Elementary School Children," *Journal of Research in Science Teaching* 4 (1966):21-27.

[6]W. W. Jones, "An Investigation of the Effect of Acknowledging Successful Autonomous Discovery by Seventh Grade Students Exposed To The Inquiry Development Program" (Dissertation Abstracts, University of Northern Colorado, 1972).

[7]D. T. Campbell and J. C. Stanley, *Experimental and Quasi-Experimental Designs For Research* (Chicago, Ill.: Rand McNally College Publishing Co., 1973).

[8]E. P. Torrance, *Creative Learning and Teaching* (New York: Dodd, Mead, 1970), p. 142.

[9]D. Birch, R. J. McKeown, and D. Weitzman, *Asia* (San Francisco, Calif., Field Educational Publications, 1969), p. 116.

[10]Hilda Taba, *Teaching Strategies and Cognitive Functioning in Elementary School Children* (San Francisco: San Francisco State College, 1966).

CHAPTER IV

RESULTS

HOMOGENEITY OF THE GROUPS

Evidence for homogeneity between the experimental and the control group at the outset of the study may be found by examining the number of male and female students in each group, the students academic rank, and the scores on the Henmon-Nelson and Gates-MacGinitie Tests.

Table II shows that there is no statistically significant difference between the number of boys and girls in each of the experimental and control groups.

Table II Sex Distribution in the Sample Population

Sex	Group	
	Inquiry	Control
Male	11	13
Female	16	13

$\chi^2 = 0.16$, $P > .05$.

Evidence for academic equality in the experimental and control groups may be seen by examining Table III which compares their academic rank, intelligence quotient and reading ability. There were fifty-one degrees of freedom and fifty-three

students in the sample.

Table III Comparison of Academic Rank, Intelligence Quotient and Reading Ability

Variable	Group	$\bar{X}$	s	t	Significance
Academic Rank	Inquiry	12.9	7.8	-0.79	n.s.
	Control	14.6	7.7		
Intelligence Quotient	Inquiry	102.7	11.9	-0.71	n.s.
	Control	104.9	10.3		
Reading Ability	Inquiry	75.7	23.4	-0.69	n.s.
	Control	79.7	18.5		

It may be noted that the control group is higher than the experimental group on all three academic variables, however, these differences were not found to be statistically significant ($p > .05$).

Academic rank refers to the academic achievement of the students in terms of the rank recorded on their permanent record cards in the school files. The ranking order was from 1 (the highest academic achievement relative to the peer group) to 26 or 27 (the lowest academic achievement). Intelligence quotient was measured by the Henmon-Nelson Tests of Mental Ability grades three to six and reading ability was measured by the Gates-MacGinitie Reading Tests.

In summary, it was established that, at the outset of

the investigation, the experimental and control groups were found not significantly different on the variables considered to be important to this study, i.e., sex distribution, academic rank, intelligence quotient and reading ability. It was therefore concluded that the experimental and control groups were drawn from the same population.

TEST OF HYPOTHESIS 1

Hypothesis number 1 states: There will be no statistically significant difference in mean scores between the experimental and the control groups on questioning fluency measured by the Inquiry Development Program Film-Loop Test.

This null hypothesis was rejected. The analysis of covariance (see Table IV)showed that the experimental group scored significantly ($p < .001$) higher on questioning fluency as measured by the Inquiry Development Program Film-Loop Test. The symbols $\bar{X}_1$ and $\bar{X}_2$ in Table 4 and in following tables refer to the pretest mean and the posttest mean, respectively. There were twenty-six degrees of freedom and twenty-seven students in the experimental group compared to twenty-five degrees of freedom and twenty-six students in the control group.

Table IV Results for the Inquiry Development Program Film-Loop Test

Group	Pretest $\bar{X}_1$	Pretest s_1	Posttest $\bar{X}_2$	Posttest s_2	F*	Significance
Inquiry	7.5	4.67	16.4	7.39	14.30	$p < .001$
Control	7.8	3.58	9.8	5.39		

*Based on analysis of covariance of posttest scores, with pretest scores as covariate.

TEST OF HYPOTHESIS 2

Hypothesis number 2 states: There will be no statistically significant difference in mean scores between the experimental and the control groups on questioning fluency measured by the Discrepant Event Test.

This null hypothesis was rejected. Table V shows that the experimental group's mean fluency score was significantly ($p < .001$) higher on the Discrepant Event Test.

The experimental group gained 1.7 questions on this posttest compared to a loss of -5.3 for the control group. The small increment in the experimental group and the decrement in the control group can be explained in terms of the difficulty of the posttest. The control group found it an onerous task to formulate even a few questions which would help them solve the discrepant event. The experimental group found the task perplexing but also challenging. Their

questioning fluency increment for this task is not consistent with the large gains found in the Inquiry Development Program Film-Loop scores.

Table V Results for the Discrepant Event Test

	Pretest		Posttest		F*	Significance
	$\bar{X}_1$	s_1	$\bar{X}_2$	s_2		
Inquiry	10.4	7.18	12.11	6.50	42.26	$p < .001$
Control	8.4	4.60	2.8	2.66		

*Based on analysis of posttest scores, with pretest scores as covariate.

TEST OF HYPOTHESIS 3

Hypothesis number 3 states: There will be no statistically significant difference in mean scores between the experimental and the control groups on the subscores of fluency, flexibility and originality and the total scores on the Torrance Tests of Creative Thinking.

This null hypothesis was rejected. The analysis of covariance (see Table VI) showed that the experimental group's scores were significantly higher for fluency ($p < .01$), flexibility ($p < .001$), originality ($p < .001$), and the total scores ($p < .001$) of the Torrance Tests of Creative Thinking.

Table VI Results for the Subscores and Total Scores of the Torrance Tests of Creative Thinking

Variable	Group	Pretest $\bar{X}_1$	Pretest s_1	Posttest $\bar{X}_2$	Posttest s_2	F*	Significance
Fluency	Inquiry	58.44	30.00	72.26	27.60	6.49	$p < .01$
	Control	56.00	20.00	51.96	34.24		
Flexibility	Inquiry	23.81	9.37	28.52	8.28	14.66	$p < .001$
	Control	22.81	8.18	20.85	7.34		
Originality	Inquiry	18.18	10.47	27.48	10.77	23.90	$p < .001$
	Control	18.38	9.07	16.73	8.79		
Total Scores	Inquiry	101.07	47.62	128.26	42.60	13.83	$p < .001$
	Control	97.19	33.30	89.54	46.43		

*Based on analysis of covariance of posttest scores, with pretest scores as covariate.

TEST OF HYPOTHESIS 4

Hypothesis number 4 states: There will be no statistically significant difference in mean scores between the experimental and the control groups in science content measured by the Sequential Tests of Educational Progress in Science.

This null hypothesis was not rejected. Table VII shows that there was no statistically significant difference ($p > .05$) in science content knowledge at the conclusion of the study.

Table VII Results for the Sequential Tests of Educational Progress in Science (STEP)

Group	$\bar{X}$	s	t	Significance
Inquiry	28.4	9.2	0.40	n.s.
Control	27.3	9.2		

The numerical difference between the experimental and the control group on the Sequential Tests of Educational Progress in Science was 1.1 which did not constitute a statistically significant difference ($p > .05$).

TEST OF HYPOTHESIS 5

Hypothesis number 5 states: There will be no statistically significant sex difference in the means of the

subscores and the total scores on the Torrance Tests of Creative Thinking.

Table VIII shows that the null hypothesis was rejected ($p < .05$) in the experimental group subscore of flexibility in the posttest version. The null hypothesis was not rejected for the other subscores or total scores in the experimental group and Table IX shows that the null hypothesis was not rejected for any of the subscores or total scores in the control group.

The results on sex differences are consistent for both the experimental and the control group. Table VIII shows that the experimental group girls scored higher on all the pretest and posttest subscores and total scores. Table IX shows that the girls in the control group, also scored higher than the boys on all the pretest and posttest subscores and total scores.

The consistency of the girls' higher scores gave rise to the question of whether their scores were significantly ($p < .05$) higher than the boys. Analysis of the scores for the experimental group (Table X) and the control group (Table XI) reveals no statistically significant ($p > .05$) sex differences on the subscroes and total scores on the Torrance Tests of Creative Thinking.

Table VIII Sex Differences in the Experimental Group on the Variables of Fluency, Flexibility, Originality, and Total Scores on the Torrance Tests of Creative Thinking

Variable	Version	Sex	$\bar{X}$	s	t	Significance
Fluency	Pretest	Male	55.0	35.85	-.49	n.s.
		Female	60.81	26.25		
	Posttest	Male	66.55	28.19	-.089	n.s.
		Female	76.19	27.40		
Flexibility	Pretest	Male	20.45	9.92	-1.59	n.s.
		Female	26.13	8.52		
	Posttest	Male	24.64	8.29	-2.16	$p < .05$
		Female	31.19	7.37		
Originality	Pretest	Male	13.27	11.28	-2.03	n.s.
		Female	22.63	12.12		
	Posttest	Male	23.45	10.40	-1.67	n.s.
		Female	30.25	10.44		
Total Score	Pretest	Male	88.73	52.34	-1.12	n.s.
		Female	109.56	43.77		
	Posttest	Male	114.64	41.96	-1.40	n.s.
		Female	137.23	53.42		

Table IX Sex Differences in the Control Group on the Variables of Fluency, Flexibility, Originality, and Total Scores on the Torrance Tests of Creative Thinking

Variable	Version	Sex	$\bar{X}$	s	t	Significance
Fluency	Pretest	Male	52.08	18.87	-0.96	n.s.
		Female	59.92	27.79		
	Posttest	Male	44.85	24.67	-1.06	n.s.
		Female	59.08	41.52		
Flexibility	Pretest	Male	21.77	9.08	-0.64	n.s.
		Female	23.85	7.39		
	Posttest	Male	20.08	6.96	-0.53	n.s.
		Female	21.62	7.90		
Originality	Pretest	Male	16.31	7.42	-1.18	n.s.
		Female	20.46	10.34		
	Posttest	Male	14.92	7.93	-1.05	n.s.
		Female	18.54	9.54		
Total Score	Pretest	Male	90.15	28.36	-1.08	n.s.
		Female	104.23	37.40		
	Posttest	Male	79.85	37.87	-1.07	n.s.
		Female	99.23	53.42		

Table X Comparison of Males vs. Females on the Subscores and the Total Scores of the Torrance Tests of Creative Thinking in the Experimental Group

Variable	Sex	Pretest $\bar{X}_1$	Pretest s_1	Posttest $\bar{X}_2$	Posttest s_2	F*	Significance
Fluency	Male	55.00	35.85	66.54	28.19	0.53	n.s.
	Female	60.81	26.25	76.19	27.40		
Flexibility	Male	20.45	9.92	24.64	8.29	2.21	n.s.
	Female	26.13	8.52	31.19	7.37		
Originality	Male	13.27	11.28	23.45	10.40	0.21	n.s.
	Female	22.63	12.12	30.25	10.44		
Total Scores	Male	88.73	52.34	114.64	41.96	0.75	n.s.
	Female	109.56	43.77	137.63	41.73		

*Based on analysis of covariance of posttest scores, with pretest scores as covariate.

Table XI Comparison of Males vs. Females on the Subscores and the Total scores of the Torrance Tests of Creative Thinking in the Control Group

Variable	Sex	Pretest $\bar{X}_1$	Pretest s_1	Posttest $\bar{X}_2$	Posttest s_2	F*	Significance
Fluency	Male	52.08	18.87	44.85	24.67	0.40	n.s.
	Female	59.92	22.79	59.08	41.52		
Flexibility	Male	21.77	9.08	20.08	6.96	0.07	n.s.
	Female	23.85	7.39	21.62	7.90		
Originality	Male	16.31	7.42	14.92	7.93	0.25	n.s.
	Female	20.46	10.34	18.54	9.55		
Total Scores	Male	90.15	28.36	90.15	28.36	0.24	n.s.
	Female	104.23	37.40	99.23	53.42		

*Based on analysis of covariance of posttest scores, with pretest scores as covariate.

TEST OF HYPOTHESIS 6

Hypothesis number 6 states: There will be no statistically significant difference in mean scores between the experimental and the control groups on the subscores of the Social Studies Inference Test.

This hypothesis was not rejected. Table XII shows that there was no statistically significant difference between the experimental and control group on any of the Social Studies Inference Test subscores of Inference, Discrimination, Accuracy, Caution, Over-Generalization, and Error.

It may be noted that both the experimental and the control groups scored lower on the variables of Inference, Discrimination, Over-Generalization, and Error; and higher on Accuracy and Caution, when the pretest scores are compared with the posttest scores. However, these differences were not statistically significant ($p > .05$).

Table XII Results of the Social Studies Inference Test

Variable	Group	Pretest $\bar{X}_1$	Pretest s_1	Posttest $\bar{X}_2$	Posttest s_2	F*	Significance
Inference	Inquiry	10.44	3.95	9.11	3.80	0.09	n.s.
	Control	10.77	3.72	8.96	2.58		
Discrimination	Inquiry	7.56	2.47	7.19	2.39	0.13	n.s.
	Control	6.77	2.66	6.73	5.30		
Accuracy	Inquiry	8.30	2.41	10.30	2.58	1.42	n.s.
	Control	8.08	2.68	11.04	2.34		
Caution	Inquiry	12.74	3.86	15.15	4.64	0.01	n.s.
	Control	12.38	3.82	15.19	4.04		
Over-Generalization	Inquiry	5.30	3.05	3.56	2.12	0.19	n.s.
	Control	5.19	2.50	3.31	1.93		
Error	Inquiry	14.11	4.14	14.07	4.60	0.10	n.s.
	Control	14.27	4.27	13.73	5.52		

*Based on analysis of covariance of posttest scores, with pretest scores as covariate.

CHAPTER 5

CONCLUSIONS

LIMITATIONS OF THE STUDY

The limitations of this study center upon the following issues:

1. The Inquiry Development Program was designed to be implemented for a school year. A teaching experiment lasting twenty weeks may not be long enough to adequately evaluate the teaching program. It may be recalled, however, that J. R. Suchman's original research occupied a comparable time span of twenty-four weeks.
2. The Inquiry Development Program was designed to consist of demonstrations and student experiments as well as inquiry into the nature of discrepant events in film-loops. A study involving the exclusive use of film-loops may not be diverse enough to adequately evaluate the entire teaching program. It may be noted that this limitation was also inherent in J. R. Suchman's original research.
3. Students in a school which was not randomly chosen may not be typical of students in other schools. It

was previously noted, however, that the intelligence quotient data suggests that the students displayed characteristics of a theoretically normal distribution.

4. A sample of only fifty-three students may not be large enough to generalize to a larger population. This sample, however, constituted a single grade level population in a school.
5. The experimenter's use of the Inquiry Development Program strategy enhanced the student's inquiry skills and divergent thinking ability. The experimenter followed the technique explicitly detailed by J. R. Suchman[1] and A. Costa, C. Lavaroni, and F. Newton[2] in consultation with professors who were familiar with the technique.

Recognizing these limitations, certain characteristics of this study add to the strength of its generalizability. Firstly, it could be recalled that the study has high internal validity. According to the criteria outlined by Campbell and Stanley[3] it is a true experimental design incorporating a stratified random sample of students. In many comparable studies, administrative restraints limit the sampling to that of intact classrooms where historical factors could produce systematic results from inquiry procedures used in other subject areas by teachers other than the

experimenter.

The next important factor to reiterate is that the mean intelligence quotient was 104 in the experimental group and 102 in the control group. These means are typical of a theoretically normal distribution. Many of the studies in the area of inquiry and creativity use atypical "gifted" students. Another important feature of this study is that the posttesting of the students was viewed as a natural outgrowth of the science units. The students did not conform to an external experimenter's expectations, i.e., the Hawthorne effect, since their usual classroom teacher administered the test activities.

Although the results of this study cannot be rigorously extended beyond the two classrooms in which the study was performed, the results are worthy of note since they are the product of a typical sample of students who were introduced to the Inquiry Development Program by their classroom teacher under a high internally valid set of conditions.

CONCLUSIONS

On the basis of the findings of this study, the following conclusions were drawn:

1. Inquiry Training in physical science is effective in increasing questioning fluency on discrepant events portrayed in physical science film-loops.

2. Inquiry Training is not more effective than the control treatment in teaching science subject-matter as measured by the Sequential Tests of Educational Progress.
3. Inquiry Training in physical science is not more effective than the control treatment in obtaining growth in critical thinking as measured by the Social Studies Inference Test.
4. There are no overall statistically significant sex differences on the subscores and total scores of the Torrance Tests of Creative Thinking.
5. Inquiry Training in physical science is effective in increasing discrepant event questioning fluency in subject areas other than physical science.
6. Inquiry Training in physical science is effective in increasing fluency, flexibility and originality of students on the Torrance Tests of Creative Thinking. To this extent, Inquiry Training is effective in increasing the divergent thinking ability of students.

DISCUSSION

The finding that the experimental group outperformed the control group on the posttest of the Inquiry Development Program film-loop was consistent with G. Schlenker's[4] research. This was the main finding in Suchman's original

research and has been corroborated by other investigators. However, it is noteworthy that the students in this study had to transfer their inquiry skills from the oral form used in the inquiry sessions, to the written form in the posttesting situation. Furthermore, the students had to undertake their inquiry privately, without feedback from their teacher or sharing of ideas in their peer group.

The conclusion that the experimental group did not score higher in science subject matter does not necessarily mean that there were no differences between the experimental and control group in this area. The conclusion merely implies that there were no differences in generalized science content measured by the Sequential Tests of Educational Progress in science. These tests were chosen because of their long-standing and wide-spread use in educational testing of general science knowledge. They did not cater to the specific knowledge gained by either the experimental or the control group and were thus not sensitive enough to detect growth in science subject matter in either the Inquiry Development Program or the Elementary Science Study students.

The literature concerning the impact of the Inquiry Development Program on general science tests is equivocal. It may be recalled that G. Schlenker showed statistically significant gains by inquiry-trained students on the Test On Understanding Science. However, he did not find concomitant

increments on the Stanford Achievement Test, Science. B. Clark[5] found that teacher lectures, demonstrations and teacher-centered class discussions were superior to inquiry training in yielding student growth in science subject matter achievement. W. Jones,[6] on the other hand, found that inquiry training resulted in greater gains in science subject matter as measured by the Cooperative General Science Test.

The finding that inquiry training was not effective in obtaining growth in critical thinking measured by the Social Studies Inference Test does not exclude the possibility that growth in critical thinking closely related to the Inquiry Development Program occurred. These tests may not have been sensitive enough to the particular content and format of the Inquiry Development Program. A review of the test items in relation to the content dealt with suggests that this was the case. It may be recalled that D. Butts and H. Jones[7] found statistically significant gains by inquiry-trained students on the Tab Inventory of Science Processes (TISP) which purports to measure the student's problem solving and reasoning ability using content and strategy similar to that of the Inquiry Development Program.

The objective of this study was to investigate whether or not the hypothesized more effective critical thinking abilities of inquiry-trained students could transfer to content other than physical science, i.e., social studies. Apparently

this was not the case. Admittedly this objective was idealistic but perhaps a test similar to the TISP could be developed retaining a simulation of the Inquiry Development Program strategy with different subject-matter content. If the Inquiry Development Program does increase critical thinking ability, then the question becomes, how strong and applicable is this ability and what are the possibilities for transfer? That was the precise question this researcher was asking but apparently the Social Studies Inference Test is too remote from the Inquiry Development Program's content and strategy to detect the upper limits of transfer.

The only subscore on the Torrance Tests of Creative Thinking in which the girls scored higher than the boys to a statistically significant extent ($p < .05$) was the flexibility posttest in the experimental group. Girls of this age level (ten and eleven years of age) typically out-perform the boys academically. The girls did score higher than the boys on all the subscores and total scores in both the pretests and posttests, however, there was no statistically significant ($p > .05$) mean-gain difference between the pretest and the posttest scores in either the experimental or the control group.

It may be recalled that F. Bills[8] found that the girls in his study scored statistically higher than the boys on several of the subscores of Guilford's creativity tests.

Bills' findings are consistent with the results in this study and differ only in the degree of achievement.

It is most interesting to note that the spread between the experimental and control groups was largest for originality and next largest for flexibility when compared with fluency. Many researchers claim that the educational value of the Inquiry Development Program is the increased questioning fluency limited to physical science discrepant events portrayed in film-loops. Increments in flexibility and originality represent a most encouraging finding and suggests an Inquiry Development Program potential for fostering autonomy in inquiry skills and divergent thinking.

It may be recalled that B. Clark[9] did not find a relationship between the Inquiry Development Program and divergent thinking in his five-week experiment. F. Bills,[10] on the other hand, found gains on four out of the six divergent thinking tasks on Guilford's creativity tests.

This study presents evidence that inquiry-trained students show increased scores in fluency, flexibility and originality on the Torrance Tests of Creative Thinking. This finding suggests a relationship between the Inquiry Development Program and divergent thinking. Although the research evidence is equivocal on this relationship, there are theoretical similarities between E. P. Torrance's concept of teaching for divergent thinking and J. R. Suchman's concept of

inquiry training, which imply a relationship.

It has previously been noted that E. P. Torrance's definition of creativity doubles as an apt description of the Inquiry Development Program technique. Moreover, Torrance's principles for rewarding creative thinking are inherent in the Inquiry Development Program procedures. Torrance and Suchman both agree that incompleteness and disharmony in the form of discrepant events is a powerful motivating force for initiating inquiry. Suchman has not specifically hypothesized a relationship between his program and divergent thinking although he often alludes to terms such as 'creative' when describing Inquiry Development Program procedures.

It may be noted that the most difficult posttest task (The Salt March) showed the largest spread between the experimental and the control groups on the variable of fluency. It could be hypothesized that the autonomy and confidence of the experimental group to inquire was most explicit in this task. The inquiry-trained students did not balk at the difficulty of the discrepant event. They inquired with confidence of making headway and later remarked that they found the problem interesting and challenging. Many students requested to continue the inquiry format with this problem during the next class. The control group, on the other hand, seemed to not have the skills and the confidence to proceed with the task. The difference in attitude and achievement between the two

groups was remarkable and it is most encouraging to consider that the inquiry-trained students were making strides toward realizing J. Richard Suchman's vision of becoming autonomous inquirers.

RECOMMENDATIONS FOR FUTURE RESEARCH

The exploratory nature of this study offers only a tentative evaluation of the Inquiry Development Program approach to learning. To substantiate the findings of this investigation, the following activities may prove valuable:

1. The study should be replicated with the experiment continuing for an entire school year.
2. The study should be replicated with a larger sample of students.
3. The study should be replicated with a larger number of high academic achievers.
4. More sensitive instruments should be used to measure the merits of the program in terms of subject matter gains.
5. More sensitive instruments should be used to measure the merits of the program in terms of critical thinking ability.
6. The Inquiry Development Program should be supplemented with the use of discrepant events in areas other than physical science to teach for transfer of inquiry skills.

Notes

[1]J. R. Suchman, *Developing Inquiry* (Chicago, Ill.: Science Research Associates, 1966).

[2]A. Costa, C. Lavaroni, and F. Newton, *Inquiry Development Extension Service, Unit II* (Chicago, Ill.: Science Research Associates, 1967).

[3]D. T. Campbell and J. C. Stanley, *Experimental and Quasi-Experimental Designs For Research* (Chicago, Ill.: Rand McNally College Publishing Co., 1973).

[4]G. Schlenker, "The Effects Of An Inquiry Development Program On Elementary School Children's Science Learnings" (Dissertation Abstracts, New York University, 1970).

[5]B. M. Clark, "An Experiment In Cultivating Creative Thinking Abilities In The Classroom" (Dissertation Abstracts, Iowa State University, 1968).

[6]W. W. Jones, "An Investigation Of The Effect of Acknowledging Successful Autonomous Discovery By Seventh Grade Students Exposed To The Inquiry Development Program" (Dissertation Abstracts, University of Northern Colorado, 1972).

[7]D. P. Butts and H. L. Jones, "Inquiry Training and Problem Solving in Elementary School Children," *Journal of Research in Science Teaching* 4 (1966):21-27.

[8]F. L. Bills, "The Development Of Divergent Thinking As A Function Of Inquiry Training" (Dissertation Abstracts, Utah State University, 1970).

[9]B. M. Clark, "An Experiment In Cultivating Creative Thinking Abilities In The Classroom" (Dissertation Abstracts, Iowa State University, 1968).

[10]Bills, "The Development Of Divergent Thinking."

APPENDIX A

TIMETABLE FOR THE STUDY

Date		Session
Jan. 17	Torrance (E & C)	
Jan. 20	Science film test (C) Film #14, "The Diving Bottle"	
	Discrepant event test (C)	
	Social Studies Inference Test (E & C)	
Jan. 21	Science film test (E) Film #14, "The Diving Bottle"	
	Discrepant event test (E)	
	Social Studies film test (E)	
	Film #2, "The Cannon"	1
Jan. 27	Social Studies film test (C)	
Jan. 28	Film #3, "The Baseball Catcher"	2
Feb. 4	Cognitive Levels test (E & C)	
	Film #4, "The Man and the Dumbells"	3
Feb. 11	Film #5, "The Five Pendulums"	4
Feb. 18	Film #6, "The Ice Cubes"	5
Feb. 25	Film #9, "The Train and the Track"	6
Mar. 4	Film #10, "The Spring Carts"	7

Date		Session
Mar. 11	Film #11, "Walking"	8
Mar. 18	Film #12, "The Sailboat and the Fan"	9
Mar. 25	Easter Break	
Apr. 1	Film #13, "The Wrenches"	10
Apr. 8	Film #15, "The Knife"	11
Apr. 15	Film #16, "Drinking Boiling Coffee"	12
Apr. 22	Film #17, "The Spring"	13
Apr. 23	Henmon Nelson test (E & C)	
Apr. 29	Film #18, "The Amusement Park"	14
May 6	Film #19, "The Pendulum and the Peg"	15
May 13	Film #21, "The Eight Pendulums"	16
May 20	Film #24, "The Long Pendulums"	17
May 27	Film #25, "The Shrinking Balloon"	18
May 30	Science film test (E & C) Film #22, "Boiling by Cooling"	
	Discrepant event test (E & C)	
June 2	Torrance (c)	
June 3	Torrance (E)	
June 9	Identify the problem (C) Film #20, "The Man and the Wheel"	
	Geography slide (C)	
	S.T.E.P. (E & C)	

Date	Session
June 10	Identify the problem (E) Film #20, "The Man and the Wheel"
	Geography slide (E)
	Taba Social Studies Inference Test (E & C)
June 16	Social Studies film test (C)
June 17	Social Studies film test (E)

APPENDIX B

THE SOCIAL STUDIES INFERENCE TEST

Grades 4-6

Explanation to students:

This booklet has some stories. After each story there are some sentences about the story. First, I will read the story out loud to you and you can follow along in your booklet. Then I will read each of the sentences and you are to decide whether the sentence is probably true, probably false, or if you can't tell whether it is probably true or false.

You have 3 different colored cards. Take the blue card first. You see on this card spaces for marking your answer.

Decide on an answer for each sentence that I read to you. Mark your answer with a heavy black mark. If you think the answer is probably true, mark in the space under "Probably True." If you think the answer is probably false, mark in the space marked "Probably False." If you can't tell from the story whether the sentence is probably true or probably false, mark in the space under "Can't Tell."

For some of the sentences "probably true" may be the correct answer. For some of the sentences "probably false" may be the correct answer. For some of the sentences "can't tell" may be the correct answer.

Example:

> Mr. Jones was a farmer in the midwest. When he heard about the discovery of gold in California, he left his family and went to California.
>
> 1. Mr. Jones went to California with his family.
>
> 2. Mr. Jones went to California because he did not like the place in which he lived.
>
> 3. Mr. Jones went to California to look for gold.

4. Mr. Jones will find gold in California.

BLUE CARD

People X and People Y:

This is about two groups of people, People X and People Y.

People X hunt and fish to get food. They often have to move because the herds of animals move from place to place.

Most of People Y are farmers. However, many of them make simple tools. The toolmakers trade the tools to the farmers in exchange for food.

1. People Y are more likely to build schools for their children than People X.

2. People X and People Y live in Africa.

3. People Y have machinery.

Mecano and Growland:

Two countries, Mecano and Growland, are next to each other. The people of Mecano have developed modern industry. They are well educated. There are colleges that train doctors, lawyers, engineers, and business men. The people who live in Growland lead more simple lives. Mostly they work on their farms. Some of them make baskets and jewelry. Their goods and farm products are traded to the Mecanos in exchange for manufactured items. There is a valley near Mecano and Growland. People from Mecano and Growland are going to live together in this valley.

4. The Growlanders in the valley will become more like the Mecanos, but the Mecanos will not become like the Growlanders.

5. The Mecanos and the Growlanders speak the same language.

6. The Mecanos and the Growlanders live together in the valley because all of their land has been used up.

Mr. Jones' Grocery Store:

Mr. Jones owns a grocery store. Often, in the last few weeks, he has not had enough bread for his customers. It has been an unusually dry season in the area and the wheat crop has not done well this year.

7. The delivery trucks have broken down so Mr. Jones is unable to get bread.

8. There was as much rainfall this year as last year.

9. The bakers have been very busy this year.

10. Mr. Jones will start baking his own bread.

11. They are using the wheat to make other things this year rather than for making bread.

12. Mr. Jones will close his store until more bread is baked.

13. The wheat crop was of poor quality.

14. The price of bread is higher this year than last year.

15. More wheat will be harvested this year than last year.

People A and People B:

People A: The vote had been very close. A number of the representatives did not like the outcome. They decided to go back to their districts and ask the people for support. This was the fourth vote on which the President had been defeated.
People B: The Chief asked his council for advice and then he told his people what he had decided. The people listened to their Chief. When he was through talking, they cheered.

16. People A and People B have the same system of government.

17. The representatives of People A are selected by the President.

18. People A will re-elect the representatives who voted for the bills the President supported.

19. The Chief of People B knew his people would do what he wanted them to do.

20. Most of the representatives of People A agreed on the issue that they had just voted on.

21. People B vote for the members of the council.

YELLOW CARD

Mr. Edwards' Farm:

Mr. Edwards' farm was in the valley. He had just finished planting his seeds. He could see the snow on the mountains. He hoped the snows would not melt too fast. The fire last summer burned most of the trees on the mountainside.

1. More water will flow into the valley this year than last year.

2. Mr. Edwards' seeds will die of frost.

3. Topsoil from the mountain will be washed down into the valley.

4. Mr. Edwards planted his seeds after the snow fell.

5. Mr. Edwards' farm is on the mountainside.

Seal Harbor:

The city of Seal Harbor is a rapidly growing transportation center. It has been served by planes, railroads, and ocean-going ships. It has just improved the airport and extended the runways so it can serve the largest and fastest jet aircraft.

6. More business and new businesses will be attracted to Seal Harbor.

7. Propeller planes will not be used very much at the Seal Harbor airport.

8. Trade with other cities will be increased.

9. Salaries in Seal Harbor will increase.

Henry and Taro:

Henry's father is a farmer. Henry is twelve years old. During the week Henry goes to school and he wants to become a teacher. On weekends he works on the farm and has learned to drive a tractor. His father is happy that Henry wants to become a teacher.

Taro is also twelve years old. Taro's father is a hunter. Taro's grandfather also was a hunter. Taro is learning to hunt from his father. Many times on the way home from hunting Taro stops to watch the fisherman. One day Taro asked his father, "Can I become a fisherman?" Taro's father said, "No, because I am a hunter."

10. Henry's father wants Henry to become a farmer.

11. Henry's grandfather was a farmer.

12. Taro will leave the tribe and become a fisherman.

13. Taro's sons will become hunters.

The Picker:

Three months after the Picker had been invented, more flander had been picked than for all of the year before. All of the machines at the textile mills were working day and night. Six months after the Picker had been put to use, the mills realized that they could not process the amount of flander sent to them.

14. Flander is used in making cloth.

15. The mills will change the way they process flander.

16. Less flander will be grown next year.

Pambo and Tom:

Pambo is twelve years old. There are no schools where Pambo lives. He does not read or write. He fishes with his father every day. Pambo is learning to cut bark from trees to make a canoe. His father teaches him many things and is proud of how well Pambo can do them.

Tom is also twelve years old. He works hard at school and

gets good grades. When he comes home from school he reads his books so that he will learn things that will help him.

17. Tom is smarter than Pambo.

18. Pambo's father can read and write.

19. Pambo is having trouble learning how to make canoes.

20. Tom reads every day because he is behind in his school work.

21. If Pambo and his family move to the city where Tom lives, Pambo will go fishing every day with his father.

GREEN CARD

Mr. Rand's Land:

Thirty years ago Mr. Rand bought a thousand acres of farmland. Many new industries have developed in the city nearby. About ten years ago Mr. Rand sold half his farmland to people who build homes. Last year Mr. Rand sold two hundred acres more and many homes have already been built on this land.

1. The people who bought the houses are coming to work on Mr. Rand's farm.

2. Mr. Rand will sell the rest of his farmland to the people building homes.

3. Mr. Rand still owns half of the farmland that he bought thirty years ago.

4. Mr. Rand sold his farmland for more money than he paid for it.

5. They are building houses for the people coming to work in the industries.

6. The people who had worked on Mr. Rand's farm went to work for industry.

7. The people who bought Mr. Rand's farmland were farmers.

Pacific Island:

An island has just been discovered in the Pacific Ocean. The natives of this island cannot read or write. Most of them are farmers. Some are fishermen who get fish from the ocean. Several food companies in California want to get the fish from the ocean around the island. These companies will send fishing boats from California and build a cannery on the island. Many people will be needed to work in the cannery.

8. Most of the islanders are fishermen.

9. The islanders will build fishing boats for the people who own the cannery.

10. The islanders will become wealthy from the fishing industry.

11. The natives will be happier because of the cannery.

Mr. Harvey's Speech:

Mr. Harvey spoke to the Founders Club last night. Here is part of what he said:

"In the early days of our country many people settled here from other countries. They came here to establish a way of life that was better than they had in their own countries. They helped build a strong America because they believed in *America*. Today the foreigners who come here do not seem to appreciate the freedom and opportunity America offers them. We ought to be more careful about who we let in and require an oath of these foreigners before we accept them."

12. Mr. Harvey feels that people who take an oath can be trusted.

13. Mr. Harvey had studied a great deal about America.

14. Mr. Harvey is running for political office.

The Koskis:

Mr. and Mrs. Koski remembered the day they docked in New

York. They had been married only two months when they arrived from Poland. America was a strange land to them. Mr. Koski worked hard for many years so his children could go to school. Ed, the oldest child, is now in college and will one day become a lawyer.

15. The Koskis came to America last year.

16. Ed is proud of his father.

17. The Koskis will return to Poland to live.

ITEM KEY

	Blue Card				Yellow Card				Green Card		
Item No.	PT	CT	PF	Item No.	PT	CT	PF	Item No.	PT	CT	PF
1.	I	C	E	1.	I	C	E	1.	E	C	I
2.	OG	A	E	2.	OG	A	E	2.	OG	A	E
3.	E	E	D	3.	I	C	E	3.	E	E	D
4.	I	C	E	4.	D	E	E	4.	I	C	E
5.	OG	A	C	5.	E	E	D	5.	I	C	E
6.	OG	A	C	6.	I	C	E	6.	OG	A	E
7.	E	C	I	7.	OG	A	E	7.	E	E	D
8.	E	C	I	8.	I	C	E	8.	E	E	D
9.	E	C	I	9.	I	C	E	9.	E	E	D
10.	E	C	I	10.	E	E	D	10.	OG	A	E
11.	E	C	I	11.	OG	A	E	11.	OG	A	E
12.	E	C	I	12.	E	C	I	12.	D	E	E
13.	OG	A	E	13.	I	C	E	13.	OG	A	E
14.	I	E	C	14.	D	E	E	14.	OG	A	E
15.	E	E	D	15.	I	C	E	15.	E	E	D
16.	E	C	I	16.	E	C	I	16.	OG	A	E
17.	E	C	I	17.	OG	A	E	17.	E	C	I
18.	OG	A	E	18.	E	C	I				
19.	I	C	E	19.	E	E	D				
20.	E	E	D	20.	E	E	D				
21.	OG	A	E	21.	E	C	I				

Key: C = Overcaution; D = Discrimination; I = Inference; OG = Overgeneralization; A = Accurate; E = Error

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